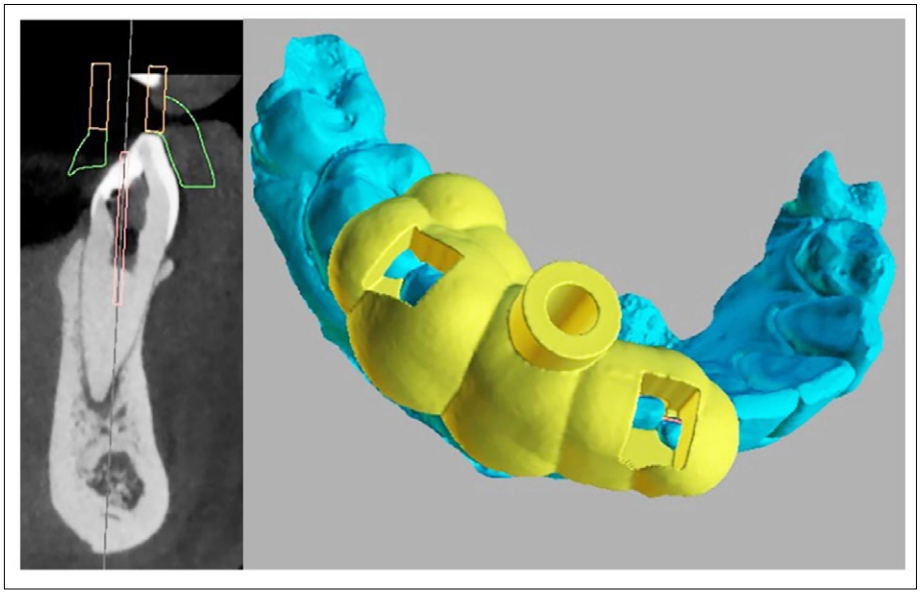
ISSN 1 121-4171

June 2020 | 1 | Vol. 34

GIORNALE ITALIANO DI ENDODONZIA



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REGISTRATION Court of Milan n° 89, 3 March 2009

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Editorial Editoriale

In the present issue we collected the most interesting and recent themes focused on the macro-topic of prevention and treatment of infections. The editorial choice is focused on the SIE (Italian Society of Endodontics) position statement about asepsis that suggests the main guidelines that should be adopted during the different phases of endodontic treatments, aiming at minimizing the risk of contamination of the root canal system.

The discussed topic is strongly influenced by the event that, dramatically, is affecting our private practice, social as well as relational life. Indeed, in the last months of 2019, the Severe acute respiratory syndrome (SARS-CoV2), better known as COVID-19, had been developed first in China then worldwide. This syndrome, characterized by a high infection and lack of resolved treatments, had been defined as "pandemic" on March 11th, 2020 by World Health Organization (WHO), becoming the second pandemic of this century.

This dramatic event has deeply influenced our professional field, critically changing our protocols in the management of patient-clinician and in the prevention of infections as well as cross-contaminations. Indeed, virus transmission is particularly devious: it basically takes place through interaction (i.e. inhalation, direct contact, or ingestion) between the host and the virus contained in the epithelium of the respiratory system and exposed mucosae, typically by flügge or other particles that possess persistence in the surrounding environment. Finally, the virus shows an unusual resistance even on surfaces not commonly involved in the viral survival, as hands, steel instruments, and also walls of the dental office. Moreover, clinicians involved in the dental practice may treat asymptomatic although COVID-19 positive patients, demonstrating how our category is one of the mostly exposed to COVID-19 infective risk.

National and International dental associations have tried to promptly provide univocal guidelines to correctly manage the patients and to preserve the dental practitioners from both direct and indirect infection.

According to this background, the present issue of GIE, as already done by other scientific Journals, publishes a highly significant and detailed paper concerning COVID-19 concern, aiming at suggesting recommendations in the field of prevention and control of SARS-CoV-2 infection within the dental office.

It should be also noticed that, although the current emergency, maximum attention to the microbial as well ergonomic control of operative area, use of Individual Protection Devices (DPI), sterilization of the instruments and guarantee of an aseptic flow work are daily adopted during the dental practice to significantly reduce the infective risk related to patients and to dental staff.

The right risk management, from both a clinical and microbiological point of view, belongs to the permanent practice of Evidence-Based Medicine that is based on the deep knowledge of therapeutic protocols and international guidelines.

Italian dentistry has always been internationally distinguished due to high quality and ability in a wide range of dental topics; unfortunately, our features, as well as those of Italian medical doctors, have usually been disregard, unappreciated and mortified. Even in this pandemic outbreak, it may happen that few patients have unrealistic demands concerning the sureness of results and time. It is well known that during the sharing-knowledge phase the treatment protocol changes very fast, and the "today" gold-standard could not be valid for tomorrow. However, the dental practitioners are always involved in primary care and first assistance of the emergency and act to minimize the clinical as well as social risks.

In conclusion, I hope that, once this editorial is published, all of us may read it just remembering a passed crisis thanks to the efficacy of the infection prevention and the modern scientific research concerning pharmacology and biotechnology.

Peer review under responsibility of Società Italiana di Endodonzia.

10.32067/GIE.2020.34.01.13

Editorial Editoriale

In questo numero abbiamo voluto creare un contenitore capace di raccogliere le più interessanti e attuali tematiche incentrate sul macro-tema della prevenzione e del trattamento delle infezioni.
La scelta editoriale è focalizzata indubbiamente sulla posizione della SIE (Società Italiana di Endodonzia) riguardo l'asepsi: nel Position Statement sono indicati i principali accorgimenti che l'operatore dovrebbe seguire durante le diverse fasi del trattamento endodontico, nell'ottica di minimizzare il rischio di contaminazione del sistema canalare.
La tematica di questo numero è fortemente influenzata dall'evento che, drammaticamente, sta toccando la nostra professione, e la nostra stessa vita sociale e relazionale.
Infatti, negli ultimi mesi del 2019 si è sviluppata e diffusa dapprima in Cina, e successivamente in molte altre parti del mondo, la sindrome respiratoria acuta grave (SARS-Cov2), nota anche come COVID-19. Questa sindrome, caratterizzata da un'alta contagiosità e da un'assenza di presidi terapeutici particolarmente risolutivi, è stata dichiarata "pandemia" in data 11 marzo 2020, divenendo la seconda pandemia di questo secolo, secondo l'Organizzazione Mondiale della Sanità (OMS).
Questo drammatico evento ha condizionato profondamente il nostro settore professionale, modificandone criticamente i protocolli nella gestione paziente-operatore e nella prevenzione delle infezioni e delle cross-contaminazioni.
La trasmissione del virus è particolarmente subdola: essa avviene principalmente attraverso l'interazione (tramite inalazione, ingestione o contatto diretto) tra il virus contenuto negli epiteli delle vie respiratorie alte e le mucose esposte, tipicamente attraverso flügge o altre particelle che mostrino persistenza nell'ambiente circostante. Infine, il virus mostra un'insolita resistenza anche su superfici tipicamente poco avvezze alla sopravvivenza di forme virali usualmente termolabili e cronolabili, come le mani, lo strumentario in acciaio e, addirittura, le pareti dello studio odontoiatrico.
Quindi, la nostra categoria inconsapevolmente può eseguire cure su pazienti infetti, ma non ancora diagnosticati per la patologia del COVID-19. Da questo si intuisce facilmente come i dentisti siano tra i professionisti maggiormente esposti al rischio infettivo da COVID-19. Le nostre associazioni di categoria nazionali e internazionali hanno cercato di fornire tempestivamente linee guida chiare e semplici per la gestione dei pazienti odontoiatrici, e per preservare i dentisti da qualsiasi rischio di contagio diretto e indiretto.
Fatta tale premessa, non potevamo esimerci dal proporre in questo numero del GIE, così come già accaduto per molte altre riviste scientifiche, la pubblicazione di un articolo molto significativo e dettagliato riguardante la problematica del COVID19, al fine di poter suggerire delle raccomandazioni nel campo della prevenzione e del controllo dell'infezione da SARS-CoV-2 all'interno dello studio odontoiatrico.
È d'obbligo, tuttavia, sottolineare che alla base della nostra professione quotidiana, e indipendentemente dall'attuale periodo critico e di emergenza, vi è sempre stata la massima attenzione alla gestione microbiologica ed ergonomica dell'area operatoria, all'utilizzo dei dispositivi di protezione personale (DPI), alla sterilità delle attrezzature e alla gestione asettica del flusso di lavoro, al fine di ridurre il rischio infettivo relativo ai pazienti e al personale di studio.
La corretta gestione del rischio, sia da un punto di vista clinico sia da un profilo meramente infettivo e microbiologico, attiene alla costante pratica della *Evidence Based Medicine* che non può prescindere da una profonda conoscenza dei protocolli e delle linee-guida internazionali. L'odontoiatria italiana si è sempre distinta a livello internazionale per qualità e per capacità di saper essere leader su moltissimi settori delle scienze odontoiatriche: purtroppo, la qualità degli odontoiatri, come quella dei medici italiani, che pure oggi vengono decantati e sublimati come professionisti simili a forme chimeriche tra il "santo" e l'"eroe", viene spesso deprezzata, incompresa e umiliata.
Anche in questo outbreak pandemico si sono visti percorsi quantomeno "attenzionabili" in cui il paziente intraprende fantasiose e capziose richieste risarcitorie per la pretesa irrealistica di dover ottenere certezza di modi, tempi e risultati. Durante la fase di sharing-knowledge, si sa, i protocolli variano al giro di lancette di un orologio: ciò che oggi è gold-standard domani sarà desueto o forse inefficace. Quello che non cambia e non può cambiare è la abnegazione della nostra categoria, sempre in prima linea, sempre pronta per essere un "settore sentinella" capace di intercettare e, spesso, disinnescare situazioni ad alto rischio clinico e sociale: non vogliamo applausi né sentirci dire *bravi*!, ma almeno non toglieteci la serenità in un momento tanto destabilizzante.
In conclusione, auspico vivamente che allorquando questo editoriale sarà pubblicato, possiamo leggerlo ripensando a una crisi oramai passata e superata grazie a un efficace connubio tra una prevenzione attuata collegialmente e una ricerca farmacologica e biotecnologica innovativa.

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MINI REVIEW ARTICLE/**MINI REVIEW DELLA LETTERATURA**

COVID-19 and dental practice: overview and protocols during pandemic

COVID-19 e odontoiatria: generalità e protocolli durante la pandemia

KEYWORDS
SARS-CoV-2, COVID-19, Dental Practice, Infection Control, Pandemic

PAROLE CHIAVE
SARS-CoV-2, COVID-19, Odontoiatria, Controllo dell'infezione, Pandemia

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Received 2020, March 28

Accepted 2020, April 2

Abstract

In December 2019, in Wuhan (China), there were described the first cases of a Severe Acute Respiratory Syndrome caused by SARS-CoV-2 and named COVID-19. Since then the disease has spread in several countries and in March 2020 the WHO declared it pandemic.
COVID-19 is associated with a wide range of manifestations from no symptoms to temperature cough, dyspnea, need for artificial ventilation and eventually death. Mortality has been reported to be around 3%. Cases of spreading from asymptomatic infected individuals have been documented.
It has become clear that among healthcare professionals, dentists are the most exposed category to the risk of such infection as the routes of transmission are contact, droplets and aerosol, therefore the necessity of providing clear guidelines has suddenly arisen.
This article is aimed at analysing the available literature about "SARS-CoV-2" and "COVID-19", and comparing it with the guidelines for other coronavirus infections and dental practice with a view to providing clinical recommendations about prevention and infection control in the dental environment.

Nel dicembre 2019 sono stati descritti a Wuhan (Cina) i primi casi di Severe Acute Respiratory Syndrome causata dal virus SARS-Cov-2 e chiamata COVID-19. La patologia si è successivamente diffusa in diversi Stati fino a che nel marzo 2020 l'OMS ha dichiarato lo stato di pandemia.
COVID-19 ha diverse possibili manifestazioni: può essere completamente asintomatica o presentarsi con febbre, tosse, dispnea e talvolta necessità di ventilazione assistita con rischio di morte. La mortalità si attesta attorno al 3%. Sono stati documentati casi di contagio avvenuto mediante portatori sani.
Dato che il virus si trasmette mediante contatto, droplet e aerosol, i dentisti risultano la categoria più a rischio di contrarre la malattia rispetto agli altri operatori sanitari. Per questo motivo delle linee guida sulla gestione della pratica odontoiatrica durante la pandemia sono quanto mai necessarie.
Lo scopo di questo articolo è di analizzare la letteratura disponibile riguardo "SARS-CoV-2" e "COVID-19", comparandola con le linee guida esistenti per gestire i coronavirus nell'ambiente odontoiatrico, al fine di poter dare delle raccomandazioni inerenti prevenzione e controllo dell'infezione da SARS-CoV-2 nello studio odontoiatrico.

Introduction

In December 2019, several cases of viral pneumonia were discovered in Wuhan, Hubei, China. A novel coronavirus was recognised as the pathogen responsible for the infection and named 2019 Novel Coronavirus (2019 -nCoV), then changed in SARS-CoV-2 (1, 2). Since then the virus has spread in 177 countries.
On the 12th of February 2020, the World Health Organisation (WHO) named COVID-19 the disease caused by SARS-CoV-2 and in March 11th, declared it a pandemic (WHO Feb 2020; WHO Mar 2020).

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Peer review under responsibility of Società Italiana di Endodonzia
10.32067/GIE.2020.34.01.08

Healthcare professionals are exposed to this virus that can be spread through contact, droplets and airborne and indeed dentists are one of the most exposed category (Gamio 2020; Peng et al. 2020).
The aim of this article is to collect the available literature and provide guidelines based on literature and guidelines about SARS and MERS epidemic events and from the information so far available on SARS-CoV-2.
A comprehensive MEDLINE search up to 22th March 2020 was conducted using medical subject headings (MeSH) in combination with 'and' or 'or'. The MeSH terms searched were 'SARS-CoV-2', 'COVID-19', 'Dental' and 'Dental Practice'. In addition, the following terms were added, 'Dental Surgery', '2019 -nCoV'.
Because of the lack of scientific papers a comprehensive MEDLINE search up to 22th March 2020 using MeSH 'SARS-CoV-2', 'COVID-19', in combination with 'and' or 'or' was carried out. All the relevant papers regarding infection control and prevention were hand-searched in order to find all possible information that may apply to the dental field.

Review

General features
Coronavirus were isolated for the first time in 1966 from patients with common cold: they are a class of enveloped positive sense RNA viruses with diameter between 60 and 140 nm whose name come from the presence of spike-like projections that may resemble a crown (7, 8).
Coronaviruses are divided in four subfamilies a, b, g, d. SARS-CoV-2 belongs to the B lineage of the b-coronaviruses. It is most likely to have in bats its natural host and appears to have many similarities with the virus SARS- CoV (9, 10).
All ages and genders are potentially affected by COVID-19 even though males seem to be more susceptible to the infection. The range of symptoms goes from a completely asymptomatic state to Acute Respiratory Distress Syndrome (ARDS) and possible death (11). Common clinical features are quite not specific including high temperature, cough, myalgia, dyspnea, sore throat and conjunctivitis but the virus can be carried by asymptomatic people that are able to infect others (Pan et al. 2020; Rodriguez-Morales; Rothe et al. 2020; Singhal 2020).
Individuals with underlying medical conditions are more susceptible to an unfavourable outcome. The risk of death of patients presenting comorbidities like cardiovascular disease, diabetes, chronic respiratory disease, cancer and COVID-19 is statistically higher (Coronavirus Outbreak 2020).
Intensive care is needed in 25-30% of the cases, with an average hospital stay of ten days. Fatality ranges between 2 and 3 % and it is more common in the elderly and people who suffer from co morbidities (15).
Three routes of transmission have been found (table 1).
1) Contact transmission: when someone touches an infected object and subsequently touches his mouth, nose or eyes. 2) Droplets transmission: when the droplets generated by cough and sneezes are ingested or inhaled. 3) Airborne transmission: when droplets mix with the air creating aerosols that may cause infection if inhaled (11, 17). A feco-oral transmission is considered possible as well (18).
Human coronaviruses can stay active on certain surfaces from hours up to few days, but are inactivated within one minute after the disinfection with 0.1% sodium hypochlorite or 62-71% ethanol (19). On the other hand the virus has demonstrated to be viable in aerosols for at least 3 hours (20).

SARS- CoV-2 and dentistry

Possible transmission
Due to the nature of SARS-Cov-2 and its routes of transmission, it is clear that dentists, dental staff and patients are at risk of infection when dental treatments are provided (6).
Contamination can happen directly between operators and patients due to droplets during pre-clinical assessment or discussion of the treatment plan but contamination of air and surfaces plays a strategic role in the diffusion of the virus.

Table 1

Possible transmission of SARS-CoV2

Transmission route	Method of transmission	References
Contact	Direct or Indirect contact with mucosae	Kampf 2020
Droplets	Droplets of infected saliva ejected with cough or sneezes	Peng 2020
Airborne	Mix of air and viruses that can be inhaled	Peng 2020
Feco-Oral	Possible transmission through digestive tract	Zhang 2020

It has been demonstrated that dental treatments and in particular dental hygiene procedures produce aerosol and splatters with presence of microorganisms, causing contamination of tools, equipment, gowns, surfaces and air (21, 22).
Contamination of surfaces is unavoidable when aerosol is produced and SARS-CoV-2 can resist several days on surfaces, putting the operators at risk of infection (19). Apparently the virus persists better at room's humidity 50% than 30% (6).

Infection Control
Standard precautions used in dental practices are able to prevent cross-infections originated by direct contacts with body fluids and contaminated surfaces. SARS-CoV-2 though, presenting three routes of transmission including the airborne needs to be dealt with Transmission-Based Precautions (17).

Patient Screening
During the outbreak of SARS-COVs it is not recommended to perform routine dental treatments as the risk of contributing to the spread of the virus is high. Dental care should be provided just for dental emergencies or urgent dental care (6).
Dental emergencies are considered potentially life threatening conditions such as uncontrolled bleeding, cellulitis with swelling that could compromise the airways, facial trauma with possible airways involvement. Hospital emergency departments are overloaded during a pandemic and urgent dental care service should be provided for those patients that otherwise would have to use hospital services. Severe dental pain and conditions like pericoronitis of third molars/surgical post extractive osteitis should be considered urgent (23).
It is therefore important to perform a telephone triage in order to assess the risks and the severity of the condition. An interview over the phone is then necessary to prevent to bring infected patients into the surgery as much as possible.
The following questions should be asked (6, 24):

1. Have you experienced fever or symptoms like cough, shortness of breath or other respiratory problems in the past 14 days?
2. Have you been in contact with someone affected by COVID-19 in the past 14 days?
3. Have you been in contact with someone reporting fever or respiratory problems in the past 14 days?
4. Did you participate in gatherings, meetings or had contact with many unacquainted people in the past 14 days?
5. Did you travel from areas with Level 3 Travel Health Notice for COVID-19? (this question can be omitted when the virus is declared at community level)

If the patient answers *yes* to any of these questions the treatment should be postponed and the patient invited to contact his physician if the answer to questions number one or two is positive.

Patient Management
When emergency care must be provided, preventive measure should be taken in order to decrease the possible viral load (25). Chlorhexidine is often used in dental practice as an antiseptic, but this will not probably be effective against SARS-CoV2. The virus appears to be vulnerable to oxidation, thus a pre-operative rinse with

1% hydrogen peroxide should reduce the viral load in the oral cavity (6, 19, 23). Other than hydrogen peroxide, Povidone 0.2% has been recommended as rinse, as these two antiseptics have been demonstrated effective to reduce salivary viral load with low risk of causing secondary complications in the oral cavity (26).

Personal Protective Equipment

SARS-CoV-2 infection may occur through direct or indirect contact and aerosol, therefore when the outbreak is at community level Transmission-Based Precautions for contact, droplets and airborne must be taken for all patients. Standard surgical masks are effective against splashes and large-sized droplets but not effective against small airborne particles thus fit-tested N-95 respirators or superior ones are required, even more when aerosol-producing treatments are performed (28, 17, 29, 27).

Protective disposable impermeable gowns and caps are recommended as well as gloves and eye protection. These medical devices should be worn before coming in contact with the patient and discarded safely before leaving the room (28, 17). It is paramount that all the staff is adequately instructed on the use and doffing of Personal Protective Equipment (PPE) as deviation from standard procedures will increase the risk of infection (30).

Air Supply

Airborne Transmission Based Precautions treatments performing aerosol should be treated in Airborne Infection Isolation Room (AIIR) that is a single-patient room designed to maximise the infection control, equipped with special air handling and ventilation capacity compliant with AIIR standards (29). A COVID-19 positive or suspected patient should not be treated in a dental surgery

Table 2

Dental Emergency and Urgent Dental Care (ADA 2020)

	Description	Conditions
Dental Emergency	Potentially life threatening conditions that require immediate care	· Uncontrolled bleeding · Diffuse bacterial infection with intra-oral or extra-oral swelling that potentially compromise the patient's airway · Trauma involving facial bones, potentially compromising the patient's airway
Urgent Dental Care	Conditions that require immediate attention to relieve severe pain/infections and to avoid patients to seek for treatment in hospital emergency departments	· Severe dental pain from pulpal inflammation · Pericoronitis or third-molar pain · Surgical post-operative osteitis, dry socket dressing changes · Abscess, or localized bacterial infection resulting in localized pain and swelling · Tooth fracture resulting in pain or causing soft tissue trauma · Dental trauma with avulsion/luxation · Dental treatment required prior to critical medical procedures · Final crown/bridge cementation if the temporary restoration is lost, broken or causing gingival irritation · Biopsy of abnormal tissue

Table 3

Recommended Precautions for SARS-CoV-2

Transmission	PPE	Indications	Environment	Patient Management	References
Contact	· Gloves (Latex or Nitrile) · Isolation Gowns · Disposable cap	Wear these PPE before any contact with the patient and dispose them safely at the room entrance. Doffing of gowns and gloves must be done following existing guidelines.	· Eliminate all unnecessary equipment from the room · Be extremely careful in the disposal of contaminated equipment	· Ask the patient to use hand sanitiser when arrives · Ask the patient to wear a mask until his treatment	6, 11, 12, 17, 29, 30, 31, 32, 33.
Droplets	· Goggles · Face Shields	Goggles with antifog system have to be preferred. Face shields are more protective, especially if extended from chin to crown	· Disposable covers help avoiding surface contamination	· Ask the patient to follow respiratory hygiene and cough etiquette · Use Rubber dam	
Airborne	· N95 Respirators (FFP2)	N95 Respirators are recommended to avoid airborne transmission. Face fitting is mandatory	· Avoid as much as possible to create aerosol · Avoid the use of rotary handpieces and minimise the use of 3 in 1 syringe · If available, patient should be treated in AIIR	· Ask the patient to rinse his mouth with 1% hydrogen peroxide solution	

that has not the above mentioned equipment as it would be impossible to use airborne precautions. Since infection from SARS-CoV-2 is proven to be possible from asymptomatic patients it is recommended not to treat patients unless it is a dental emergency and, even in case of asymptomatic patients, all PPE for airborne precaution should be used, all possible care has to be used to reduce the amount of aerosol produced and the single patient room has to have the door closed and adequate ventilation to dilute the infected air. Table 2 reports what is recognised as dental emergency and urgent dental care according to the American Dental Association (23). Recommended precautions are summarised in table 3. If the patient is symptomatic or at high risk to be infected he should attend the practice and, if he does, be asked to wait in a closed room with a surgical mask covering nose and mouth, then the patient should be referred to the hospital or dealt with as regulated by the local health authority (17, 31).

Disinfection

Alcohol based or sodium hypochlorite based disinfectants are active against coronaviruses and they should be used to disinfect not only every component of the dental chair but the surfaces that can be in contact with aerosol spray as well. Removing from the room every not necessary equipment and covering all possible surfaces with disposable covers may help in improving the contact infection control.

Conclusions

Sars-CoV-2 is a very infective virus that causes COVID-19, a disease with a very broad range of manifestations, from lack of symptoms to ARDS and eventually death. Because of the routes of transmission of this pathogen dentists are among the health professionals who are exposed to high risk of infection.
When the disease is at community level, it is paramount that dental care professionals protect themselves, their staff and patients, avoiding any risk of spreading the virus. It is important to remember that completely asymptomatic patients are carriers of the infection.
In this view it is mandatory to postpone any elective treatments and dentists should treat only emergencies or provide care for those whom, if not treated, would need hospital care (table 2). In any case risk assessment over the phone is important to avoid high risk patients to attend the surgery if this is not equipped for proper airborne infection control.
In the dental environment infection may occur because of direct or indirect contacts with body fluids of an infected person or touching contaminated surfaces and then touching eyes or face. Droplets are a possible route of transmission as well as aerosol generated from dental treatments (table 1).
When treating a dental emergency during the outbreak of an airborne transmitted pathogen, Standard Precautions for infection control are not sufficient and Transmission Based Precautions must be applied.
Ideally treatments should be provided in AIIR when treating patients that have possibly come in contact with the virus. Because dental practices are not usually equipped with an AIIR, if an emergency arises it is important to use a single patient room with closed door, ensure adequate ventilation to the room, remove all unnecessary equipment and cover all surfaces that can be contaminated.
Because of the aerosol produced, operator and assistant must wear face fitting N95 respirators, goggles/face shields, isolation gowns, gloves and disposable caps. These PPE must be worn before any contact with the patient and dis-

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posed safely before leaving the room. It is important that dental staff is correctly instructed on the correct use and disposal of protective equipment as incorrect doffing has been linked with increased risk of infection.
Patients should be requested to disinfect their hands on the arrival with an alcohol based hand sanitiser, to follow respiratory hygiene and cough etiquette and to wear a surgical mask until the treatment commences. A rinse with 1% hydrogen peroxide may be helpful to reduce the amount of SARS-CoV-2 in the saliva.
Dental aerosol should be avoided: use of ultrasonic scaler or high speed handpieces is not recommended and the use of the 3 in 1 syringe should be reduced. Rubber dam must be used when possible and should cover mouth and nose.
Dental surgery decontamination has to be carefully performed. The virus is rapidly inactivated by disinfectant containing 0.1% sodium hypochlorite or 62-71% ethanol. Because of the aerosols the room has to be adequately ventilated to reduce the amount of virus present in the air.

SARS- CoV-2 is a challenge for healthcare professionals. During the outbreak of the disease only emergency treatments are recommended and special precautions and PPE must be used when providing dental care. Training and correct information about prevention and control of airborne infections should be provided to healthcare workers.

Clinical Relevance

COVID-19 is a major concern for public health and dentists are among the healthcare professionals facing the greatest risks of infection.
This article provides an overview on the disease and its routes of transmissions and gives indications for prevention and infection control in the dental environment.

Conflict of Interest

The Authors deny any conflict of interest.

Acknowledgements

No acknowledgements are needed.

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Position Statement on Asepsis in Endodontics

Position Statement: l'Asepsi in Endodonzia

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DOI 10.32067/GIE.2020.34.01.04

The purpose of Italian Society of Endodontics (SIE) is to promote and show excellence in endodontic knowledge, and to help all members to improve their endodontic treatment for the benefit of patient safety and increase the success of their treatment.
Endodontic success depends on many factors, the most important of which is prevention and management of problems that could lead to unfavourable results during orthograde endodontic treatment.
Asepsis is one of the most important factors faced during endodontic treatment: the operator needs to follow some precautions to minimize the risk of infection (or reinfection) of the root canal system.
SIE suggests the procedures that the operator should follow during the endodontic treatment to minimize risks of contamination of the root canal system.
These suggestions are made on the base of scientific evidence that show how endodontic failures are caused by microrganisms from the oral cavity.

Preparing the Operative Field

- To eliminate or decrease the bacterial concentration, the patient should rinse the mouth with clorexidine 0.2% for 1 minute. Calculus and plaque present on the tooth should be removed with a scaler or an ultrasonic device.
- All the instruments and tools should be sterile and should be discarded in case of contamination. The gloves should be also be changed if contaminated by touching non sterile objects or surfaces.

Access Cavity and Endodontic Treatment

- The access to the endodontic cavity should be performed after isolating the tooth with rubber dam. All the carious tissues should be removed completely.
- After removing the carious tissues it is recommended to disinfect the tooth and the operative field with sodium hypoclorite 5%, Ethanol 80% for 2 minutes.
- Single use gloves and aspirator tips should be changed before accessing the endodontic space.
- The tip of any Endodontic files (hand or rotary) should not come into contact with any surface potentially contaminated by external bacteria (Gloves or Rubber Dam).

Root Canal Obturation

- Root canals should be dried using sterile paper points.
- Gutta percha used for obturation of root canal system should be disinfected (leaving it in sodium hypoclorite 5% for at least 1 minute).
- Spatula, flat plastic and any mixing pad should be sterile.

La Società Italiana di Endodonzia (SIE) ha lo scopo di promuovere e divulgare conoscenze endodontiche che tendono all'eccellenza e che permettano ai soci di innalzare il livello qualitativo delle cure endodontiche nell'interesse della salute del paziente.
Il successo della terapia endodontica dipende da molti fattori e dalla prevenzione e gestione di situazioni che possano influire negativamente sull'outcome del trattamento endodontico ortogrado. Tra queste è sicuramente importante il problema relativo all'asepsi, cioè agli accorgimenti che l'operatore dovrebbe seguire per minimizzare il rischio di contaminazione del sistema canalare durante il trattamento endodontico ortogrado.
Sulla base di un'evidenza scientifica sul ruolo dei microorganismi nei fallimenti endodontici e sulla presenza di batteri provenienti dal cavo orale all'interno del sistema canalare nei casi di fallimento dei trattamenti canalari ortogradi, la Società Italiana di Endodonzia indica delle norme procedurali che l'operatore dovrebbe seguire durante le diverse fasi del trattamento nell'ottica di minimizzare il rischio di contaminazione del sistema canalare durante il trattamento endodontico ortogrado.

Preparazione al trattamento
- *Nell'ottica di ridurre il numero globale di batteri prima della procedura clinica è consigliato uno sciacquo con clorexidina allo 0,2% per un minuto ed è consigliata la rimozione di placca/tartaro dalla superficie dell'elemento che deve essere trattato.*
- *Tutto lo strumentario utilizzato deve essere sterile e dovrebbe essere sostituito in caso di contaminazione, così come i guanti devono essere cambiati ogni qualvolta tocchino oggetti e superfici fuori dal tray con gli strumenti sterili.*

Coronal Seal

To prevent reinfection of the root canal system, after endodontic the filling it is strongly recommended to seal the orifice using adhesive restorative materials or glass ionomer cements.

What a Position Statement is

The Position Statement is a guide to help all members of the SIE to better understand their role in dealing with problems that could arise during endodontic treatment in daily practice.
The position statement is produced by Expert members which study clinical problems and review the international scientific literature in order to reach their conclusion. The Position Statement is a view of the Society and can be discussed, modified and revised at any point. These statements are not guidelines in the strict sense but only recommendations, to help those clinicians who want to improve their clinical results and follow some protocols suggested by the Italian Endodontic Society.

Cos'è un Position Statement

Il Position Statement è una nota informativa che viene data ai soci sulla considerazione e posizione, appunto, che la Società ha relativamente a una problematica che i soci si possono trovare ad affrontare durante la pratica clinica quotidiana (oppure relativamente a una problematica di interesse endodontico.)
Sebbene sia frutto di un lavoro di soci esperti che analizzano il problema sia dal punto di vista clinico sia dal punto di vista scientifico previa analisi della letteratura scientifica internazionale, il Position Statement rimane comunque un punto di vista della Società e come tale è discutibile, opinabile e modificabile alla luce di future acquisizioni scientifiche relative all'argomento di cui è oggetto, e comunque non ambisce a essere una linea guida nel senso stretto del termine, né tantomeno una raccomandazione clinica e come tale non può essere utilizzata; il Position Statement è uno strumento informativo che aiuta il professionista che voglia seguire dei percorsi decisionali e degli approcci terapeutici condivisi dalla Società Italiana di Endodonzia, percorsi sostenibili sia clinicamente che scientificamente.

Accesso e trattamento dello spazio endodontico
- *L'accesso allo spazio endodontico deve essere eseguito solo dopo aver isolato correttamente il dente con la diga di gomma e aver rimosso il tessuto carioso.*
- *Una volta eliminato tutto il tessuto carioso è consigliabile disinfettare il campo operatorio con una soluzione disinfettante (ipoclorito di sodio 5%, etanolo 80% per 2 minuti).*
- *Guanti monouso e cannula aspiratrice dovrebbero essere cambiati prima di accedere allo spazio endodontico.*
- *La parte lavorante degli strumenti canalari non deve mai entrare in contatto con superfici potenzialmente contaminate con batteri esterni come guanti o diga di gomma.*

Otturazione del canale
- *Il canale deve essere asciugato mediante l'utilizzo di coni di carta sterili.*
- *La guttaperca utilizzata per la chiusura canalare deve essere disinfettata (bagno con ipoclorito di sodio al 5% per un minuto).*
- *Spatola e vetro per la miscelazione del cemento devono essere sterili.*

Sigillo coronale
- *Per prevenire la reinfezione dello spazio endodontico dopo l'otturazione è fortemente consigliato il sigillo degli orifizi coronali utilizzando materiali da restauro su base adesiva o cementi vetroionomerici.*

KEYWORDS
Orthograde Endodontic Treatment, Contamination Of The Root Canal System, Asepsis, Procedures, Root Canal Obturation, Coronal Seal.

PAROLE CHIAVE
Outcome trattamento endodontico ortogrado, contaminazione del sistema canalare, asepsi, norme procedurali, otturazione del canale, sigillo coronale.

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Winner of Giorgio Lavagnoli Award 36th SIE National Congress 2019

CASE SERIES/**CASI CLINICI**

Treatment of obliterated root canals using various guided endodontic techniques

Trattamento di canali obliterati con tecnica di endodonzia guidata

KEYWORDS
Endodontic access, Guided endodontics, Minimally-invasive, Calcified canal, CBCT, Intraoral scanning

PAROLE CHIAVE
Cavità di accesso, Endodonzia guidata, Minima-invasività, Canali calcificati, CBCT, impronta digitale

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Received 2020, February 13

Accepted 2020, March 3

Abstract

Objective: *This article reports on four endodontic treatments of obliterated teeth using a static guided endodontic (GE) technique. The aim is to demonstrate the benefits and limits of static guided endodontics.*
Cases: *The four patients were referred for endodontic treatment of an obliterated tooth. The teeth did not respond to pulp vitality test. Periapical X-rays and cone-beam computed tomography (CBCT) revealed the presence of a periapical lesion and root canal obliteration. Patients' consent was obtained to perform GE orthograde treatment. The clinical cases were treated by GE using different static fixed guides depending on the case: a closed guide and a metal sleeve and a open guide with a system guiding the head of the contra-angle.*
Treatment planning and guide manufacture were achieved by means of software programs initially designed for implantology, but which can also be used by endodontists. Root canal patency was obtained in all patients. In each of the four cases, drilling was done using a small diameter (0.75 mm) cylindrical drill (FFDM Pneumat Tivoly; Bourges; France). Once canal patency was obtained using a manual file, classic endodontic treatment could be performed.
Conclusions: *Static GE assists endodontists in the management of complex cases by enabling centered drilling of the canal with minimum risk of deviating from the virtually planned path. The novel choice of a small-diameter drill (0.75 mm) helps maximize the preservation of the dental tissues.*

Obiettivo: *questo articolo riporta quattro trattamenti endodontici di denti obliterati con una tecnica di endodonzia guidata (EG) statica. L'obiettivo è di mettere in evidenza l'interesse e i limiti dell'endodonzia guidata statica.*
Casi: *i quattro pazienti si sono presentati in appuntamento per il trattamento endodontico di un dente obliterato. I denti non rispondevano ai test di vitalità. Le radiografie periapicali e la CBCT mostrano la presenza di una lesione periapicale e di un'obliterazione canalare. Con l'accordo dei pazienti, é stato deciso di realizzare un trattamento endodontico ortogrado con EG. Questi casi sono stati trattati con EG con diversi tipi di dime statiche: una dima "chiusa" e una boccola metallica, una dima "chiusa" senza boccola metallica, una dima "aperta", utilizzando un sistema che guida la testa del contrangolo.*
Le pianificazioni e la creazione delle dime sono state realizzate con dei programmi inizialmente dedicati all'implantologia ma che sono trasferibili all'endodonzia. La pervietà canalare é stata ritrovata in ciascuno dei casi. In ognuno dei casi l'apertura é stata realizzata con una fresa cilindrica di piccolo diametro (0.75 mm) (FFDM Pneumat Tivoly; Bourges; France). Una volta ritrovata la percorribilità del canale con una lima manuale, il trattamento endodontico é stato eseguito in maniera classica.
Conclusione: *l'EG aiuta l'endodontista nella gestione dei casi complessi. Permette una apertura centrata sul canale con minimo rischio di deviazione significativa della traiettoria rispetto al progetto virtuale. La scelta di una fresa di piccolo diametro (0.75 mm) é innovativa in termini di conservazione dei tessuti dentali.*

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Peer review under responsibility of Società Italiana di Endodonzia
10.32067/GIE.2020.34.01.06

Introduction

The process of canal obliteration (CO) is characterized by the apposition of secondary or tertiary dentin, resulting in loss of volume in the pulpal space. CO can result from various causes (1):

- Pathological: trauma, decays, iatrogenic factors (bulky restorations or orthodontic movements) or occlusal overload.
- Physiological: age-related.

According to the study by Holcomb and Gregory, 4% of the population is affected by CO (2). In the event of trauma, the incidence reaches 22% (3). Root canal obliteration is considered to be a defence mechanism of the pulp, the vitality of which is often preserved. Esthetically, this usually leads to yellowish discolouration, which can be treated by external whitening and/or by placing a veneer (4). Endodontic treatment is only indicated when the canal obliteration is associated with radiological signs revealing a periapical lesion or clinical signs of irreversible pulpitis. This clinical situation poses a challenge for the practitioner. Even using a microscope, the risk of intra-operative error is very high (5).

Traditional cavity access has a design that has been the standard for a long time (6). Recently, Clark and Khademi introduced a novel access cavity model which highlights preservation of dental structures (7, 8). A new approach to access cavity preparation was described for the first time in 2013 by Kfir et al. for the treatment of a type 3 dens invaginatus using an endodontic guide (9). For this purpose, they segmented the dental structure by means of CBCT to achieve a resin 3D model of the tooth. The model served to plan and manufacture a resin guide. As a result, a drill could be guided towards the invagination to be treated while preserving pulpal vitality of the tooth. Byun et al. (10) reproduced this technique to treat two teeth with complex endodontic anatomies. Shortly afterwards, Van der Meer et al. (11) suggested a digital planning protocol for endodontic use inspired by implantology protocols. They merged a DICOM file obtained by CBCT with a Standard Tessellation Language (STL) file obtained from an intraoral optical impression. They calculated the drilling axis with the aid of an implant planning software and created a virtual guide. The virtual guide was then downloaded as an STL file to print a resin guide by means of a 3D printer. The guide enabled the drill to be centred towards the canal of an obliterated tooth. Such planning of the access cavity made it possible to preserve the dental structure and avoid deviations that may jeopardize tooth prognosis (12).

Static Guided Endodontics (GE) was then made simpler by using a single software program combining all the stages of the planning process, from visualization of the STL and DICOM files, to design the static guide and then printing the guide in resin materials. Some authors have applied this technique in cases involving maxillary (13) and mandibular incisor (14) and molar (15) root canal obliteration, as well as for removal of fiber-reinforced posts (16). In this article, four clinical cases were described involving the use of an endodontic static guide to perform endodontic treatment in a calcified root canal.

Report

Case 1

A 50-year-old female patient was referred following unsuccessful endodontic treatment on the mandibular right canine (tooth 43). She reported a trauma which had occurred 15 years before. The tooth presented with yellowish discoloration, was painful to percussion and reported a negative response to electric and thermal sensitivity tests (figure 1). This finding was confirmed by CBCT (VGI, Evo NewTom) with a 55 mm scan field of view and 100-micron resolution. The patient's informed consent was obtained to perform orthograde treatment by GE. The STL file of the arch

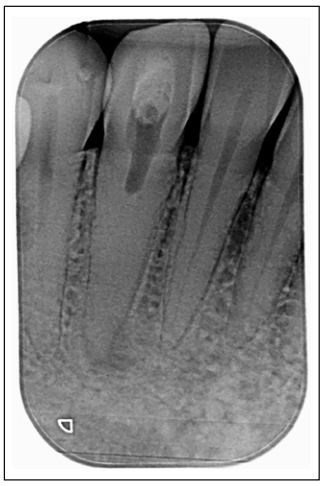


Figure 1
Preoperative X-ray. The patient was referred for treatment of tooth 43 displaying calcification and symptomatic periapical periodontitis.

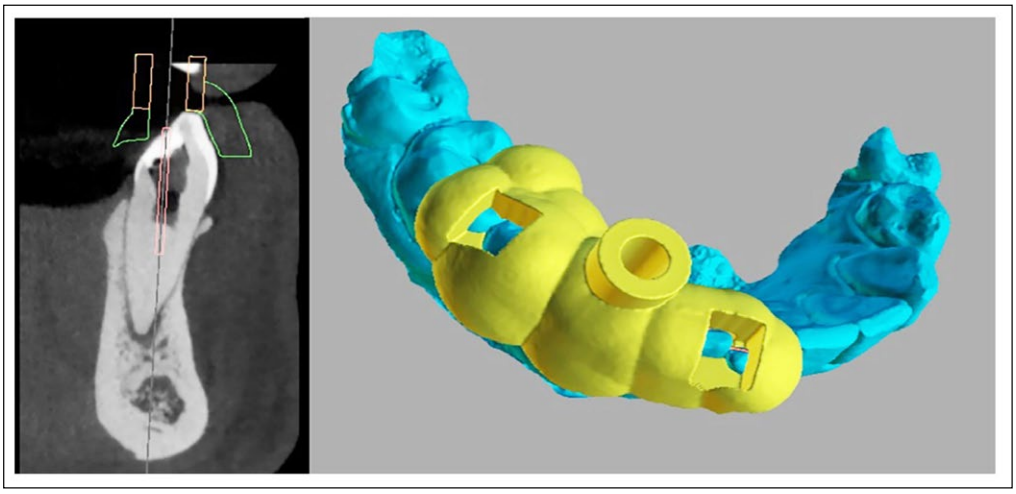


Figure 2
Planning the guide. The guide was designed using BlueSkyPlan freeware. The bur was designed and planned on the dicom file and oriented to ensure correct endodontic access to the calcified canal.

was obtained by optical impression and uploaded to the BlueSky Plan software (BlueSkyBio; LLC; Grayslake; IL; USA) The aim was to superimpose the digital image of the arch on the CBCT views. Merging of the two files was achieved by means of fixed reference points on the crown surface of all the teeth of the full arch. In this way, the inner surface of the guide can be modelled depending on the digital impression (figure 2). The sleeve slot was realised according to the position of the drill simulated on the DICOM images. Finally, two occlusal windows were virtually created on the guide to check proper clinical fit. The STL file for the guide was then downloaded and dispatched for 3D printing. The guide was printed in resin using a Formlabs 2 printer (Formlabs Inc; Sommerville; MA; USA). In fact, the metal sleeve was then inserted under friction into the resin guide to orient a drill 0.75 mm in diameter and 23 mm in length (FFDM Pneumat Tivoly; Bourges; France) (figure 3). During the clinical appointment the operative field was isolated using a rubber dam placed on several teeth to avoid interference between the guide and the clamp. The guide was tested to ensure a proper fit and stability on the teeth. The drill, mounted on a low-speed contra-angle, was inserted into the sleeve, then rotated at 20,000 RPM. The guide was kept very stable by the clinician during drilling. At every millimeter of progress along the canal, the guide was withdrawn to allow the access cavity to

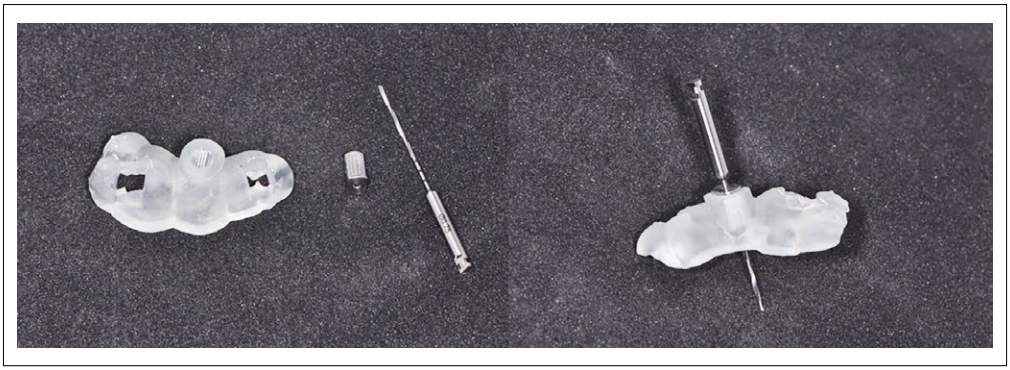


Figure 3
3D impression of the guide. The resin guide was printed; the bur used was cylindrical (0.75 mm in diameter and 23 mm in length) (FFDM Pneumat Tivoly) *(made by Asselin Bonichon lab)*.

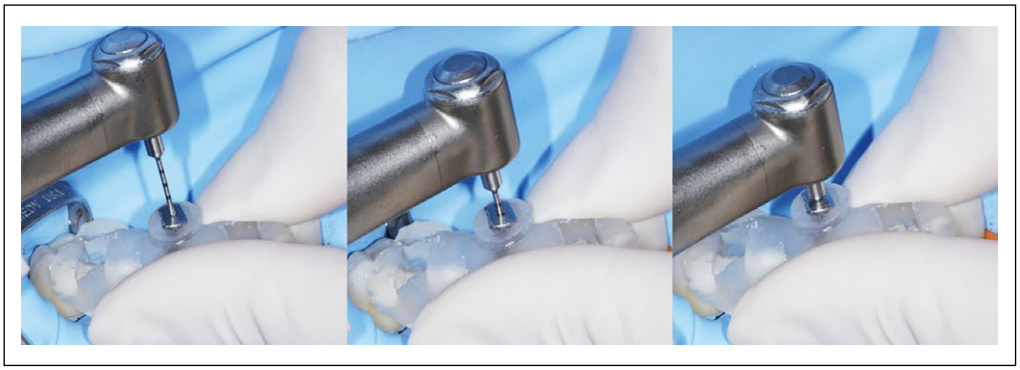
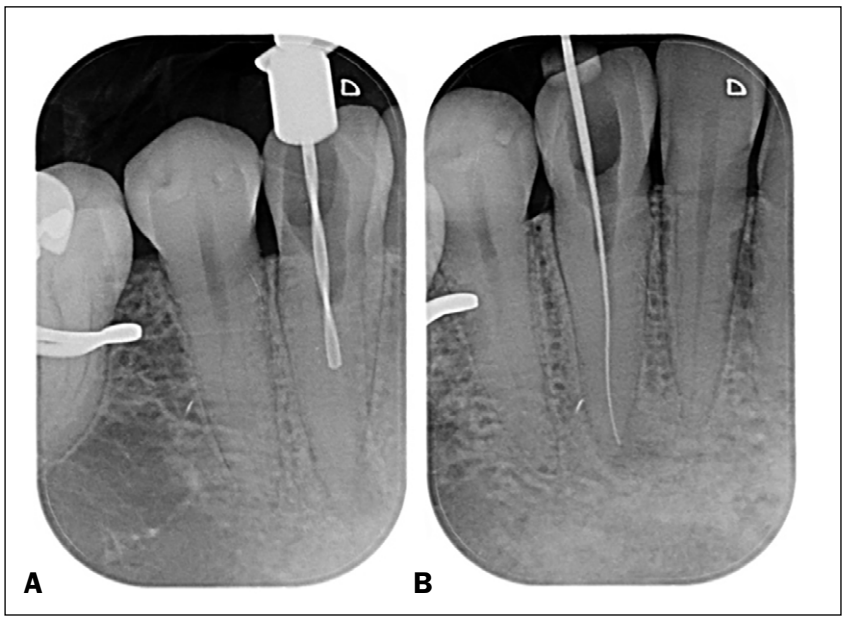


Figure 4
Drilling path. A staggered drilling pattern was performed. At every millimeter of progress along the canal, the guide was withdrawn to allow irrigation of the access cavity and avoid overheating of the dentin and accumulation of dentin debris.

be irrigated. The irrigation avoids overheating of the dentine and accumulation of dentine debris (figure 4). An intraoperative radiograph was taken to confirm the correct trajectory during the treatment (figure 5A). Once the drill was fully inserted into the sleeve, patency was checked by means of a C+ .06 file (Dentsply Sirona Endodontics, Ballaigues, Switzerland) and endodontic treatment was normally completed (figure 5B). Shaping was performed using the ProTaper Gold System (Dentsply Sirona Endodontics, Ballaigues, Switzerland). The irrigation consisted of a sodium hypochlorite 3% solution (Vistadental, Racine, Wisconsin, USA) and EDTA 17% solution (Vistadental, Racine, Wisconsin, USA) The canal was then filled using a warm vertical compaction technique (figure 6). Lastly, the tooth was obturated at crown level using an occlusal composite.

Figure 5
Intraoperative X-rays to confirm the axes **(A)** and restore patency **(B)**.



Case 2
A 46-year-old male patient was referred for esthetic reasons regarding the upper right central incisor (tooth 11). The tooth showed no response to electric and thermal vitality tests and was asymptomatic when subjected to percussion and palpation. The patient reported a trauma falling from his bicycle 15 years before. An emergency treatment was initially performed by his first dentist at the time of the trauma, but unsuccessfully. The tooth had been restored with composite. No symptoms had appeared over the years. Radiological examination by periapical x-ray and CBCT revealed a periapical lesion and the almost complete obliteration of the root canal of tooth 11 (figure 7A, C). GE treatment was scheduled in agreement with the patient. The treatment was performed using the same protocol as for case #1 (figure 8). The resin guide and the metal sleeve helped to obtain root canal patency 3 mm from the apex, following a 17 mm of coronal drilling through the guide. Once root canal patency was obtained, shaping was performed using the ProTaper Gold system (Dentsply Sirona Endodontics) and filling of the root canal was performed using a cold obturation technique combining Totalfill bioceramic sealer (FKJ, La ChauxdeFonds, Switzerland) and a single gutta-percha cone (PD, Vevey, Switzerland). The tooth was

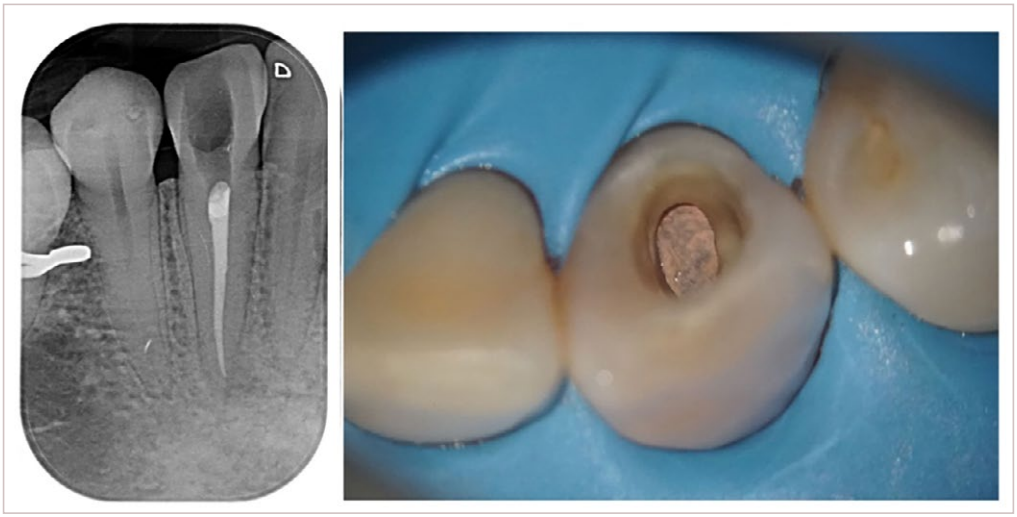


Figure 6
The endodontic treatment was performed using classical endodontic techniques.

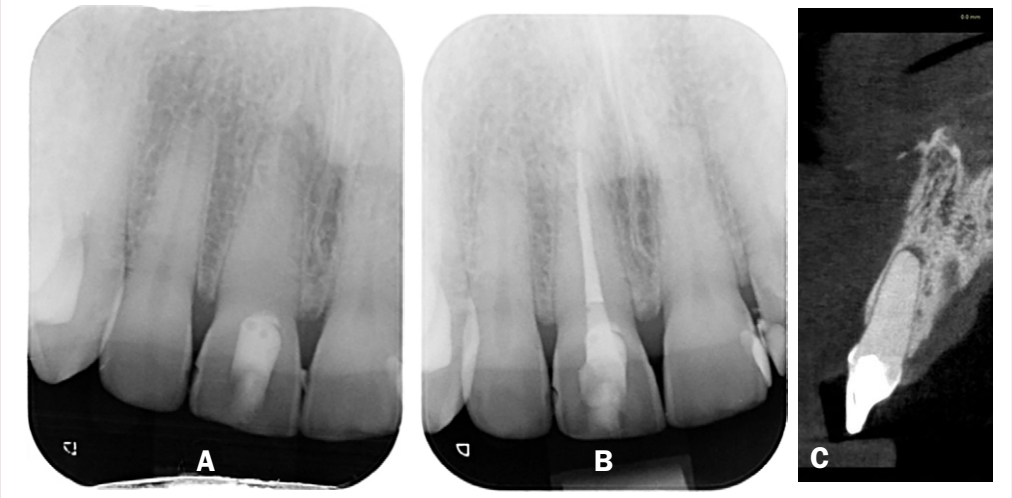


Figure 7
(A) Pre- and **(B)** post-operative X-ray and CBCT slice **(C)** of tooth 11 of case 2. Tooth 11 was calcified.

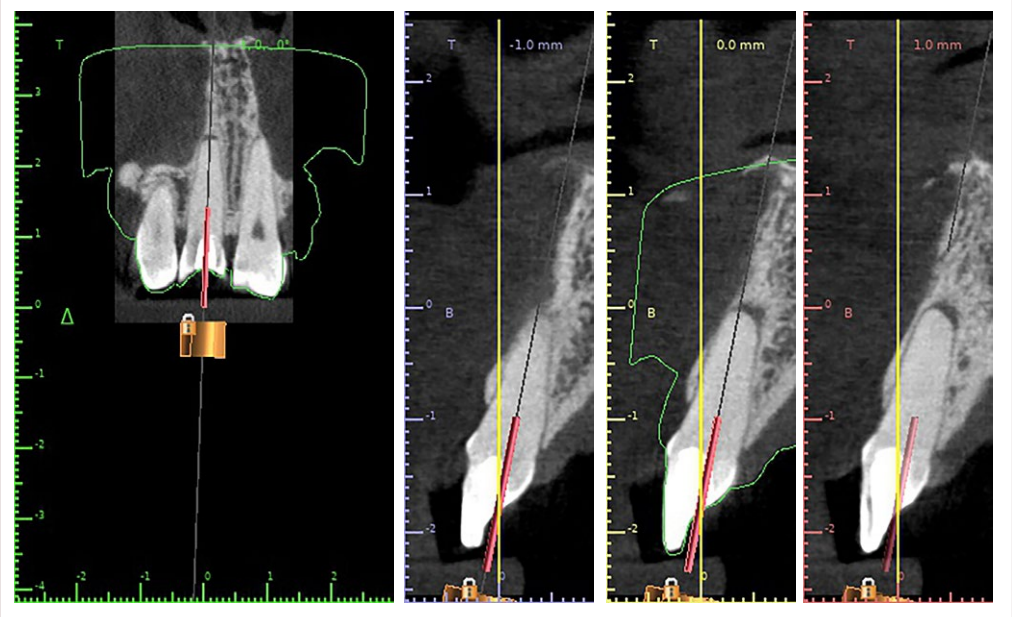


Figure 8
Planning endodontic access with BlueSkyPlan.

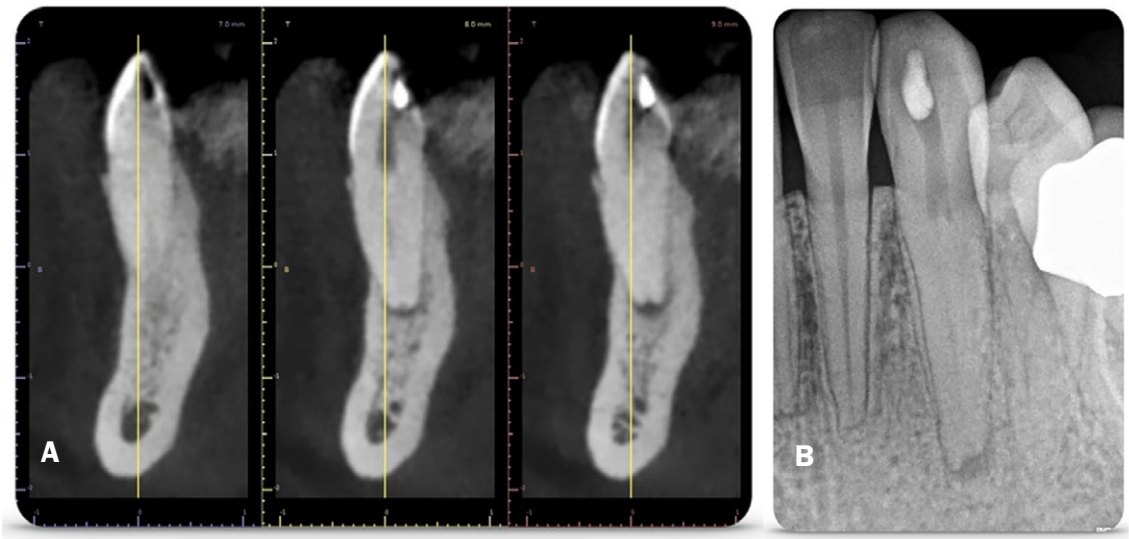


Figure 9
Pre-operative cbct **(A)** and X-ray **(B)** of tooth 33 of case 3. The patient was referred for treatment of tooth 33 displaying calcification and symptomatic periapical periodontitis *(courtesy Dr Virginie Touboul)*.

restored with glass ionomer cement (Fuji II, GC Corporation, Tokyo, Japan) and a resin composite resin.

Case 3
This 43-year-old female patient was referred by her dentist for orthodontic treatment on the mandibular left canine (tooth 33). She had a trauma on the left side of her mandible 8 years previously. The tooth became yellow in the recent years and symptomatic over the past few months. The patient complained of pain on percussion and described an episode of spontaneous pain which receded after antibiotic treatment. Following this episode of pain, her dentist attempted a first endodontic treatment, but unsuccessfully. The intra-oral radiograph showed a periapical lesion and root canal obliteration, confirmed by CBCT (figure 9A, B). The diagnosis was symptomatic apical periodontitis.
With the patient consent, GE treatment was planned. In this case it was decided not to place a sleeve. The static resin guide was fabricated with a guide hole 7 mm in length adapted to the drill diameter (figure 10)
The initial access achieved by the previous intervention was incorrect. Consequently, in order to make the access cavity along the axis of the root canal that was previously identified by the CBCT, it was essential to mark a reference point on the enamel through the guidance hole using a graphite pencil

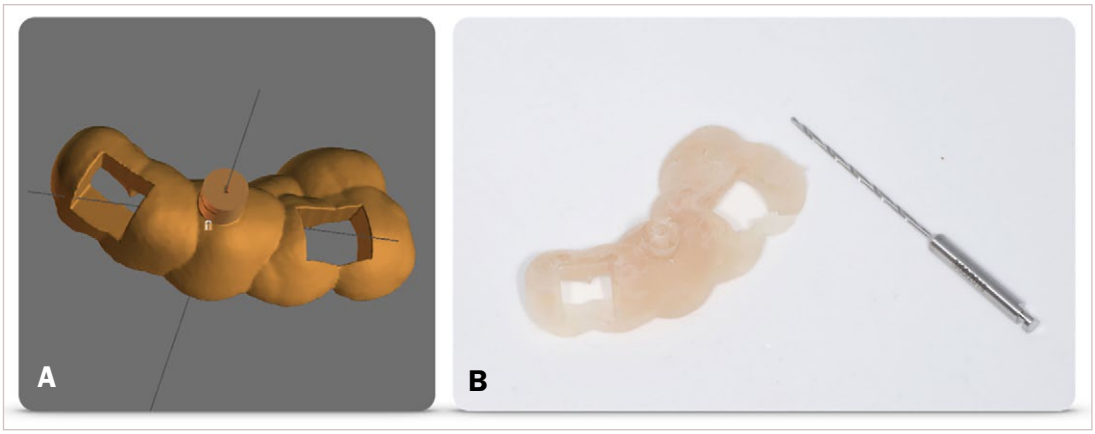


Figure 10
Planning **(A)** and Printing **(B)** the guide. The resin guide is sleeveless and was fabricated with a 7 mm in length guidance orifice and adapted to the drill diameter.

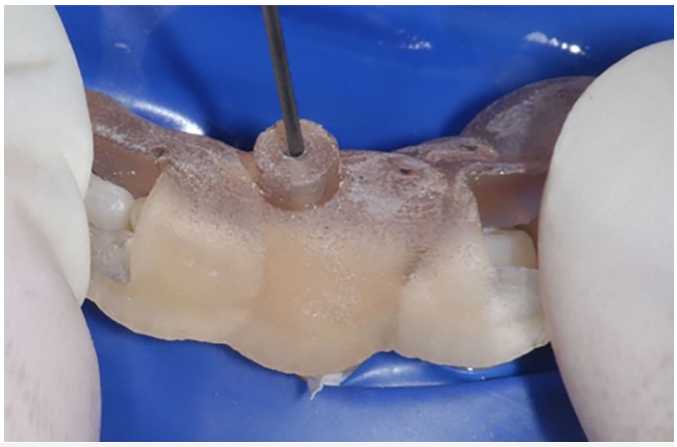


Figure 11
Marking a reference point for the first access. It is essential to mark a reference point on the enamel through the guidance hole using a graphite pencil lead.

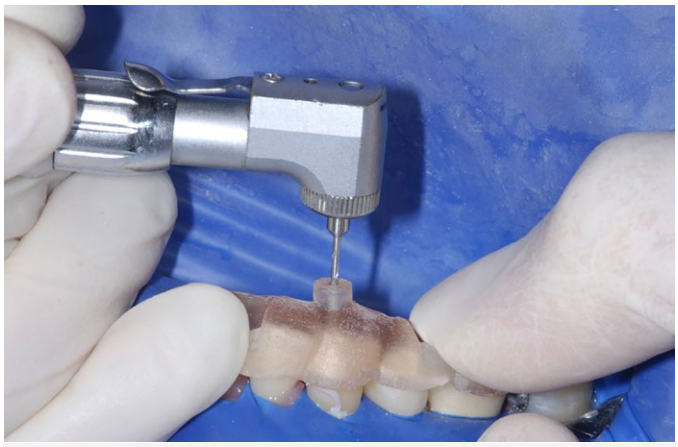
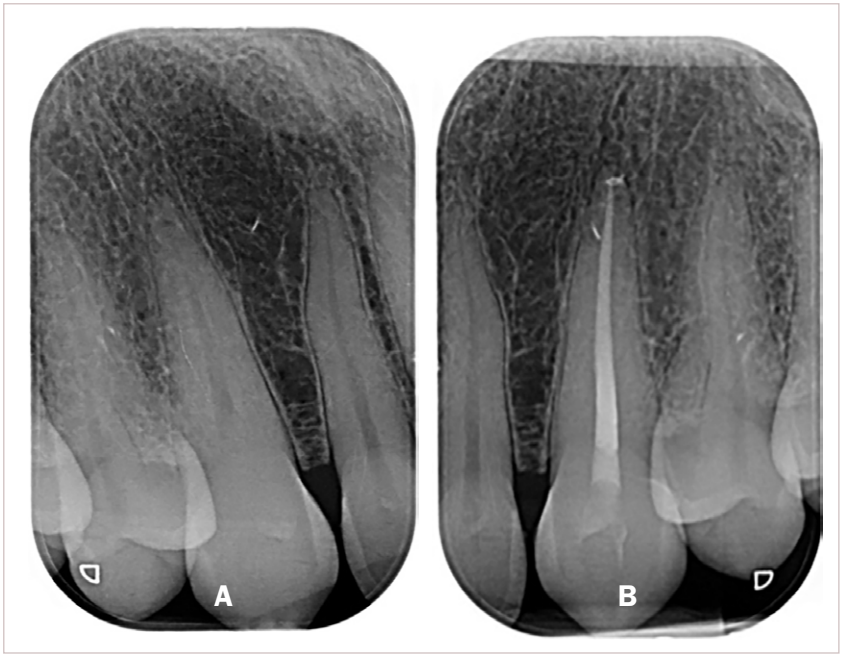


Figure 12
Drilling path. Drilling was then performed following the protocol step-by-step used in Case 1.

lead (figure 11). A diamond bur was used to open the access cavity into enamel and to achieve a flat dentine surface perpendicular to the drill axis. Drilling was then performed following the protocol step-by-step used in Case #1 (figure 12).
Once the apical root canal patency was obtained using a manual file, shaping was performed using ProTaper Gold (Dentsply Sirona Endodontics, Ballaigues, Switzerland) and filling was carried out using a warm vertical compaction technique. The tooth was then restored with resin composite.

Figure 13
Pre- and postoperative X-ray case 4. This system enabled us to quickly locate the endodontic canal without excessive damage. Classic end of treatment was achieved *(courtesy Dr Cyril Perez)*.



Case 4
A 35-year-old female patient was referred complaining of pain involving the maxillary right canine (tooth 13) over the previous 6 months. Clinical examination showed that the tooth was sensitive to axial percussion and buccal palpation. Electric and thermal sensitivity tests were negative. The tooth also displayed yellow discolouration. The patient could not remember having undergone a trauma in the past. Pulpal necrosis was diagnosed and canal obliteration was observed on radiograph (figure 13A). The CBCT provided by the patient confirmed the presence of canal obliteration up to the middle third. With the patient consent, orthograde endodontic treatment was planned using the 2ingis guided endodontics system. 2Ingis is a system of surgical guides originally designed for the placement of dental implants. The drilling guidance is obtained by a linear movement of the head of the contra-angle sliding through two rails incorporated in the drilling template printed. A silicon impression was taken during the initial visit. The impression was then scanned by the dental laboratory, which produced a STL

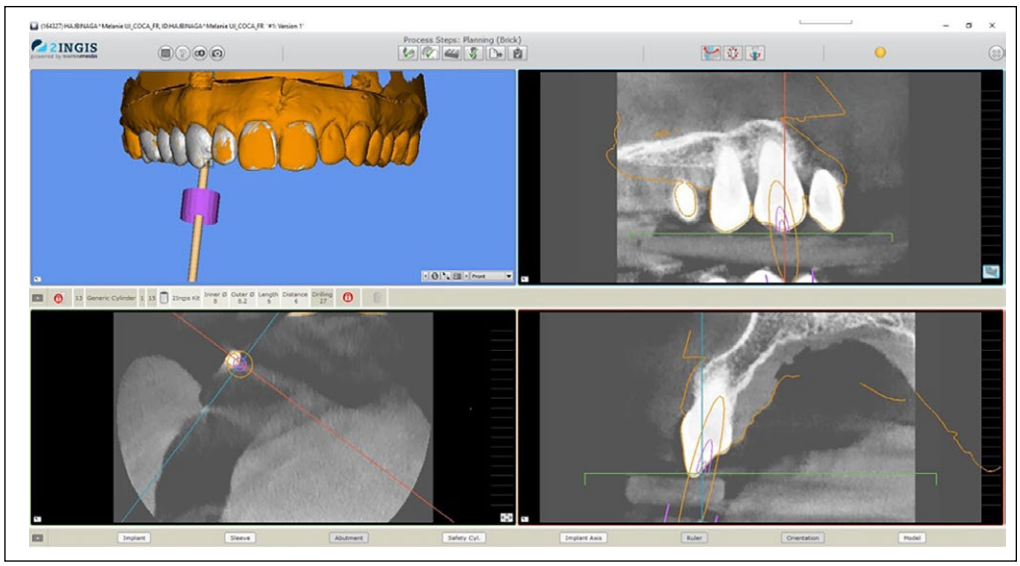


Figure 14
Planning the guide with SMOP software (2ingis).

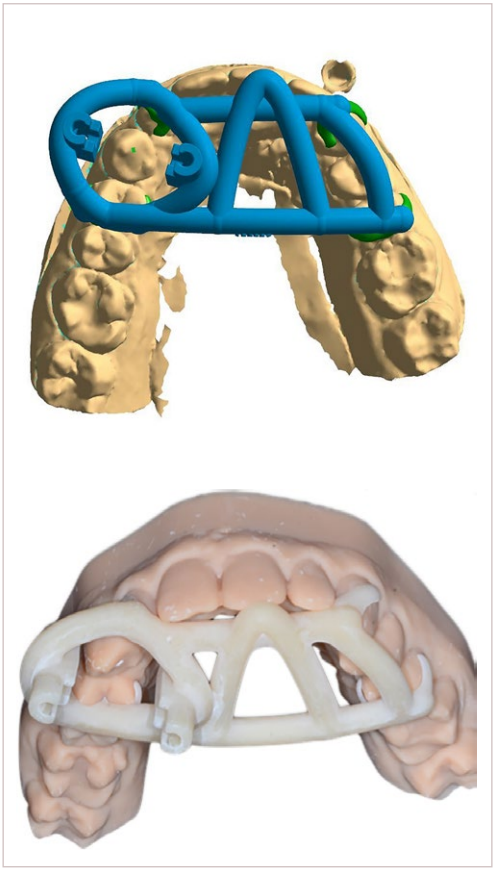


Figure 14A
The digital design of the 2ingis guide and his 3D impression. The guide is digitally designed using certain teeth for support.

Figure 15
Clinical view. The 2ingis guide designed to direct the head of the contra-angle.

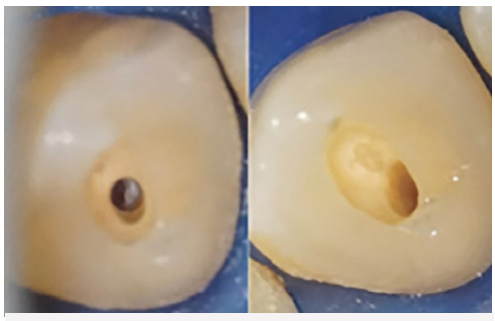


Figure 16
Cavity access with 2ingis technique: a diamond bur mounted on the contra-angle and guided by the 2ingis system was used to prepare the cavity access.

file of the model. The drilling plan was drawn up by the 2ingis company using SMOP software (Swissmeda; Baar; Switzerland) (figure 14). The plan was verified and validated by the operator and an endodontic guide was digitally designed using four teeth as support (figure 15) and printed. A diamond bur mounted on the contra-angle at a speed of 40,000 RPM and guided by the 2ingis system was used to prepare the access cavity into the enamel. Then, a 0.75 drill with

a guided low-speed contra-angle head at a speed of 20,000 RPM was used to penetrate into the dentine.
The irrigation is achieved by the water spray of the contrangle. This system enables to quickly locate the endodontic canal without excessive sacrifice of the tooth structure. A standard endodontic treatment was then performed in one visit once the canal orifice was located followed by the placement of a coronal resin composite restoration (figure 16).

Discussion

In 2005, the American Association of Endodontists published a form for the assessment of endodontic treatment difficulty. Management of root-canal obliteration is included in the high level of difficulty (17). Different techniques have been reported for the management of obliterated canals. Some authors suggested orientating the axis of the access cavity along the axis of the tooth in order to improve visibility of the dentine (18). The use of dental microscope in conjunction with long-necked burs or ultrasound inserts was also recommended (18) It has also been suggested to take numerous intraoperative X-rays to control and reorientate the drilling axis to gain access to the canal (8). The new concept of guided endodontic access (GE) is based on the use of protocols from guided implantology to perform a safe cavity access in difficult cases as calcified canals. This technique consists of planning the drilling path using a software merging the STL and DICOM data. The digital guide exported by the digital project is printed with a 3D printer in a resin material.
The four clinical cases presented in this article demonstrated that conservative maintainance of sound dental tissues is one of the main advantages of GE. Less invasive than the classic techniques, GE also limits the risk of deviation and reduces operative time (19, 20, 21). Endodontic surgery also offers an alternative solution although, with this technique, the endodontic canal cannot always be cleaned along its entire length (22).
On the other hand, in situations involving obliterated canals after the curve, endodontic surgery is the most appropriate treatment approach. Studies on obliterated teeth are still needed to compare the respective success rates of endodontic surgery and GE orthograde treatment. Meanwhile, the two techniques remain complementary. Guided implantology supplies the know-how to enable its application to endodontics. It has been demonstrated that the guided technique can position an implant more accurately compared with a free-hand technique (23). As a result, the guided approach can be considered more predictable. Nonetheless, deviations ranging from 2.29° to 5.2° are considered tolerable in implantology (24, 25). In GE, such deviations can be considered significant in cases of very apical canal obliteration. Recently, several studies have attempted to validate this endodontic treatment technique for obliterated pulp canals. Buchgreitz et al. reported a linear drill deviation of 0.46 mm at the apical target (21). Two other studies have shown the presence of angle deviations ranging from 1.59° to 1.81° using drills with a diameter of 0.85 mm and 1.5 mm, respectively (19, 20). The authors judged these margins of error to be minimal.
The clinical protocol proposed in the present report include 3 main features:

1. The use of a static guide over only 3-4 teeth. Generally, the static guides presented in case reports involved the entire arch and are even stabilized in some cases with miniscrews inserted in the bone (26). A less extensive guide makes easier the isolation and the periapical radiography. Conversely, stability is diminished, although this had no great impact on the successful outcome of the presented clinical cases.
2. The use of a small-diameter drill (0.75 mm) (FFDM-PneumatTivoly; Bourges; France). The literature reports description of drill diameters between 0.85 mm and 1.5 mm (19, 20). A 0.75 mm drill permits a less invasive procedure, even to the apical third. On the downside, the smaller is the drill diameter, the more flexible is the drill and the greater is the risk of deviation during the

firsts steps of the access procedure. However, case 3 showed that even the apical region of the obliterated canal can be successfully reached. While the benefits of using less extensive guides and small diameter drills appear obvious, clinical studies are needed to confirm the reproducibility of the technique.

3. The planning and fabrication of the guide were done using the BlueSky Plan planning software program (BlueSkyBio; LLC; Grayslake; IL; USA). This software is free of charge and only the downloading of the STL file of the guide is subject to payment. A DICOM file taken from a CBCT and a STL file taken from a digital impression of the teeth may be merged in the system. CBCT scans can be performed in a radiology laboratory or in the dental office and digital impressions can be made in a laboratory from a silicon impression or directly in the mouth using an intra-oral scanner. The GE technique therefore may be also performed without any special equipment in the dental office.

The accuracy of GE drilling is linked to a series of errors to be avoided. Accuracy is dependent on the quality of both the CBCT and the digital impression, on the successful merging of the two files, on the drilling plan, on the printing of the guide and on the clinical step-by-step. During the planning stage, it may sometimes be difficult to locate the canal on the CBCT.

The literature reports that, in the event of pulpal canal calcification, the canal space of single-root teeth is always located in the center of the root in an axial view (18). Importantly, the drilling axis will sometimes be aligned with the main tooth axis, meaning the access cavity will be situated very close to the free edge of the tooth in the anterior region.

During the clinical procedures, the access cavity plays a crucial role. Its design must help avoid any interference between the drill and the cavity axial walls. The floor of the cavity must be flat and perpendicular to the drilling axis. Failing in this objective may lead to the fact that the drill could be deviated as soon as the drilling action begins and the tip may slide across the sloping cavity floor. The access cavity must be prepared using a diamond bur to start access in the enamel. To locate the access cavity, the guide can be used to mark the first point of contact through the sleeve by means of a graphite pencil. This phase can be repeated several times in order to find a flat central access point with no lateral interference. This step is essential whether preparing a first-line access cavity or during retreatment where the access already exists.

The second possible error during the clinical step-by-step may be connected to a precise positioning of the guide. Proper insertion of the guide must be verified using the openings on its occlusal surface. The guide must be held firmly in place during the drilling procedures to avoid it vibrating and being dislodged. Lastly, the contra-angle must be held as close as possible to the head of the instrument and should be brought down passively to avoid rotating the assemblage formed by the contra-angle, the drill and the guide.

Thus, a microscope can still provide a useful service. The endodontic guide serves to drill millimetre by millimetre towards the apex. At each step, the guide must be removed to allow the canal to be probed manually and to help check the canal patency. At all stages, when the guide is removed, the canal can also be rinsed out to prevent dentine remnants from accumulating and forming a blockage. Rinsing also avoids overheating of the dentine during drilling. Clinicians should keep in mind that CBCT resolution may identify a canal more apically that what may happen clinically.

Thus, it is important to try if a manual file may be inserted in the canal even if drilling is not arrived to the apical point of the guide, as the further the drill is used towards the apex, the greater is the

risk of deviating from the canal path. In the event of deviation, CBCT can be used to relocate the canal intra-operatively with techniques not using an endodontic guide.
Further advances in GE will possibly lead to the metal sleeve being not used, thus avoiding positioning errors when inserting the sleeve in the guide. In fact, depending on the printer and its settings, as well as the resin used to build up the guide, the sleeve can be inserted in the guide with varying degrees of passivity. It may happen that the sleeve moves in the guide or that it could not be completely inserted. Note that, when not using a metal sleeve, it is important to use guides made from very hard materials.
Unlike the previous cases that used closed static endodontic guides, in the case 4 the 2ingis solution was adopted. This system uses an open endodontic guide system that guides not the drill but the head of the contra-angle.
The technique using a closed guide has the disadvantage of preventing irrigation during the drilling phase, thus increasing the risk of accumulated dentin remnants and, probably, of metal debris due to drilling through the metal sleeve. Lack of irrigation will also cause both the drill and the tooth to heat-up. For this reason, it is important to advance gradually with the drill, millimetre by millimetre, stopping and rinsing in between the steps.
The 2ingis system enables irrigation during drilling and allows the use of any kind of bur, including small-diameter, long-necked round burs as well as diamond burs, which can create the access directly into the enamel.
On the other hand, the absence of a sleeve increases the risk of oscillation of the bur, as it rotates free. A study using the 2ingis system in implantology reported a mean deviation angle of 2.85°. It also described more precise deviations than with implant guides using sleeves (27).
An alternative to obtain a guided access in endodontics is a new dynamic three-dimensional technology. This free-hand method works with an image-guided procedure merging CBCT data and a computer assisted software, guiding the high-speed handpiece and bur during the clinicals procedures. This technique could be the future of guided endodontics even if up to date, this kind of technology presents some limits for a full application in the Endodontic field such as the accuracy declared by the manufacturer companies of about 0.5 mm and the radiographic artifacts due to the presence of metal crowns (28).

Conclusions

Endodontic treatment of a calcified tooth is a challenge for the dentist, even if equipped with a microscope, as the risk of intra-operative errors is very high (2). The precision of the GE technique seems to provide a valid alternative to endodontic surgery for the treatment of calcified canals. GE helps gain canal permeability reducing operative time respect to a free-hand approach. The 2ingis system helps overcome the irrigation issue and leaves the clinician free to choose the bur to be used. This open endodontic concept appears to be better suited to endodontic interventions than closed guides.

Clinical Relevance

This article describes several variations of the guided technique in the endodontic treatment of obliterated canals and highlights its advantages and limitations.

Conflict of Interest

The authors declare they have no conflicts of interest.

Acknowledgemets

The authors wish to thank Dr Cyril Perez for his contribution to the development of the technique, Dr Virginie Touboul for support in treating one of the clinical cases, and Asselin Bonnichon for developing the Cad-Cam technique for use in GE.

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CASE REPORT/**CASO CLINICO**

Regenerative endodontic treatment options for immature permanent teeth: a case report with 21-month follow-up

Alternative terapeutiche per denti permanenti immaturi nel campo della rigenerazione endodontica: descrizione di un caso clinico con controlli fino a 21 mesi

KEYWORDS
Regenerative Endodontics, Incisor, Calcium Hydroxide

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Endodonzia Rigenerativa, Incisivo, Idrossido di Calcio

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Received 2020, January 30
Accepted 2020, March 16

Abstract

A treatment option for necrotic teeth with incompletely formed roots is apexification with calcium hydroxide, which induces the formation of a hard tissue barrier at the apex, however, in the long term, this medicament may increase the brittleness of dentin walls because of its hygroscopic and proteolytic properties, in addition to the disadvantage of requiring multiple appointments. An alternative to this is the mineral trioxide aggregate (MTA) artificial barrier technique, that unfortunately share with the previous one the disadvantage of preventing the complete root maturation. A new possible treatment for young permanent teeth with necrotic pulps is pulp regeneration, whose advantage lies in the stimulation of new tissue formation within the root canal. Pulp revascularization is based on the disinfection of the root canal system, often performed with irrigating solutions and intracanal medicaments, accompanied by induction of periapical bleeding and formation of a blood clot that will fill the root canal.
The aim of this study was to present a case of avulsion of teeth 11 and 21, both with open apices, treated with replantation associated with regenerative endodontic therapy, but varying the intracanal medicaments used: calcium hydroxide in tooth 11 and double antibiotic paste in tooth 21. Pulp revascularization proved to be effective with both intracanal medicaments used, promoting symptom resolution and complete root development, including apical closure, even in the absence of a well-defined clinical.

Una opzione per il trattamento dei denti necrotici con radici non formate completamente è la apecificazione con l'idrossido di calcio, la quale induce la formazione di una barriera di tessuto duro a livello apicale, tuttavia, nel lungo termine, questa medicazione può aumentare la fragilità delle pareti dentinali per via delle sue proprietà igroscopiche e proteolitiche, inoltre questa tecnica ha lo svantaggio di richiedere molteplici sedute. Un'alternativa è la tecnica della barriera artificiale con l'utilizzo del Mineral Trioxide Aggregate (MTA) che, sfortunatamente, condivide con la tecnica precedente lo svantaggio di impedire il completo sviluppo radicolare. Una nuova possibilità di cura per i denti permanenti immaturi con la polpa necrotica è la rigenerazione, il cui vantaggio giace nella stimolazione della formazione di nuovo tessuto dentro al canale radicolare. La rivascolarizzazione della polpa si basa nella disinfezione del sistema canalare radicolare, spesso eseguita con l'utilizzo di soluzioni irriganti e medicazioni intra-canalari, accompagnata dall'induzione del sanguinamento peri-apicale e la formazione di un coagulo sanguigno che andrà a riempire il canale radicolare.
Lo scopo di questo studio è stato quello di presentare il caso di un paziente con i denti 1.1 e 2.1 immaturi con apici aperti, avulsi, trattati con il reimpianto e associato a terapie rigenerative endodontiche, variando le medicazioni intra-canalari utilizzate: idrossido di calcio sul dente 1.1 e una pasta bi-antibiotica (DAP) sul dente 2.1. La rivascolarizzazione della polpa si è provata efficiente utilizzando le due medicazioni, promovendo la risoluzione dei sintomi e il completamento dello sviluppo radicolare, includendo la chiusura apicale, anche in assenza di un protocollo clinico ben stabilito.

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Peer review under responsibility of Società Italiana di Endodonzia
10.32067/GIE.2020.34.01.05

Introduction

Endodontic therapy for immature permanent teeth with necrotic pulps is a major challenge in dentistry. With pulp necrosis, the dentin walls of the root canal remain thin and susceptible to fracture, thus limiting biomechanical preparation (1, 2).

The treatment of choice for necrotic teeth with incompletely formed roots is apexification with calcium hydroxide, which induces the formation of a hard tissue barrier at the apex (3). However, in the long term, this medicament may increase the brittleness of dentin walls because of its hygroscopic and proteolytic properties, in addition to the disadvantage of requiring multiple appointments (4). An endodontic treatment alternative for necrotic teeth with open apices is the creation of an artificial root-end barrier with mineral trioxide aggregate (MTA) (5). This technique has the advantage of reducing the number of treatment appointments. Nevertheless, both methods (apexification with calcium hydroxide and artificial apical barrier technique with MTA) have the disadvantage of not allowing the continuation of root development (6, 7).

A treatment option for young permanent teeth with necrotic pulps is pulp regeneration, whose major advantage lies in the stimulation of new tissue formation within the root canal (8). Pulp revascularization is based on the disinfection of the root canal system, often performed with irrigating solutions and intracanal medicaments, accompanied by induction of periapical bleeding and formation of a blood clot that will fill the root canal. Undifferentiated cells originating from the apical papillae, associated with growth factors, will then initiate the formation of new tissue within the root canal.

Controlling intracanal infection is crucial to the success of regenerative endodontic procedures (9, 10). In conventional endodontic therapy, the reduction of bacterial loads along with adequate root canal sealing with filling material are often sufficient to control infection. The absence of substrate to maintain the viability and proliferation of these microorganisms ultimately determines their death. However, in regenerative endodontic procedures, the apex is not sealed, since communication of the root canal with periapical tissues is an essential source of nutrition for the newly formed tissue. Conversely, this condition may also provide an access for bacterial substrate, negatively interfering with the success of the therapy (11,12). Therefore, creating and maintaining an aseptic environment is essential to allow the establishment of the new tissue in the root canal space.

In view of the foregoing, it is necessary to determine a strict disinfection protocol before a pulp regeneration approach. In the protocol for regenerative endodontic procedures proposed by the American Association of Endodontists (13), the placement of antibiotic or calcium hydroxide pastes as intracanal medicaments for 1 to 4 weeks is recommended for disinfection of the canal space.

Calcium hydroxide paste is widely used in endodontics to disinfect the root canal system and to induce periapical tissue repair (14). As an alternative to this medicament, antibiotic pastes have also been used to control infection in endodontic therapy. The combination of antibiotics increases the spectrum of action of the medicament, potentially improving the level of canal disinfection. For this purpose, the triple antibiotic paste (TAP) (15), composed of ciprofloxacin, metronidazole, and minocycline, was proposed for use as an antimicrobial agent in endodontic therapy (16). However, depending on the concentration of the components, this medicament may have cytotoxic effects (17). In addition, several studies have reported color changes in the crown after the use of TAP, attributable to one of the components of the mixture, minocycline, a derivative of tetracycline (17, 18, 19) that is known to induce tooth staining. In this context, alternative medicaments to TAP have been studied, such as the double antibiotic paste (DAP) (20), which is composed of only ciprofloxacin and metronidazole.

The aim of this study was to present a case

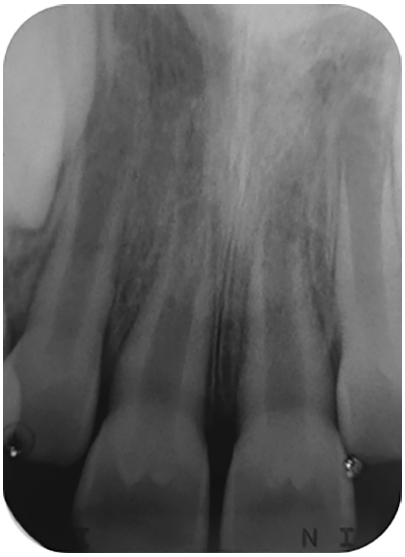

Figure 1
Initial periapical radiographic exam.

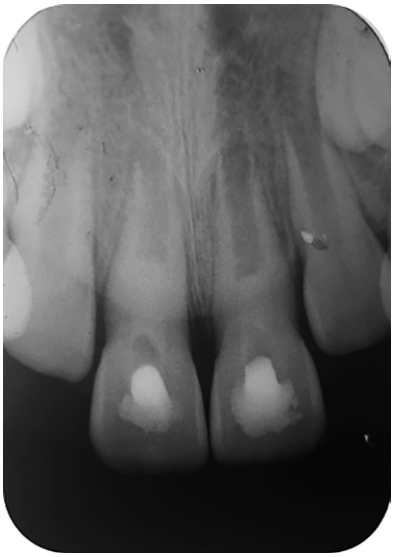

Figure 2
Radiographic exam with intracanal medicament.

of avulsion of teeth #11 and #21, both with open apices, treated with replantation associated with regenerative endodontic therapy, varying the intracanal medicaments used.

Case report

This study was approved by the Research Ethics Committee of São Leopoldo Mandic School of Dentistry, Brazil (approval number 3.404.274).

An 8-year-old girl was brought by her mother to the emergency department of Universidade de Fortaleza (UNIFOR) complaining that teeth #11 and #21 were sensitive to palpation and percussion and of a dark discoloration in one of them; both were buccally inclined. The patient had experienced a traumatic injury as a result of falling from a bicycle 30 days prior, with avulsion of teeth #11 and #21, which were replanted about 10 minutes after the accident by a dental surgeon at the local primary care unit. The mother's patient related that a flexible splint was used in both teeth for 14 days. Initial radiographic examination revealed that the 2 affected maxillary incisors had incompletely formed roots, with apical opening greater than 3 mm, leading to the indication of regenerative endodontic procedures in an

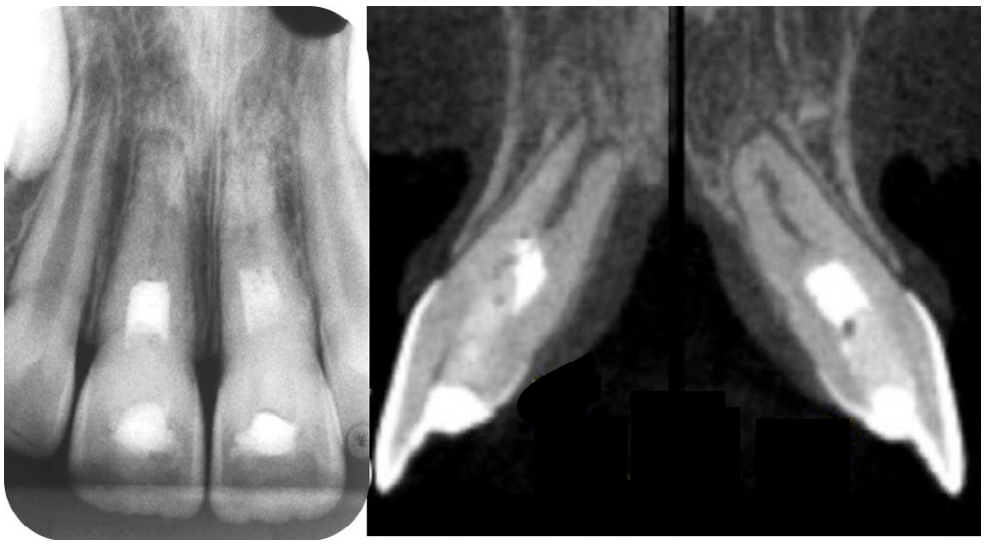

Figure 3
Final periapical radiograph exam.

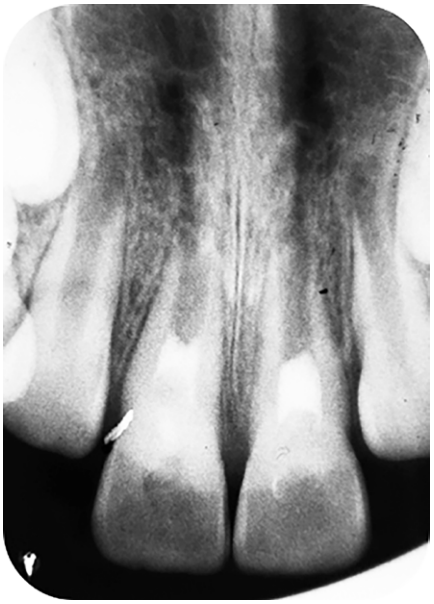

Figure 4
14-month follow-up showing that apical closure of tooth #21 and that the apex of tooth #11 was still open.

attempt to induce the continuation of root development (figure 1).
At the first appointment, the root canals of both teeth were emptied and cleaned. Access cavities were prepared, and the root canals were irrigated with saline solution and debrided with a #100 K-file (Dentsply, Rio de Janeiro, Brazil). A solution of 2.5% sodium hypochlorite (Biodinâmica, Ibiporã, Brazil) was carefully dripped to avoid leakage to the periapical region, since root apices were open. The canals were flushed with EDTA (Biodinâmica, Ibiporã, Brazil) for 3 minutes to remove the smear layer, followed by final irrigation with saline solution. As an intracanal medicament, a calcium hydroxide paste (Biodinâmica, Ibiporã, Brazil) associated with 2% chlorhexidine gel (Biodinâmica, Ibiporã, Brazil) was used in tooth #11, and DAP consisting of metronidazole and ciprofloxacin was used in tooth #21 (figure 2).
The patient returned 20 days later. At this appointment, the paste was removed, and bleeding was induced into the canal space of both teeth by irritating the apical tissues with a #100 K-file until a blood clot was achieved. A sterile collagen sponge (Hemospon; Maquira, Maringá, Brazil) was used to promote hemostasis, also providing a basis for the placement and stabilization of MTA (Angelus, Londrina, Brazil) performed afterwards. The teeth were then restored with resin-modified glass ionomer cement (Vitremer; 3M, São Paulo, Brazil), and a final periapical radiograph was taken (figure 3).
A 14-month follow-up radiograph suggested root development in both teeth. Tomographic image showed that apical closure of tooth #21 began to take place and that the apex of tooth #11 was still open (figure 4). A second tomographic image, 21 months after the trauma, showed the 2 incisors with completely formed roots and complete apical closure (figure 5).

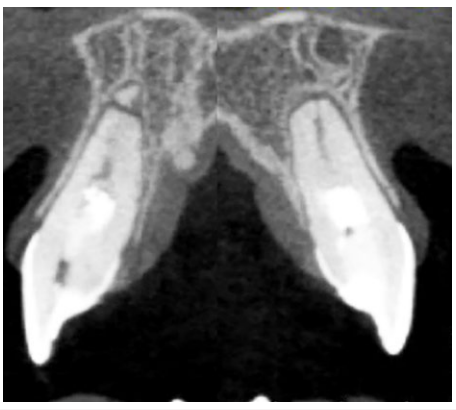

Figure 5
21-month follow-up showing completely formed roots and complete apical closure.

Discussion

Regenerative endodontic therapy aims to biologically direct the growth of injured structures or even repair damaged tissues of the dentin-pulp complex, forming viable structures that, preferably, originate from similar primary tissues (21). Despite the high success rates of this therapy described in the literature, no consensus has been reached on a clinical protocol, particularly regarding irrigating solutions and intracanal medicaments (22). Maniglia-Ferreira et al. (23) concluded that, despite the lack of an established treatment protocol, it is extremely important to combine effective disinfection with the use of a series of pastes to create an environment conducive to pulp revascularization and root formation.
Decontamination of the root canal system is a critical step for further pulp regeneration. However, in immature permanent teeth, the mechanical removal of microorganisms is limited due to the thin dentin wall; therefore, it seems more prudent to promote root canal

cleaning by using copious irrigation and intracanal medicament (8).
Sodium hypochlorite and chlorhexidine digluconate are the chemical substances most commonly used as irrigants in regenerative therapy. Both have good antimicrobial potential, but chlorhexidine, different from sodium hypochlorite, is ineffective in dissolving organic debris (24). In the case reported here, sodium hypochlorite was used with great caution by slowly dripping to prevent leakage of the solution into the periapex, since root apices were open. Subsequently, EDTA irrigation was used to remove the smear layer, followed by final irrigation with saline solution to neutralize the environment. According to Reynolds et al. (25) and Shin et al. (26), the use of saline solution as a final irrigant is of utmost importance to reduce cytotoxicity for stem cells. Galler et al. (27) stated that the success of regenerative therapy is dependent on the use of chelating agents, such as EDTA. Trevino et al. (28) confirmed that EDTA contributes to the survival of apical stem cells.
Regarding intracanal medicament, a calcium hydroxide P.A. paste associated with 2% chlorhexidine gel was used in tooth #11(24,29), while DAP consisting of metronidazole and ciprofloxacin was used in tooth #21 following a similar protocol employed by Maniglia-Ferreira et al. (2017) (23) in a similar case of an avulsed immature permanent tooth with necrotic pulp.
Dhillon et al. (30) recommended that the patient should return 30 days after the first appointment for induction of apical bleeding so that blood would fill the root canal up to the cementoenamel junction. After hemostasis, the blood clot formed in the region provided a basis for the placement of MTA. Ding et al. (31) added that MTA cervical barrier was necessary to prevent microorganisms from entering the canal. In the case reported here, the patient returned 20 days after the first appointment because she lived in another city. At this appointment, periapical bleeding was induced, followed by clot formation and MTA placement. Formation of a clot along with necrotic pulp tissue act as a scaffold for the ingrowth of new tissue, in which undifferentiated cells originating from the apical papillae and platelet-derived growth factors will direct cell differentiation (32). Souza Filho et al. (33) stated that, when in contact with the dentin wall, undifferentiated mesenchymal cells synthesize and secrete a cementoid tissue, promoting space closure and strengthening the root canal structure.
In cases of regenerative therapy, follow-up is essential to achieve successful clinical results. Chen et al. (34) suggested a minimum follow-up of 6 months. Chueh et al. (35) reported that, within a period of 10 to 13 months, complete root development was achieved in immature permanent teeth with necrotic pulps. In the case reported here, the patient was followed up at 14 months and at 21 months. In the last follow-up visit, completion of root development was observed, including apical closure of both teeth, in addition to resolution of symptoms and a positive response to pulp vitality test.

Conclusion

Based on what has been reported here, in cases of necrotic immature permanent teeth treated with regenerative endodontic procedures, pulp revascularization proved to be effective with both intracanal medicaments used, promoting symptom resolution and the completion of root development, including apical closure, even in the absence of a well-defined clinical protocol.

Clinical Relevance

This case report shows two regenerative endodontic therapy in the same patient with two different intracanals medicaments used.

Conflict of Interest

The authors deny any conflicts of interest related to this study.

Acknowledgements

Special thanks to the University of Fortaleza and the Federal University of Pelotas for their continued support.

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Winner of The Best Poster SIE Award 36th SIE National Congress 2019

ORIGINAL ARTICLE/**ARTICOLO ORIGINALE**

Root canal morphology of lower lateral incisors: a CBCT in vivo study

Morfologia del sistema endodontico negli incisivi inferiori: uno studio in vivo attraverso la tomografia computerizzata cone beam

KEYWORDS
CBCT, Lower Incisor, Endodontic Anatomy

PAROLE CHIAVE
CBCT, incisivi inferiori, morfologia endodontica

Abstract

Aim: *The aim of this study was to analyze the root canal configuration in mandibular central and lateral incisors in vivo using cone-beam computed tomography (CBCT) imaging in a European population.*
Methodology: *A total of 500 mandibular lateral incisors from 250 patients were examined using CBCT imaging, previously taken for diagnosis and treatment. The number of roots, root canal system configuration, presence of apical confluences, distance between confluences and radiographic root end, symmetry between left and right elements were recorded and statistically analyzed.*
Results: *All the examinated teeth presented only one root.*
Conclusions: *The percentage of Vertucci type II configuration was higher than expected, being more frequent than type III. Other configurations were present but rare.*

Obiettivo: *lo scopo del presente studio è analizzare la morfologia endodontica degli incisivi laterali inferiori utilizzando la tomografia computerizzata cone beam (CBCT).*
Metodologia: *sono stati presi in esame 500 incisivi inferiori provenienti dalle scansioni CBCT di 250 pazienti, precedentemente effettuate per motivazioni diagnostiche e di trattamento. Sono stati esaminati i seguenti parametri: numero di radici, configurazione del sistema endodontico, presenza di confluenze apicali, distanza tra le confluenze e apice radiografico, simmetria tra gli elementi sinistro e destro nello stesso individuo; i risultati così ottenuti sono stati analizzati statisticamente.*
Risultati: *tutti gli elementi dentari esaminati presentavano una sola radice, mentre la configurazione dei canali radicolari risultava variabile.*
Conclusioni: *la percentuale di riscontro di configurazioni endodontiche complesse è risultata maggiore del previsto, presentandosi più frequentemente come tipo II di Vertucci; sono inoltre presenti altre configurazioni complesse, quali tipo III e tipo VII di Vertucci.*

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Received 2019, December 28

Accepted, 2020, February 26

Introduction

The study of the anatomy is very important in endodontics, since most of the errors that occur during an endodontic treatment are related to failure to respect the canal anatomy (1); the existence of an untreated canal may be a reason to fail (2, 3). The study of endodontic anatomy can be divided into ex vivo methods, performed on extracted teeth, and in vivo methods, performed on patients (4).
Multiple methods having been used (6), including canal staining and clearing techniques (5, 6), dentin troughing under magnification (7), scanning electron microscope (8, 9), micro-computed tomography (micro CT) (10, 11), magnetic resonance (12), ultrasonics (13), serial cross-sectioning

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Peer review under responsibility of Società Italiana di Endodonzia
10.32067/GIE.2020.34.01.14

(14, 15), radiographic examination (16, 17) and CBCT (cone beam computer tomography) (18-22).
In research studies CBCT is usually associated with a larger number of samples, because it does not need extractions; moreover it defines precisely the position of the tooth and allow studies about symmetry.
In clinical practice the use of CBCT overcomes the limitations of conventional radiography, allowing visualization in 3D and reducing the superimposition of the surrounding structures (23-43).
Tooth configurations are usually classified according to Vertucci and the great majority of studies used this classification; more recently Ahmed and Dummer (44) proposed a new classification. It is a more accurate method, based on in vitro microCT (45) evaluations of extracted teeth. Therefore it requires higher resolution of images which is not always achievable by in vivo CBCT to avoid unnecessary high radiation doses to the patient.

Materials and Methods

Sample selection
A total of 500 mandibular lateral incisors selected from the CBCT examinations of 250 patients (130 males and 120 females) with an age ranging between 18 and 79 years were examined.
Images were obtained from CBCT examinations as part of diagnosis and treatment planning of patients who required large field of view for reasons including facial trauma or maxillary sinusitis, preoperative assessment for multiple implants, orthodontic treatment because of impacted teeth and for endodontic reasons. Ethical Committee was used for all the individual participants included in the study: the research was approved by the Ethics Committee of Sapienza, University of Rome (ref. 582/17).
The samples were selected according to the following criteria:

- available CBCT images of lower incisors with complete root formation;
- absence of root canal treatment;
- high-quality images of CBCT.

Teeth with immature apices and root resorption were excluded.

Image acquisition
The CBCT images had been taken using the GXDP-500 system (Gendex Dental, Biberach, Germany), operating at 90 kVp and 7 mA, with an exposure time of 23 s and a voxel size of 0.2 mm^3, with a field of view of 13, 9, 13 cm, with an estimated dose of about 50 mSv, allowing measurements to an accuracy of 0.2 mm.

Image evaluation
Through the use of Horos™ software (The Horos Project, 64-bit medical image viewer, GNU Lesser General Public Licence, version 3.0) three-dimensional reconstructions were analyzed to evaluate the parameters of interest.
The images were reworked according to the axial, sagittal, and coronal planes.
CBCT images were viewed on reconstructions according to the axial plane, scrolling the cursor in the coronal-apical direction before, and then in the apical-coronal, to get a detailed view of the root canal system of examined teeth. This action was repeated three times, and when the images in the axial plane were not clear, the teeth were also inspected in three-dimensional.
The following parameters were evaluated:

- number of roots;
- root canal system configuration (using as a reference Vertucci classification);
- presence of apical confluences;
- distance between confluences and radiographic root end;
- symmetry between left and right elements in the same individual.

The classification of the canal morphology was done according to the Vertucci's criteria:

- Type I: single canal from the pulp chamber to the apex;
- Type II: two different canals emerge from the pulp chamber but converge to the apex;
- Type III: a canal emerges from the pulp chamber, divides into two within the root and emerges into one at the apex;
- Type VII: one canal in the pulp chamber that divides and rejoins within the root, and redivides into two canals at the apex.

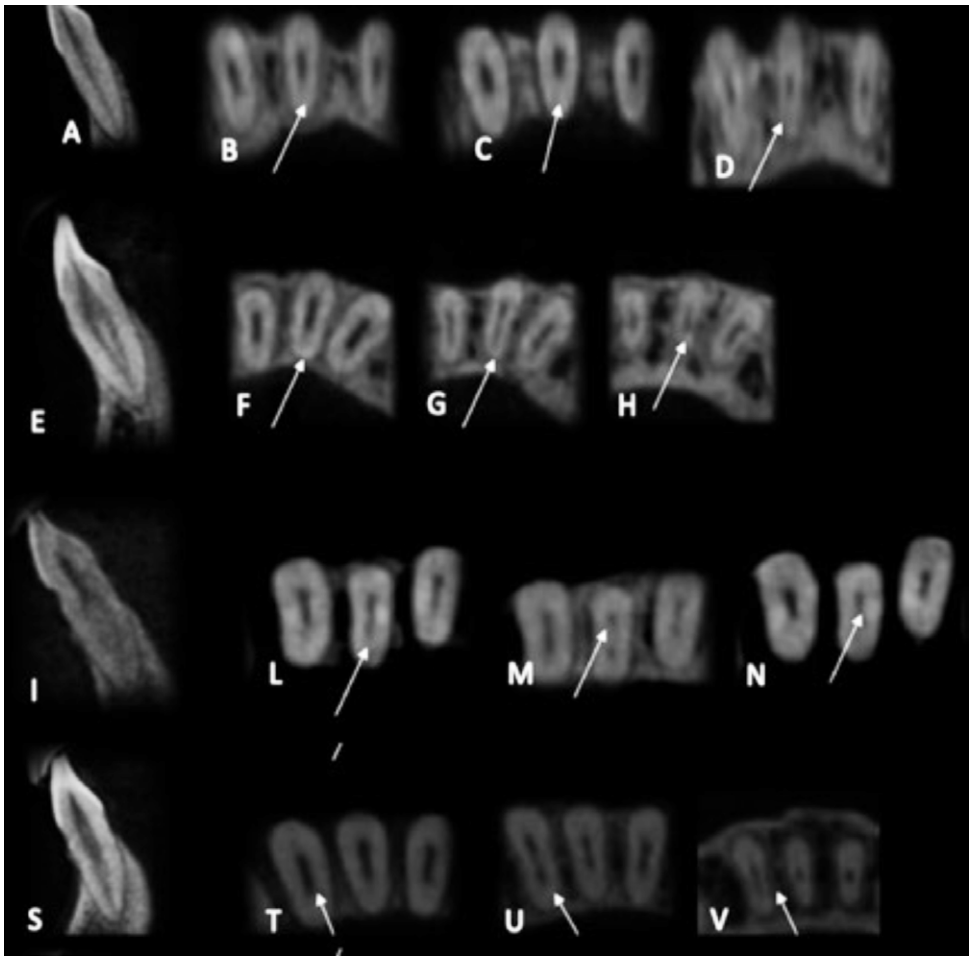

Figure 1
Sagittal plane of CBCT scanning Type I **(A)**, Type II **(E)**, Type III **(I)**, Type VII **(S)**. Axial plane of CBCT scanning in the coronal, middle, and apical thirds of the root displayed variations in canal morphology: **(B-D)** Type I, **(F-H)** Type II, **(L-N)** Type III, **(T-V)** Type VII.

Statistical Analysis
The results were analysed statistically using SPSS 20.0 (SPSS, Inc., Chicago, IL, USA) with the significance set at $P<0.05$. One-way ANOVA was used for the association between the variables along with the post hoc tests, Tukey's HSD and Games–Howell. The t-test was used to compare the means of canal length and distance from confluence to apical foramen.

Results

Number of roots and canal system configuration according to Vertucci:
- all examinated teeth presented only one root,
- for mandibular lateral incisors type I Vertucci configuration was present in 53% of cases, type II Vertucci configuration in 30% of cases, type III Vertucci configuration in 15% of cases, type VII Vertucci configuration in 2% of cases.

Apical confluences were present in all the incisors with a type II, type III and type VII Vertucci configuration; overall were present in 47% of examined cases.
The average distance between confluences and radiographic root end was 3,102 mm in type II Vertucci configuration and 3,234 mm in type III Vertucci configuration, and 2,802 mm in type VII Vertucci configuration.
Symmetry of root canal morphology between left and right in the same individual was found in 86% of cases.

Table 1

Prevalence of the Number of Root Canals in Mandibular Lateral Incisors

Tooth	1 canal (%)	2 canals (%)	Total
Mandibular lateral incisors	265 (53,0)	235 (47,0)	500

Table 2

Distribution of Root Canal Types according to Vertucci Classification in Mandibular Lateral Incisors

Tooth	Type I	Type II	Type III	Type VII	Total
Mandibular lateral incisors, n (%)	265 (53,0)	150 (30,0)	75 (15,0)	10 (2,0)	500 (100)

Discussion

Our results showed a high prevalence of type II configuration in mandibular lateral incisors. More precisely type II configuration was found in 30% of the teeth examined. This result was in agreement with the study by Benjamin and Dawson (23). On the contrary, the majority of studies (24-33, 40) performed on the mandibular lateral incisors, showed a significantly lower prevalence, ranging from 1% to 26,9%.

Type I Vertucci configuration was present in 53% of mandibular lateral incisors, lower when compared to the majority studies (23-28, 36-42), in accordance with Kartal et al (31), and superior to Sert et al (29). The total range was from 89,4% to 36,8%.

Type III Vertucci configuration was found 15% in mandibular lateral incisors. These findings were different from the majorities of previous researches (23-33), which showed an average percentage ranging from 0% to 27%.

Type VII Vertucci configuration was found in 2% of mandibular lateral incisors; interestingly, only the research by Han et al (32) ever showed this configuration (0,08% in mandibular lateral incisors).

The mean distance between confluences in type II mandibular lateral incisors was 3,102 mm (ranging from 1,442 mm to 6,432 mm). Similarly, in type III configuration in mandibular lateral incisors was 3,234 mm (ranging from 1,429 mm to 6,231 mm). These results were in accordance with a previous study (43) performed on confluences in molars, and significantly lower than the research of Han et al (32), performed on mandibular incisors, who reported that distribution was concentrated in the 6-12 mm range. The mean distance in type VII was 2,802 mm (ranging from 2,648 mm to 3,014 mm) in lateral incisors. Concerning with the symmetry between right and left in the same individual, we found the percentage of 86% in mandibular lateral incisors; our results were similar with the research by Kayaoglu et al (41) and lower than other studies performed on molars (43).

Conclusions

Some of the findings from the present study can be clinically relevant. The percentage of mandibular incisors presenting a complex anatomy (two canals with different config-

urations) is higher than previously reported. Type VII Vertucci configuration was clearly found before only in a single study.
No study previously reported the localization of confluences in lower incisors. They are mostly found in the apical third, 3-4 mm shorter than radiographic root end.
The controlateral teeth usually showed a high percentage of similar anatomy: simmetry between right and left in the same individual was found in 86% of cases.
These results highlighted the need for accurate preoperative radiographic exams to identify canal configuration: multiple radiographs with different angles or CBCT.

Clinical Relevance

Complex endodontic anatomies can be identify only with preoperative radiographic exam.

Conflict of Interest

The authors declares that there is no conflict of interest.

Acknowledgements

No acknowledgements.

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Winner of Riccardo Gerberoglio Award 36th SIE National Congress 2019

ORIGINAL ARTICLE/**ARTICOLO ORIGINALE**

Antibacterial effects of two synthetic peptides against *Enterococcus faecalis* biofilms: a preliminary *in vitro* study

KEYWORDS
Antimicrobial peptides, Biofilms, Confocal laser scanner microscopy, Enterococcus faecalis

PAROLE CHIAVE
Peptidi antimicrobici, Biofilm, Microscopia a scansione laser, Enterococcus faecalis

Effetti antibatterici di due peptidi sintetici nei confronti di biofilm di Enterococcus faecalis: studio preliminare in vitro

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Received 2020, January 31

Accepted 2020, February 25

Abstract

Aim: *Current endodontic techniques are unable to fully eradicate intracanal bacteria. Thus, new agents that effectively eliminate endodontic pathogens are needed. The aim of this study was to assess the antibacterial properties of two synthetic peptides, namely KP and L18R, against planktonic cells and biofilms of the endodontic pathogen Enterococcus faecalis.*
Methodology: *KP and L18R bactericidal activity against E. faecalis ATCC 29212 was evaluated by colony forming unit assays and the half maximal effective concentration (EC_{50}) was calculated. The effect of peptides on E. faecalis biofilm formation onto polystyrene plates was also assessed by the crystal violet assay. Confocal laser scanning microscopy (CLSM) analysis was carried out to compare the effects of KP, L18R and a $Ca(OH)_2$ saturated solution in an in vitro model of dental infection consisting in 2-day-old E. faecalis biofilms grown on hydroxyapatite disks.*
Results: *Both KP and L18R showed strong bactericidal activity against planktonic E. faecalis. L18R proved to be 10-folds more effective than KP (KP and L18R EC_{50} values=4.520×10^{-6} M and 3.624×10^{-7} M, respectively). Peptides inhibited E. faecalis biofilm formation in a dose-dependent manner and L18R resulted more effective*

Obiettivo: *le tecniche tradizionali di disinfezione endodontica non sono in grado di eliminare completamente i microrganismi del sistema canalare e, pertanto, si rende necessario lo sviluppo di nuovi agenti antimicrobici efficaci nei confronti dei microrganismi endodontici. Lo scopo di questo studio è la valutazione in vitro delle proprietà antibatteriche di due peptidi sintetici, denominati KP e L18R, nei confronti di cellule in sospensione e biofilm del patogeno endodontico Enterococcus faecalis.*
Materiali e metodi: *l'attività battericida di KP e L18R nei confronti di E. faecalis ATCC 29212 in forma planctonica è stata valutata mediante saggi convenzionali di determinazione di unità formanti colonia, stabilendo la concentrazione in grado di inibire il 50% della crescita batterica (EC_{50}), mentre l'effetto dei peptidi sulla formazione di biofilm in piastre di polistirene è stato studiato mediante saggio con il cristal violetto. È stata condotta, inoltre, un'analisi al microscopio confocale a scansione laser (MCSL) per valutare l'azione di KP, L18R e di una soluzione satura di $Ca(OH)_2$ in un modello in vitro di infezione endodontica rappresentato da biofilm di E. faecalis cresciuti per 2 giorni su dischetti di idrossiapatite.*
Risultati: *KP e L18R hanno mostrato un'efficace attività battericida nei confronti di E. faecalis allo stato planctonico e L18R si è mostrato 10 volte più efficace rispetto KP (EC_{50}=$4,520\times10^{-6}$ M e $3,624\times10^{-7}$ M, rispettivamente, per KP e L18R). Entrambi i peptidi hanno causato una riduzione dose-dipendente della*

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Peer review under responsibility of Società Italiana di Endodonzia
10.32067/GIE.2020.34.01.15

Abstract

than KP. CLSM images showed that $Ca(OH)_2$, KP and L18R remarkably impaired E. faecalis biofilms pre-grown on hydroxyapatite.
Conclusions: *KP and L18R effectively inhibited E. faecalis, both in planktonic and biofilm form. L18R demonstrated a more potent antibacterial activity than KP. These preliminary results suggest that antimicrobial peptides may represent a promising new strategy for endodontic infection control.*

formazione del biofilm e L18R è risultato più efficace rispetto KP. Le immagini ottenute mediante analisi al MCSL hanno mostrato una alterazione della struttura di biofilm di E. faecalis pre-formato su dischetti di idrossiapatite in presenza di $Ca(OH)_2$, KP e L18R.
Conclusioni: *entrambi i peptidi analizzati sono in grado di inibire E. faecalis, sia in forma planctonica che di biofilm e L18R si è dimostrato più efficace rispetto a KP. Questi risultati preliminari suggeriscono che i peptidi antimicrobici possono rappresentare una promettente strategia per il controllo delle infezioni endodontiche.*

Introduction

Endodontic treatment aims to resolve or prevent apical periodontitis eliminating the microorganisms from the root canal system (1). Unfortunately, current antimicrobial chemo-mechanical techniques have shown several limitations in microbial eradication (2, 3) and inter-appointment intracanal medications are often necessary (4). Treatment with calcium hydroxide, $Ca(OH)_2$, is the most widely used (5). $Ca(OH)_2$ antimicrobial properties depend on the release and diffusion of hydroxyl ions (OH^-) that cause a strongly alkaline environment and inhibit the growth of many endodontic pathogens (6). In clinical conditions, the activity of $Ca(OH)_2$ is limited by the inherent buffering capacity of the dentine (7). *Enterococcus faecalis*, a Gram-positive facultative anaerobic species frequently found in endodontic treatment failures, showed a relative resistance to $Ca(OH)_2$ (8, 9). One of the strategies adopted by *E. faecalis* to resist to antimicrobials is the formation of biofilms on the canal surfaces, alone or in combination with other species (10). Biofilms are formed by bacterial cells grown on a solid surface and enveloped in a self-produced polysaccharide and protein extracellular matrix. Eradication of microrganisms in biofilms is much more difficult in comparison to planktonic cells. Given these considerations, the exploitation of new effective antibiofilm substances would be beneficial to improve endodontic treatment success.

Antimicrobial peptides (AMPs) are a group of short, low-molecular-weight peptide sequences with a wide spectrum of antimicrobial activities (11). Their mechanism of action has not been fully elucidated, but for many of them seems to be mediated by a cell membrane damage finally leading to cell death (12). Other proposed mechanisms of killing are not related to membrane permeabilization. Some AMPs can cross the cell membrane through direct penetration or by a transporter mediated mechanism and interact with intracellular targets inducing several toxic effects, including enzyme inhibition, DNA degradation, formation of reactive oxygen species and ATP leakage (13).

AMPs could be distinguished in natural and synthetic ones. The former are produced by most living organisms, plants and animals, from mammals to insects, as a component of their innate immune system, and even bacteria and fungi. Examples of natural peptides are nisin synthesised by *Lactobacillus lactis* (14) or cathelicidin LL-37, expressed by human neutrophils and epithelial tissues (15). Beside natural AMPs, a wide library of synthetic peptides has been created in order to improve antimicrobial activities, to optimize pharmacological properties and to reduce production costs. Among synthetic peptides, two recently described AMPs, namely KP and L18R, have shown promising antimicrobial activities.

KP (killer peptide) is a decapeptide derived from a recombinant anti-idiotypic antibody, which is the internal image of a wide-spectrum antimicrobial yeast toxin (16). KP proved to be effective against protozoa, fungi, bacteria and viruses (17). L18R, derived from a gene (IGHJ2) encoding a human immunoglobulin heavy chain, displayed a strong fungicidal activity *in vitro* and *in vivo* (18). Both peptides did not show detectable toxicity to different human cells, including erythrocytes, epithelial cells and peripheral blood mononuclear cells (17-19).
The aim of this preliminary study was to assess the antibacterial properties of KP and L18R against planktonic cells and biofilms of the endodontic pathogen *E. faecalis*.

Materials and Methods

Peptides
KP (AKVTMTCSAS, molecular weight 998.2) and L18R (LLVLRSLGPWHPGHCLLR, molecular weight 2068.1) were synthesised at the CRIBI Biotechnology Center (University of Padua, Italy) with the solid phase peptide synthesis method using a multiple peptide synthesiser (SyroII, MultiSynTech GmbH, Witten, Germany). Then, the peptides were solubilised in dimethylsulphoxide at a concentration of 20 mg/ml. For the experiments, KP and L18R were diluted in sterile distilled water to the suitable concentrations.

Bactericidal activity against planktonic E. faecalis cells
The reference *E. faecalis* ATCC 29212 strain was grown in Brain Heart Infusion Agar (BHA; Sigma-Aldrich, St. Louis, USA) plates and maintained by biweekly passages. Peptide antibacterial activity was evaluated by colony forming unit (CFU) assay, as previously described (20). Briefly, 100 µl of a suspension of *E. faecalis* ATCC 29212 at a concentration of approximately 10^4 cells/ml were incubated in a 96-well microplate in the absence (control) or presence of each peptide, at decreasing concentrations. After 5 h at 37 °C, bacterial suspensions were seeded on BHA plates and colonies were counted after 24 hours of incubation at 37 °C. Killing percentage was calculated in relation to the number of colonies in controls. Three independent experiments were performed. The half maximal effective concentration (EC_{50}) was calculated by nonlinear regression analysis using Prism 4.01 (Graph Pad software, San Diego, USA).

Inhibition of E. faecalis biofilm formation on polystyrene surfaces
KP and L18R effects on early stages of *E. faecalis* ATCC 29212 biofilm formation were investigated as follows. Overnight cultures in Brain Heart Infusion Broth (BHI; Sigma-Aldrich, St. Louis, USA) supplemented with 0.25% glucose (BHIg) were diluted to 7.5×10^6 cells/ml in fresh medium and 200 µl of the suspension were transferred into wells of polystyrene flat-bottom 96-well plates (Corning Incorporated, New York, USA). After 90 min at 37 °C, non-adherent bacterial cells were washed off. Decreasing concentrations of peptides in 200 µl of sterile distilled water were added to the wells while controls were incubated in 200 µl of water for 5 h at 37 °C. Subsequently, the wells were washed and 200 µl/well of BHIg were added and incubated at 37 °C for 24 h.
After 48 h, biofilm mass was assessed by the crystal violet assay. The medium was removed and the wells were dried at 80 °C for 15 minutes and then stained using 200 µl/well of 0.25% crystal violet (Sigma-Aldrich, St. Louis, USA) for 15 min. Then the wells were washed three times with phosphate-buffered saline (PBS) and dried for 12 hours in a dark room. Then, 200 µl/well of 85% ethanol was added and the absorbance at 540 nm was measured using a microplate reader (Multiskan Ascent Microplate Reader, Thermo Electron, Waltham, USA). The results were expressed as percentage of biofilm mass reduction in relation to untreated controls.

Inhibition of E. faecalis biofilm on hydroxyapatite disks

In order to evaluate the antibiofilm properties, an *in vitro* model of root canal infection was employed using hydroxyapatite (HA) disks. HA disks were prepared according to Lagori et al. (21). Briefly, 0.15 g of HA powder (Sigma Aldrich, St. Louis, USA) were placed in a 12.891-mm diameter mould (Specac Inc., Fort Washington, USA). HA powder was compressed using a hydraulic press (Eurocem EPI 1, Settimo Milanese, Italy) at the pressure of 50 bars. Disks were heated under vacuum at 980 °C. Sterilized HA disks were incubated with 500 µl of a 7.5×10^6 cells/ml *E. faecalis* ATCC 29212 suspension for 48 h at 37 °C in a flat-bottom 24-well plate. After incubation, the medium was washed off and the disks were treated (500 µl/well) with a saturated solution of $Ca(OH)_2$ endodontic dressing, KP (100 µg/ml) or L18R (50 µg/ml) for 24 h. Control samples were incubated with sterile water. The saturated solution of $Ca(OH)_2$ was previously prepared by mixing 38 mg of Calxyl (OCO, OCO Präparate GmbH, Dirmstein, Germany) with 10 mL of sterile distilled water. The preparation was centrifuged at 3000 g and aqueous supernatant was filtered aseptically using a sterile 25 mm diameter (0.22 µm) syringe filter (Millex®, Merck Millipore, Burlington, USA).

After treatment, the disks were processed for confocal laser scanning microscopy (CLSM) by washing with sterile water and staining with 500 µl/well of a fluorescent staining solution containing 0.3% SYTO9 and 0.3% propidium iodide (LIVE/DEAD FilmTracer™ LIVE/DEAD® Biofilm Viability Kit, Invitrogen, Paisley, UK). SYTO 9 and propidium iodide selectively stain alive cells in green and dead cells in red, respectively. A LSM 510 Meta scan head integrated with the Axiovert 200 M inverted microscope (Carl Zeiss, Jena, Germany) using a 40×NA1.3 oil immersion lens was employed for observation. The excitation/emission wavelengths were 480/500 nm for SYTO 9 and 490/635 nm for propidium iodide. A stack of 80-100 slices was captured along the Z-axis of the biofilm. CLSM images were acquired and 3D reconstructed with Imaris 9.5.0 software (Bitplane AG, Zurich, Switzerland). Each experiment was performed in duplicate.

Results

KP and L18R bactericidal activity against planktonic cells

CFU assays were carried out on planktonic *E. faecalis* ATCC 29212. Both peptides showed a significant activity against the endodontic pathogen (figure 1), with EC_{50} values in the micromolar range, 4.520×10^{-6} M and 3.624×10^{-7} M for KP and L18R, respectively. Notably, EC_{50} values for L18R were approximately 10-fold lower.

Inhibitory effects of KP and L18R on early stages of E. faecalis biofilm development

The ability of peptides to inhibit *E. faecalis* biofilm formation onto polystyrene plates was investigated by crystal violet assay. Both KP and L18R proved to notably reduce the biofilm mass in a dose-dependent manner (figure 2). In particular, KP at 50 µg/ml concentration caused 35% biofilm mass reduction. Conversely, at the same concentration, L18R determined a 73% biofilm mass reduction. As for the bactericidal activity against planktonic cells, L18R resulted more effective in biofilm inhibition in comparison to KP.

KP and L18R inhibition of E. faecalis biofilm on hydroxyapatite disks

Antibiofilm properties of KP and L18R against 2 day-old *E. faecalis* ATCC 29212 biofilms grown on HA disk were assessed using CLSM in comparison with samples treated with a saturated $Ca(OH)_2$ endodontic dressing solution. 3D CLSM image reconstructions of control samples (water incubation) showed a homogeneous and robust biofilm layer with a majority of cells alive (figure 3A). Instead, HA disks exposed to saturated $Ca(OH)_2$ solution, KP (100 µg/ml), and L18R (50 µg/ml)

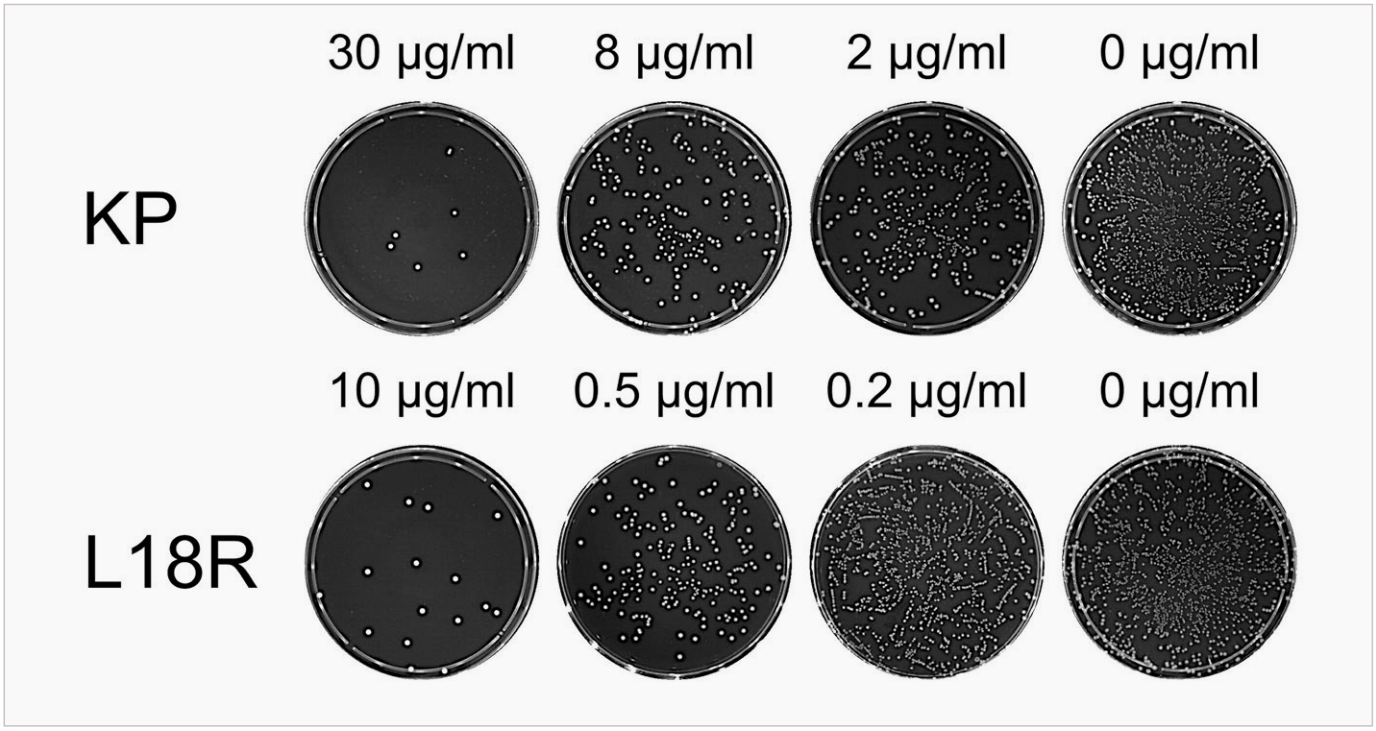

Figure 1
KP and L18R effects against *E. faecalis* ATCC 29212 planktonic cells determined by CFU assay. Representative plates show *E. faecalis* ATCC 29212 inhibition at different KP and L18R concentrations.

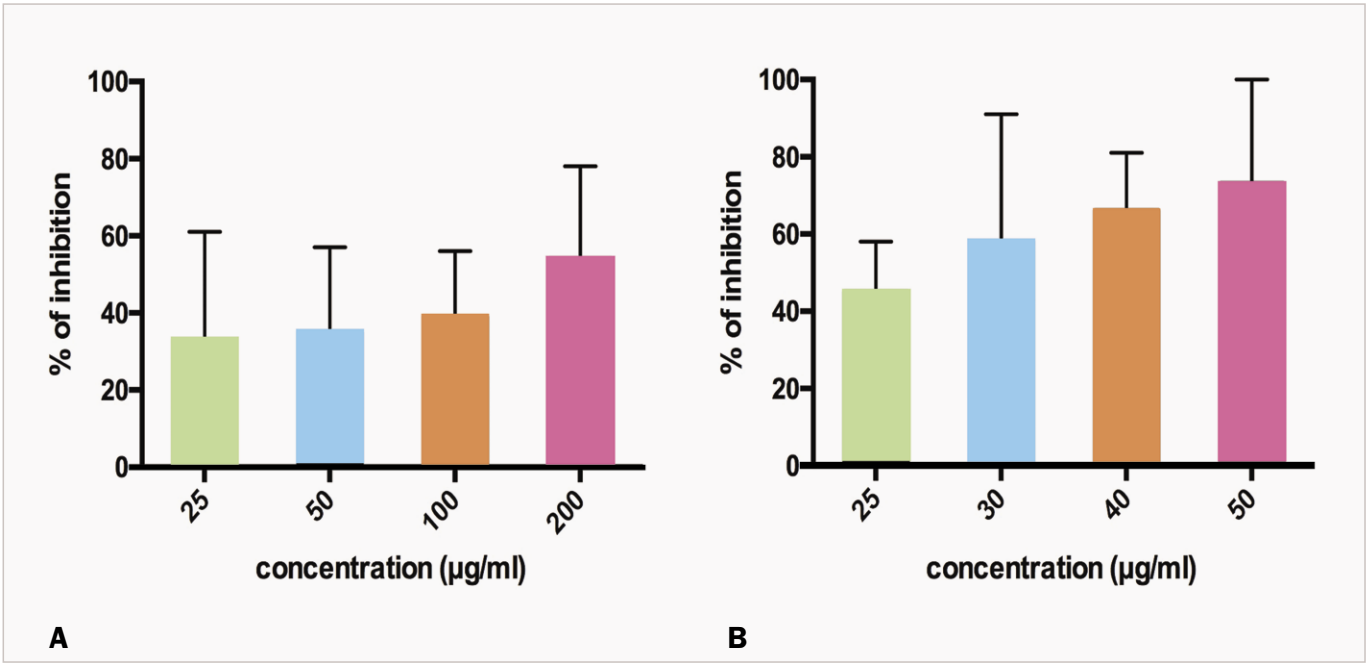

Figure 2
KP **(A)** and L18R **(B)** effects against *E. faecalis* ATCC 29212 biofilm. Biofilm mass was determined by crystal violet assay, comparing samples treated with different peptide concentrations to untreated samples. Data are presented as mean ± SD of at least three independent experiments.

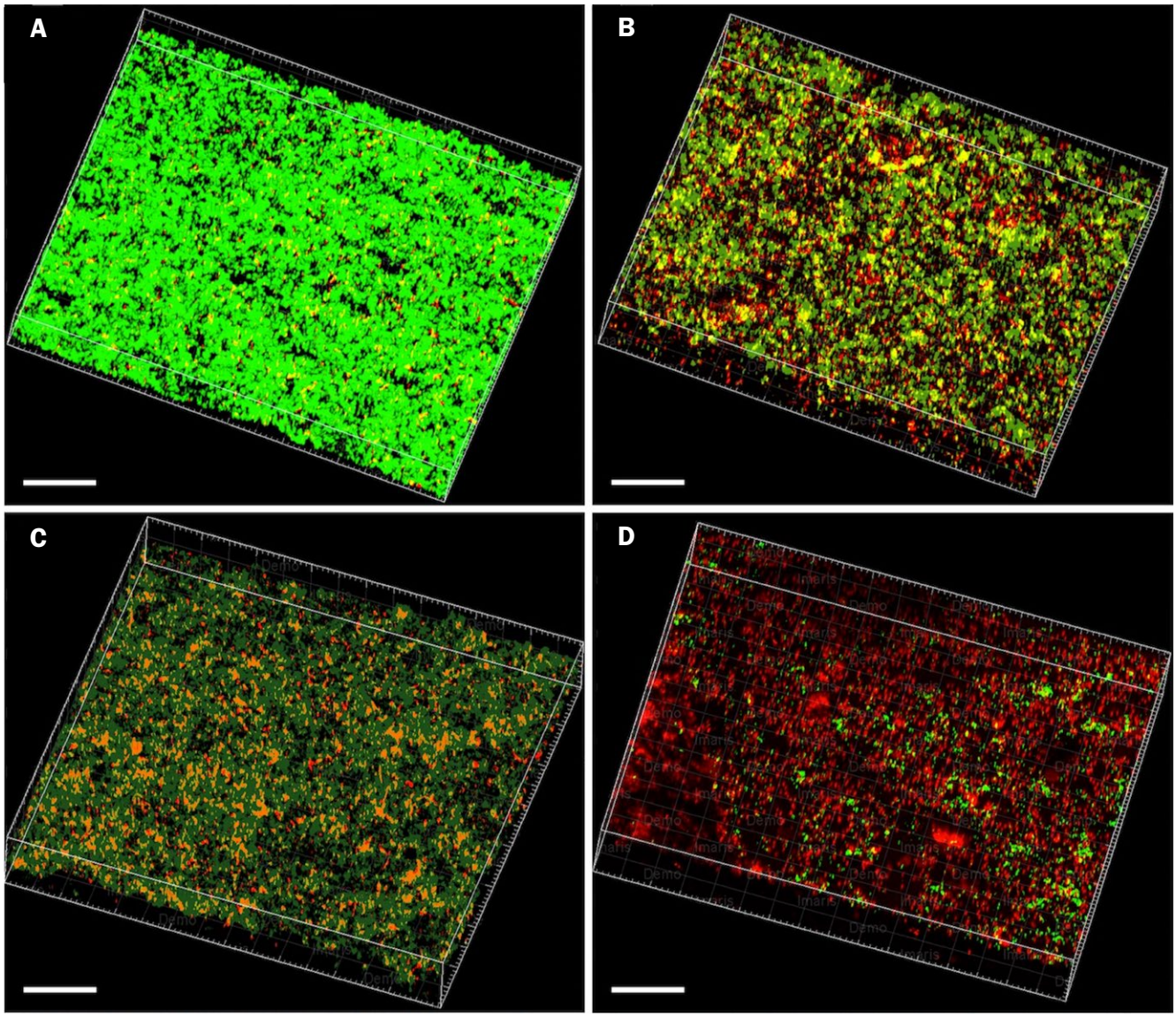

Figure 3
Representative 3D reconstruction of confocal laser scanning microscopy (CLSM) images of *E. faecalis* biofilms on HA disks. Images represent 2 day-old *E. faecalis* ATCC 29212 biofilms exposed for 24 h to H_2O (control, A), $Ca(OH)_2$ saturated solution (B), 100 µg/ml KP (C) and 50 µg/ml L18R (D) and stained with SYTO9 and propidium iodide. Green, live cells; red, dead cells. Bars=50 µm.

showed an impaired biofilm layer, with a consistent number of dead cells (figure 3B-D). Overall, the qualitative analysis of the images revealed a similar effect of $Ca(OH)_2$ solution and KP treatments, while L18R appeared as the most effective in reducing both the total biomass and the viability of the biofilm.

Discussion

The persistence of *E. faecalis* in the root canal system after conventional decontamination is considered a possible cause of endodontic treatment failure (22). Compared to other endodontic pathogens found in infected root canals, this Gram-positive facultative anaerobic species showed some resistance to sodium hypochlorite (23), a commonly used endodontic irrigant, and proved to be less susceptible to calcium hydroxide (24, 25), which is widely employed as intracanal medication. Since *E. faecalis* ability to form biofilm on root canal surfaces contributes to its resistance, the search for new alternative antibacterial substances able to inhibit *E. faecalis* both in planktonic and biofilm form is encouraged.

The present study evaluated *in vitro* the effects of two synthetic immunoglobulin-derived peptides against *E. faecalis* ATCC 29212. The peptide L18R resulted more effective than KP against the bacterium, both in planktonic and biofilm form. In particular, the EC_{50} of L18R against planktonic cells resulted 10-fold lower as compared to KP. Moreover, L18R exhibited stronger inhibition of biofilm formation as compared to KP. The effect of both peptides were also evaluated in a model of established dental infection consisting of a 2 day-old *E. faecalis* biofilm grown on HA disks in comparison to the effect of a saturated $Ca(OH)_2$ endodontic dressing solution.
The qualitative analysis of CLSM images demonstrated that both KP and L18R were able to impair the biofilm structure, reducing the number of attached and viable cells. The partial resistance of *E. faecalis* to $Ca(OH)_2$, as reported by other authors (24, 25), was confirmed. L18R was associated to the highest proportion of dead cells and to the lowest cell density compared to the other experimental groups, demonstrating a strong detaching effect of the peptide.
The mechanism of KP antibacterial activity is still not fully understood. In previous studies on yeasts, it was demonstrated that the physico-chemical properties of KP and its interaction with superficial cell-wall glucan-like structures were at the basis of the antifungal effects (17). It is possible to speculate that interactions with the surface of the bacterial cells may be involved in the antimicrobial action of the peptide. For L18R, an interaction with the cell membrane of yeasts followed by direct penetration via an energy independent pathway was hypothesised and made plausible by the hydrophobic face of the peptide (18).
As demonstrated in previous studies (17-19) an important feature of KP and L18R is the low toxicity, that could be partially explained by the cationic property of their molecules. Indeed, the peptides can easily interact with the negatively charged membranes of bacterial cells, while do not bind to the zwitterionic membranes of mammalian cells (26). This feature may represent an important advantage over other treatments, such as $Ca(OH)_2$, for which a certain degree of toxicity against eukaryotic cells was demonstrated (27).
The results reported in this study are the first investigations on KP and L18R effects against an endodontic pathogen. Prior to consider the use of these peptides as a strategy for endodontic infection control, it will be necessary to evaluate the effects against other microorganisms and employ multi-species biofilm models for a better simulation of the clinical scenario.

Conclusions

Both KP and L18R demonstrated marked inhibitory abilities against planktonic cells and biofilms of the endodontic pathogen *E. faecalis* in the experimental conditions adopted. L18R showed better performances as compared to KP and its possible role as endodontic disinfectant should be further investigated.

Clinical Relevance

For their antibiofilm activity, AMPs may be promising agents for root canal infection control in the future.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be considered as a potential conflict of interest.

Acknowledgments

We want to thank Dr. Francesca Poggia, Dr. Federica Placa and Chiara Mirabile for their support during the laboratory work and Dr. Silvana Belletti for CLSM analysis, performed in the Laboratory of Confocal Microscopy of the Department of Medicine and Surgery at the University of Parma.

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ORIGINAL ARTICLE/**ARTICOLO ORIGINALE**

Evaluation of the root canal tridimensional filling with warm vertical condensation, carrier-based technique and single cone with bioceramic sealer: a micro-CT study

Valutazione della qualità del sigillo canalare mediante micro-CT: cono singolo con bioceramiche VS onda continua di condensazione VS guttaperca calda veicolata da carrier

KEYWORDS
Bioceramic Sealer, Micro-CT, Root Canal Obturation, Root Canal Sealers, Volumetric Distortion

PAROLE CHIAVE
Cemento bioceramico, Micro-CT, Otturazione canalare, Cementi canalari, Alterazione volumetrica

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Received 2020, February 20

Accepted 2020, March 17

Abstract

Aim: *To compare the quality of the tridimensional (3D) filling and the presence of radiographic translucencies after root canal obturation with three different techniques: warm vertical condensation, carrier-based and single cone with bioceramic sealer.*
Methodology: *Thirty single-rooted human teeth extracted for periodontal reasons were selected. Glide path was performed with ProGlider and shaping with ProTaper Next (PTN) X1, X2 and X3 up to working length (WL). The specimens were randomly divided into three groups (N=10) for the final 3D filling step: Buchanan's continuous wave of condensation (Group 1, G1), Thermafil® (Group 2, G2) or TotalFill® BC Points™ combined with TotalFill® BC Sealer (Group 3, G3).*
Micro-CT scans were performed after the obturation step and the slices were 3D reconstructed with standardized parameters. Afterwards, the filled area and the associated radiographic translucencies were computer-isolated, and their volumes were calculated.
The statistical analysis was performed using one-way ANOVA and the post-hoc Student-Newmann-Keuls (P<0,05).

Scopo: *questo studio si pone come obiettivo la valutazione della qualità del sigillo, mediante analisi micro-tomografica computerizzata, in termini di presenza di difetti di riempimento del sistema canalare, dell'otturazione ottenuta con tre diverse metodiche: la tecnica dell'onda continua di condensazione, della guttaperca plasticizzata veicolata da carrier e la tecnica di otturazione con cono singolo di guttaperca abbinato al sealer bioceramico.*
Materiali e metodi: *sono stati selezionati trenta elementi dentari monoradicolati, estratti per motivi parodontali. Dopo aver eseguito l'accesso endodontico, la sagomatura è stata effettuata con sistema Protaper Next™, fino a X3, a lunghezza di lavoro (WL), irrigando con NaOCl 5% ed EDTA 10%.*
I campioni sono stati casualmente suddivisi in tre gruppi (N=10).
Il primo gruppo (G1) è stato otturato con la tecnica dell'onda continua di condensazione di Buchanan. Il secondo gruppo (G2) con guttaperca riscaldata veicolata da carrier (Thermafil®). Il terzo gruppo (G3) è stato infine otturato con cono singolo di guttaperca TotalFill® BC Points™ abbinato a sealer bioceramico TotalFill® BC Sealer™, secondo le specifiche della casa produttrice. Tutti i campioni sono stati analizzati tramite scansioni micro-tomografiche computerizzate (micro-CT), utilizzando parametri standardizzati. Dalle immagini ottenute sono stati calcolati tridimensionalmente i volumi dell'otturazione e delle aree di radiotrasparenza associate, tramite Materialise Mimics Medical™ e Geomagic Qualify®.

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Peer review under responsibility of Società Italiana di Endodonzia
10.32067/GIE.2020.34.01.07

Abstract

Results: *The mean percentage of translucency areas in the warm vertical condensation group was 1,23%, whereas in the carrier-based group was 4,22% and in the single cone with bioceramic sealer group was 10,44%. The differences between the groups were statistically significant (P=0,029).*

Conclusions: *All the obturation techniques provided an adequate 3D root canal filling. However, the null hypothesis of a superimposable 3D filling quality between groups was refused. The single cone technique with bioceramic sealer represented a viable clinical alternative, although it seemed more operator-dependent than the others.*

Le analisi statistiche sono state effettuate utilizzando l'analisi one-way ANOVA ed il test post-hoc Student-Newmann-Keuls ad un livello di significatività di P<0,05.

Risultati: *la media della percentuale delle aree di minor radiodensità nel gruppo G1 è stata 1.23%, nel gruppo G2 4.22%, nel gruppo G3 10.44%. Le differenze tra i tre gruppi si sono dimostrate statisticamente significative (P=0,029).*

Conclusioni: *con le limitazioni di questo studio, possiamo affermare che in tutti i gruppi sia stata ottenuta un'otturazione tridimensionale soddisfacente, in linea con i dati dalla letteratura scientifica. Le tecniche dell'onda continua di condensazione e della guttaperca veicolata da carrier si sono dimostrate di maggiore predicibilità rispetto all'otturazione con sealer bioceramico. Tuttavia, quest'ultima rimane una valida alternativa in campo clinico, anche se è risultata essere ancora maggiormente operatore-dipendente.*

Introduction

During endodontic treatment, the obturation's quality is considered a main feature for a good prognosis: it aims to fill the entire root canal system and to seal it from any bacterial contamination (1). Anatomical variations such as isthmuses or bifurcations may be considered a challenge for the operator during this critical phase.

The perfect sealer and filling material have yet to be found. Its ideal characteristics have been described by Grossman in 1988 (2) and revised by Kaur in 2015 (3).

In modern endodontics, warm vertical condensation and thermo-plasticized carrier-based techniques are commonly used. Warm vertical condensation was described by Schilder in 1967 (4). In 1998, Buchanan proposed the continuous wave of condensation: it takes all the advantages of the Schilder's techniques achieving a 3D filling of the endodontic system and requiring a single heat compaction of 15 seconds (5, 6). Nowadays, thermo-plasticized carrier-based gutta-percha is taking hold solidly for its simplicity combined with high-performance (7).

Both of these techniques share the use of zinc oxide eugenol (ZOE) sealer, which is indicated as the obturation's weak link, so its volume percentage should be lower than the filling material (4, 8).

Bioceramics are a large family of root repairing cements and root canal sealers. Thanks to their high pH and ability to produce hydrated calcium silicate gel and calcium hydroxide, they have been proven highly biocompatible and nontoxic: these properties make them particularly suitable in dentistry (9, 10). One of the most well-known bioceramic-based material is mineral trioxide aggregate (MTA), a mixture of Portland cement and bismuth oxide (11). Through the years, bioceramic-based materials have been used mainly as retrograde filling materials, root repair cements or root canal sealers (12, 13, 14). Due to their capability to produce mineral tags, bioceramic sealers are supposed to bond chemically and mechanically dentinal tubules (15, 16). Nowadays, the clinical use of bioceramic-based materials endodontic sealer is widely documented (9, 17, 18). Radiopacity is an important characteristic for any filling material in order to assess the treatment's quality. Micro-computed tomography (micro-CT) is a modern highly accurate method proposed to assess the obturation quality through the three-dimensional analysis of the root canal volumes: it is widely documented as non-destructive, non-invasive, (19) repeatable and reliable, (20, 21) representing nowadays one of the best in vitro methods in the endodontics research field (22-25).

The aim of this micro-CT study is to evaluate the quality of the tridimensional fill-

ing and the presence of radiographic translucencies after the root canal obturation with three different techniques: warm vertical condensation, carrier-based technique and single cone with bioceramic sealer.

Materials and Methods

Specimen selection
For this study, intact single-rooted human teeth with closed apex, freshly extracted due to periodontal disease, were recruited and immediately stored in a NaCl 0.9% W/V solution after the extraction. Once the debridement of root's surface with a Gracey's curette was done, each tooth was restored in NaCl 0.9% W/V solution. The test tube was fixed on a customized support for low resolution scout scans (SS) (SkyScan 1172®: ©Bruker microCT, Kontich, Belgium) to obtain a general vision of the root canal system. Starting from the SS, thirty teeth with single roundish canal were selected.

Endodontic treatment
After performing a minimally invasive endodontic access, the canal was scouted with a #10 k-file (Dentsply Maillefer, Ballaigues, Switzerland). Working length (WL) was assessed with a microscope (OPMI Pro Ergo®, Carl Zeiss, Oberkochen, Germany) when the instrument's tip became just visible at the apex. The glide path and the shaping were achieved respectively with ProGlider (PG) (Dentsply Maillefer, Ballaigues, Switzerland) and with ProTaper Next (PTN) (Dentsply Maillefer) X1, X2 and X3 using the X-Smart plusTM motor according the manufacturer's instruction (300 rpm, 4 Ncm), always up to WL. Each instrument was used for a maximum of 3 cycles and then discarded. The irrigation between every instrument was performed with 5% NaOCl (Niclor 5; Ogna, Muggiò, Italy) alternated with 10% EDTA (Tubuliclean; Ogna) by using a 5 mL syringe and 30-gauge side-vented needle.
All specimens were randomly divided into three groups (N=10) for the final 3D filling step: continuous wave condensation (Group 1), carried-based obturation (Group 2) or bioceramic sealer (Group 3).

Continuous wave of condensation group (G1)
In Group 1 (G1) a dedicated gutta-percha X3 cone (Dentsply Maillefer) was selected and covered with a light coat of ZOE endodontic sealer, mixed according to manufacturer's instructions (Pulp Canal Sealer EWT; Kerr, Orange, CA). The cone was inserted up to 0.5 mm from the working length of each sample, checking the correct tug-back. An M plugger (EIE/Analytic, Redmond, WA) which penetrated within 5 mm from the working length was selected. A DownPak heat source (Hu-Friedy, Chicago, IL) heated the cone till 5 mm from working length and the plasticized gutta-percha was gently compacted with the plugger. Afterwards, backfilling step was performed with Obtura III (Analytic Technologies, Redmond, WA).

Carrier-based group (G2)
For the 3D filling step in Group 2 (G2), a small amount of ZOE endodontic sealer (Pulp Canal Sealer EWT; Kerr, Orange, CA), mixed according to manufacturer's instructions, was placed over the canal access, then a size .35 Thermafil plastic obturator (Dentsply, Tulsa Dental Products, Tulsa, OK) was heated in a Thermaprep oven (Dentsply Tulsa) for 30 seconds and inserted with firm apical pressure up to working length in the canal. The carrier was cut at the canal orefice.

Bioceramics group (G3)
In Group 3 (G3) a size .30 gutta-percha cone TotalFill® BC PointsTM (Brasseler U.S.A. Dental, LLC One Brasseler Boulevard Savannah, Georgia 31419, USA) was selected, in order to check its correct tug-back up to working length. A small amount of premixed TotalFill® BC SealerTM (Brasseler U.S.A. Dental, LLC One Brasseler Boulevard Savannah, Georgia 31419, USA) was placed in the canal through the intracanal tip of the pre-loaded syringe, and gently spreaded over the canal walls. The gutta-percha cone as well was covered with a light coat of sealer and finally placed in the canal up to working length. To guarantee better filling proprieties, the cone was clock-wise rotated in the final 3 mm of its insertion.

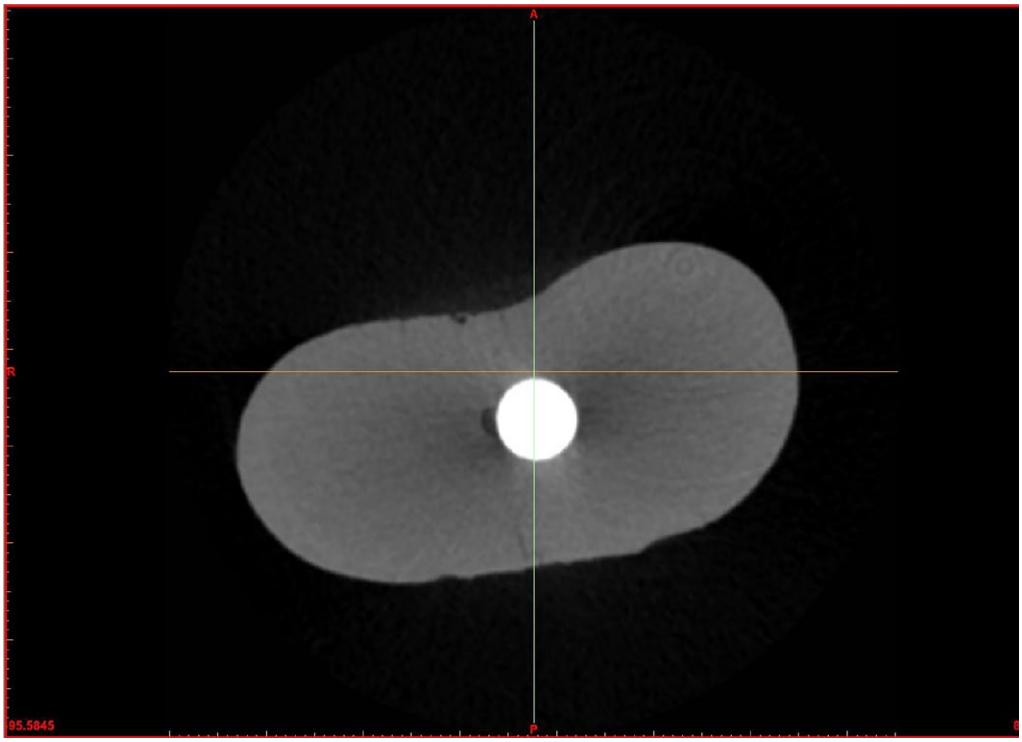

Figure 1
Example of a micro-CT G2 specimen slice.

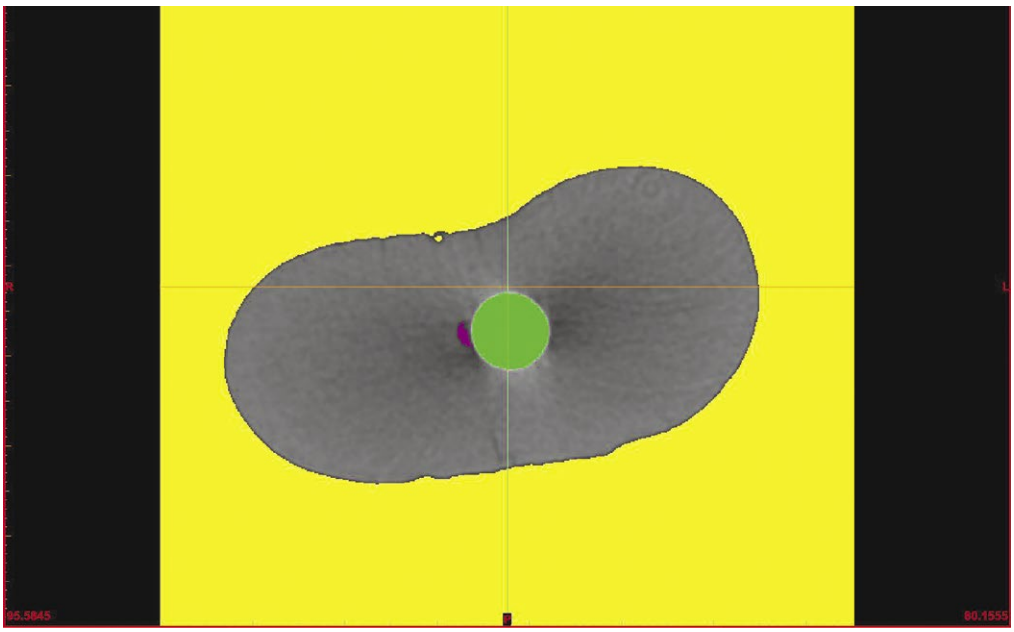

Figure 2
Masks selection: green for carrier-based gutta-percha obturation and ZOE sealer; yellow for space outside the specimen; purple for intra-canalar voids.

Endodontic access in all the specimens was sealed with a provisional sealer and then the teeth were stored again in a NaCl 0.9% W/V solution.

Micro-CT scans
Test tubes were fixed on the customized support for high resolution scans (100 kV, 100 µA) (SkyScan 1172®: ©Bruker microCT, Kontich, Belgium), with an isotropic resolution of 12.53 µm/pixel, in a 3 hours timeframe approximately for each specimen. Rotation step of the specimens was set at 0.4 degrees and averaging of 4 frames, through a physical 2 mm Copper and Aluminum filter. Once the scans were

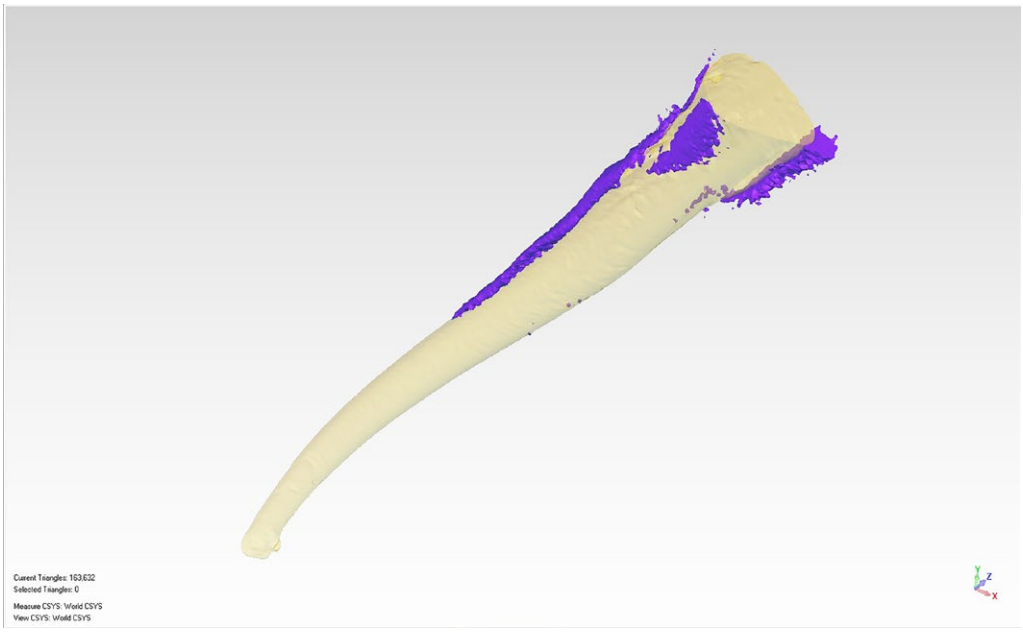

Figure 3
The 3D rendering of the previous G2 specimen with its obturation voids: ochre for carrier-based gutta-percha and ZOE sealer; purple for intra-canalar voids.

done, each acquisition was reconstructed with the software NRecon (©2012 Bruker) using standardized parameters for the whole study: 15% beam hardening; artifact correction between 4 and 8, depending on the specimen's artifact; smoothing between 3 and 5, depending on the specimen's radiodensity: Output histogram as well was standardized on the HU scale (min: 0; max: 0.064) (figure 1).

Digital analysis
Afterwards the software Materialise Mimics MedicalTM (Materialise NV) was used for processing the reconstructed files: region of interest (ROI) was selected starting from the cement-enamel junction (CEJ) up to the root apex.
Two different masks were selected over the ROI: obturation mask (Mobt) (lower threshold=1,624; higher threshold=3,194 on the HU scale) including areas with similar radiodensity to the gutta-percha and bioceramic sealer; voids mask (Mvds) (lower threshold= 1,024; higher threshold=-300 in the HU scale) including areas with similar radiodensity to the space outside the tooth. After this selection, Mobt was dilated of 30 pixels, assuming that eventual obturation voids extend no more for 375,9 µm from the radicular walls.
With an intersection between dilated Mobt and Mvds we obtained a pores mask (Mpor), as result of regions around for 0.3 mm and inside the obturation that have same radiodensity of the specimen's outside space (figure 2).
Mobt, Mvds and Mpor were exported in .stl files and renderized with the software Geomagic Qualify 12.0 (©2010 Geomagic), which also helped in the calculation (in µm3) of the obturation volume (Vobt) and pores volume (Vpor) (figure 3).

Results

To calculate the rate of the pores in the selected areas (Rpor) the following proportion was used:

(Vobt + Vpor) : 100 = Vpor : Rpor

Table 1 shows obturation volume, pores volume and pores rate for each sample and all the three groups mean values.
The statistical analysis was performed with one-way ANOVA test and the post-hoc Student-Newmann-Keuls test (P<0,05). The mean percentage of translucency areas in G1 was 1,23%, whereas in G2 was 4,22% and in G3 was 10,44%. The differences between the three groups were statistically significant (P=0,029). The null hypothesis of a superimposable 3D filling quality between the three groups was refused.

Table 1

Shows obturation volume, pores volume and pores rate for each sample and groups mean values

Group	Specimen	Obturation volume (μm³)	Pores volume (μm³)	Pores rate (%)
G1 (Continuous wave of condensation group)	WAV_01	13079.354794	67.012520	0.5
	WAV_02	8158.053783	19.798954	0.2
	WAV_03	6047.494961	4.322310	0.1
	WAV_04	18622.551407	107.023199	0.6
	WAV_05	9154.671449	326.944672	3.4
	WAV_06	10406.475035	44.739567	0.4
	WAV_07	7475.083765	20.232366	0.3
	WAV_08	12030.724405	691.364789	5.4
	WAV_09	6671.881436	5.616137	0.1
	WAV_10	14336.876706	195.714099	1.3
G1 MEAN VALUES		**10598.3**	**148.3**	**1.23**
G2 (Carrier-based gutta-percha group)	CAR_01	10944.11089	117.166773	1.1
	CAR_02	19517.0993	109.192633	0.5
	CAR_03	10329.0327	139.868864	1.3
	CAR_04	12477.193891	2651.3298	17.5
	CAR_05	10388.39338	414.6046	3.8
	CAR_06	9497.214289	8.524728	0.08
	CAR_07	9672.531468	475.833332	4.6
	CAR_08	9790.794203	143.298172	1.4
	CAR_09	9280.845704	1096.38577	10.5
	CAR_10	10944.11089	110.191466	1.0
G2 MEAN VALUES		**11284.1**	**526.6**	**4.22**
G3 (Single cone with bioceramic sealer group)	BIO_01	15161.606403	910.076029	5.7
	BIO_02	15883.825857	705.336862	4.3
	BIO_03	11490.327005	994.420567	8.0
	BIO_04	5075.217904	173.934894	3.3
	BIO_05	7810.608117	2869.873788	26.9
	BIO_06	20555.635418	2138.462997	9.4
	BIO_07	10045.453751	2149.309631	17.6
	BIO_08	15779.903813	715.423583	4.3
	BIO_09	15401.496286	2850.362639	15.6
	BIO_10	13228.770685	1363.863580	9.3
G3 MEAN VALUES		**13043.3**	**1487.1**	**10.44**

Discussion

In the present study micro-CT scans were used to compare the quality of the 3D filling and the presence of radiographic translucencies of three different root canal obturation techniques: warm vertical condensation, carrier-based technique and single cone with bioceramic sealer. The same parameters among the different group were analyzed: obturation volume, pores volume and pores rate. No obturation technique showed a completely filled canal system.

The obturation techniques used during this study presented similar characteristics: they are biocompatible, radiopaque and inert, (26) offering a stable apical and intra-canalar seal. The results of this study are comparable with previously published scientific data about the continuous wave of condensation and the carrier-based techniques and a good 3D filling of the root canal system was achieved (6, 27).

Both continuous wave and carried based techniques are based on minimum sealer interface concept, while the bioceramic sealer single cone technique starts from Grossman's concept of maximum sealer interface with the gutta-percha cone intended as a carrier. This difference probably makes this obturation technique more operator-dependent compared with the other two.

Eltair et al. reported that the use of different types of gutta-percha cones compositions doesn't affects significantly the quality of the endodontic seal (28).

Micro-CT have been validated as a viable method to tridimensionally evaluate the endodontic anatomy, that instrument shaping outcomes and the obturation quality (29). Moreover, it is accurate, reproducible, repeatable and non-destructive against the specimens (30, 31). In the present study, the areas of major radiolucency isolable in our scans (Mpo) represented a lack of filling of the tested obturation material.

These areas were frequently associated with a higher physical density of the bioceramic sealer which resulted in the formation of internal voids or in lacks of filling at the interface against the root canal walls. In conclusion, the standardization of the 3D root canal filling quality may be more operator dependent using the single cone bioceramic technique.

Conclusions

Within the limitations of this study, all the obturation techniques provided an adequate 3D root canal filling. The single cone technique with bioceramic sealer represented a viable clinical alternative, although it seemed more operator-dependent than the continuous wave of condensation and carrier-based gutta-percha techniques.

Clinical Relevance

3D filling is a key element for a successful endodontic treatment: continuous wave of condensation and carrier-based gutta-percha proved to be two more predictable techniques. The single cone with bioceramics, thanks to their biocompatibility proprieties, is a viable clinical alternative, although more operator-dependent.

Conflict of Interest

We affirm that we have no financial affiliation (e.g. employment, direct payment, stock holdings, retainers, consultantships, patent licensing arrangements or honoraria) or involvement with any commercial organization with direct financial interest in the subject or materials discussed in this manuscript, nor have any such arrangements existed in the past three years. The Authors declare no competing conflict of interests with the materials discussed in this manuscript.

Acknowledgements

Micro-CT scans were performed at C.I.R. Dental School (Via Nizza 230, 10100 Turin, Italy).

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ORIGINAL ARTICLE/**ARTICOLO ORIGINALE**

Diagnostic accuracy of two cone-beam computed tomography systems for detection of strip perforation in the mesial root of mandibular molars

Precisione diagnostica di due sistemi di tomografia cone-beam per la rilevazione di stripping nella radice mesiale di molari mandibolari

KEYWORDS
Cone Beam Computer Tomography, Three Dimensional Imaging, Accuracy

PAROLE CHIAVE
Tomografia Computerizzata Cone Beam, Immagine 3D, Precisione

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Received 2019, August 22

Accepted 2019, January 15

Abstract

Aim: *This study aimed to compare the diagnostic accuracy of two cone-beam computed tomography (CBCT) systems for detection of strip perforation in the mesiobuccal canal of mandibular molars after root canal treatment.*
Methodology: *The curved mesiobuccal canals of mandibular first and second molars were instrumented as part of endodontic treatment. The canals were strip-perforated using #2 and #3 Gates-Glidden drills in distoaxial direction at 1 to 3 mm distance from the furcation. The canals were filled with gutta-percha and AH26 sealer with lateral compaction technique. The teeth were then mounted in dry bovine mandible and underwent CBCT using Acteon and NewTom CBCT systems. The CBCT scans were evaluated by two observers, and the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of the two CBCT systems for detection of strip perforation were determined and compared using the Chi-square test.*
Results: *The sensitivity and specificity for detection of strip perforation were 51.3% and 46.3% for Acteon, and 55% and 38.8% for NewTom CBCT system, respectively. The difference between the two CBCT systems for detection of strip perforation was not significant (Chi-square test, P>0.05).*
Conclusions: *The accuracy of Acteon and NewTom CBCT systems for detection of strip perforation is low, and no significant difference was noted between the two systems in this respect.*

Scopo: *lo studio ha lo scopo di comparare la precisione diagnostica di due sistemi di tomografia computerizzata cone-beam (CBCT) per la rilevazione di stripping nella radice mesiale di molari mandibolari dopo il trattamento canalare.*
Metodologia: *canali mesio-buccali curvi di primi e secondi molari mandibolari erano strumentati durante il trattamento endodontico. I canali erano perforati usando frese Gates-Glidden #2 e #3 in direzione disto-assiale da 1 a 3 mm di distanza dalla forcazione. I canali erano otturati con gutta-percha e cemento AH26 con tecnica di condensazione laterale. I denti erano poi montati in mandibole essiccate di bovino ed erano sottoposte a CBCT usando i sistemi Acteon e NewTom CBCT. Le scansioni CBCT sono state valutate da due osservatori e la sensibilità, la specificità, il valore predittivo positivo (PPV), il valore predittivo negativo (NPV) e l'accuratezza dei due sistemi CBCT per il rilevamento dello stripping sono stati determinati e confrontati utilizzando il test Chi-quadrato.*
Risultati: *la sensibilità e la specificità per il rilevamento dello stripping sono state rispettivamente del 51,3% e 46,3% per Acteon e 55% e 38,8% per il sistema CBCT NewTom. La differenza tra i due sistemi CBCT per il rilevamento dello stripping non era significativa (test Chi-quadro, P>0,05).*
Conclusioni: *l'accuratezza dei sistemi Acteon e NewTom CBCT per il rilevamento dello stripping è bassa e non sono state rilevate differenze significative tra i due sistemi.*

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Peer review under responsibility of Società Italiana di Endodonzia
10.32067/GIE.2020.34.01.01

Introduction

Root perforation is defined as a pathological and/or mechanical communication between the root canal system and the tooth supporting structures (1). Root perforation occurs in 2% to 12% of the endodontically-treated teeth (2) and is responsible for 10% of the endodontic treatment failures. It can compromise the peri-radicular tissue health and root integrity (1, 3).

Strip perforation is longitudinal perforation of the root that commonly occurs in the danger zone of the mesial root of mandibular molars due to over-instrumentation of this region (4). Several tools and techniques such as endoscopes (5), microscopes (6), electronic apex locators (7) and optical coherence tomography scan (8) have been recommended for detection of root perforation. However, none of the abovementioned diagnostic modalities can detect perforations in obturated roots because these modalities are mainly based on visualization of the empty root canal or penetration into it (9).

Cone-beam computed tomography (CBCT) is a valuable diagnostic tool for detection of periapical lesions and evaluation of their healing course (10], vertical root fractures (11), internal and external root canal anatomy (12) and root resorption defects (13). Also, evidence shows that the sensitivity of CBCT is significantly higher than that of periapical radiography for detection of strip perforation; however, the risk of misdiagnosis of strip perforation is still high in both modalities (9).

The patient radiation dose of CBCT is generally higher than that of conventional periapical radiography (14) and it may be used along with periapical radiography in presence/absence of root filling materials for detection of endodontic complications such as strip perforation (15, 16). However, no previous study is available comparing two CBCT systems. Thus, this study aimed to assess the diagnostic accuracy of two different CBCT systems for detection of strip perforation in the mesial root of mandibular molars ex vivo.

Material and Methods

This ex vivo study evaluated (77) mandibular first and second molars and was approved by the ethics committee of Zahedan University of Medical Sciences (IR.ZAUMS.REC.1397.70).

The teeth were immersed in 5.25% sodium hypochlorite (chloraxid PPH CERKAMED Wojciech Powlowski, Poland) for disinfection and were then stored in distilled water.

All teeth were inspected under an endodontic surgery microscope and those with cracks, fracture or external resorption were excluded. Next, all teeth underwent digital periapical radiography to measure the canal curvature and ensure absence of canal calcification and internal resorption.

Access cavity was prepared and the coronal pulp tissue was removed. Canal patency was ensured using a #15 K-file (Mani Inc., Utsunomiya, Japan), and the working length was determined by introducing the file into the canal and observing its tip at the apical foramen; 1 mm was subtracted from this length to determine the working length.

The root canals were instrumented using #15 to #35 K-files (Mani Inc., Utsunomiya, Japan) with the step-back technique. The canals were repeatedly rinsed with 2% sodium hypochlorite (chloraxid PPH CERKAMED Wojciech Powlowski, Poland) with a 27-gauge needle.

After completion of instrumentation, each canal was rinsed with 2 mL of distilled water and the teeth were stored in distilled water until the next step.

Root perforation

To induce root perforation, danger zone dentin of the mesiobuccal canal was thinned using #2 and #3 Gates-Glidden drills (Dentsply Maillefer, Switzerland) in distoaxial direction at 1 to 3 mm from the furcation level until strip perforation occurred. The perforation was ensured by inserting a #20 K-file (Mani Inc., Utsunomiya, Japan) into the perforation with no resistance felt. Next, the corono-apical diameter of the per-

foration was measured by a digital caliper with ±0.001-inch accuracy per 6 inches (Mitutoyo Corp., Tokyo, Japan).

Canal obturation

The canals were dried with #30 and #35 paper points (Aridanet, Tehran, Iran). AH26 sealer (Dentsply Maillefer, Ballaigues, Switzerland) was mixed according to the manufacturer's instructions and delivered into the canal using a Lentulo spiral operating at 400 rpm for 5 seconds. Next, a #30 gutta-percha (Gapadent, Tianjin, China) with 0.02 taper was dipped in sealer and reached to the working length. The rest of the canal was filled with #20 and #25 accessory gutta-percha points using #25 and #30 spreaders (Mani Inc., Utsunomiya, Japan) with lateral compaction technique. The roots were stored at 37 °C and 100% humidity for 2 weeks and they were then mounted in extraction sockets in a dry bovine mandible. Three layers of dental wax were applied on the bone surface to simulate the soft tissue and fix the teeth in the extraction sockets.

CBCT

Dry mandible was positioned such that it simulated the position of patients during CBCT in the clinical setting. The CBCT scans were obtained with Acteon CBCT system (Acteon Group, Norwich, United Kingdom) with the exposure settings of 85 kVp, 8 mA, 80×80 field of view, 0.2 mm voxel size and 10 s of exposure time, and NewTom Giano extraoral imaging system (Vila Silverstrini, Verona, Italy) with 90 kVp, 0.6 mA, 80x50 mm field of view, 0.2 mm voxel size and 10 s of exposure time. In this setting, minimum scatter radiation was observed.

Any discontinuation in the external surface of the root at the site of furcation was considered as strip perforation. Two observers independently observed the images in a random fashion and reported their diagnosis as "presence of perforation", "absence of perforation" or "possibility of perforation" (suspected cases when perforation could not be clearly detected).

The two observers discussed the cases with the possibility of perforation until a consensus was reached.

Statistical analysis

Two calibrated observers observed the images independently.

The diagnosis of strip perforation was made by not observing the tooth structure at the interface of furcation and root canal filling (figure 1).

The overall agreement between the two observers was calculated using the Cohen's kappa. Values >0.70 indicated excellent agreement, and values <0.70 indicated poor agreement.

The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of the two CBCT systems were calculated.

Table 1

Sensitivity, specificity, positive predictive value, negative predictive value and accuracy of the two CBCT systems

First observer	Second observer	Total				
	ACTEON	NewTom	ACTEON	NewTom	ACTEON	NewTom
Sensitivity	55	62.5	47.5	47.5	51.3	55
Specificity	42.5	32.5	50	45	46.3	38.8
PPV	44	48	51	46	47.5	47
NPV	44	46	51	46	47.5	46
Accuracy	48	47	48	46	48	46.5

PPV: Positive predictive value; NPV: Negative predictive value

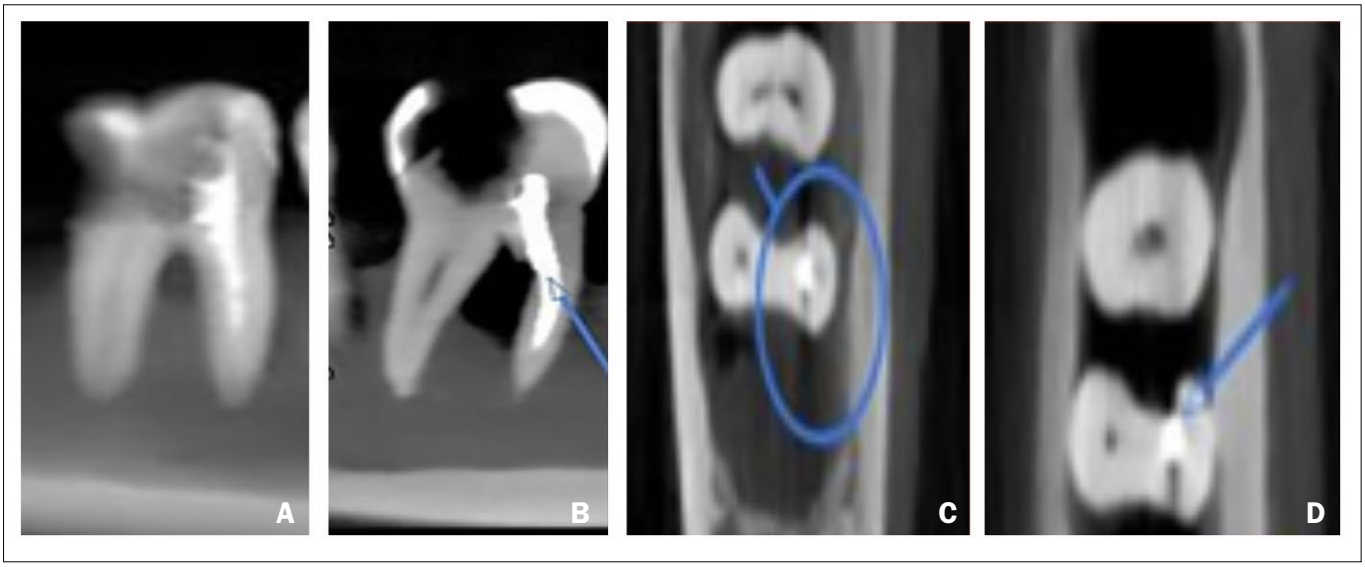

Figure 1
(A) Sagittal section of a tooth without perforation **(B)** sagittal section of a tooth with mesiobuccal canal perforation (arrow) **(C)** axial section without perforation (circle) and **(D)** axial section with perforation (arrow).

The two systems were compared using the Chi-square test. Data were analyzed using SPSS version 20 (SPSS Inc., IL, USA) with 95% confidence interval.

Results

Table 1 shows the sensitivity, specificity, PPV, NPV and accuracy of CBCT scans for detection of strip perforation of the root. No significant difference was noted by the first (P=0.161) or the second (P=0.436) observer in detection of strip perforation between the two CBCT systems.
In all observations, CBCT scans taken by the Acteon system overall detected 53% (81/154) of strip perforations while the NewTom system detected 58.4% (90/154) of strip perforations with no significant difference between the two systems (P=0.285). Also, considering the accuracy values <50%, none of the two systems had optimally high accuracy for detection of strip perforation. The overall inter-observer agreement was high for both Acteon (k=0.86) and NewTom (k=0.79) CBCT systems.

Discussion

Root perforations in the cervical third of the root and pulp chamber floor have a poorer prognosis than the perforations in the middle third and apical third of the root.
On the other hand, literature is poor regarding the accuracy of different CBCT systems for detection of strip perforations. Thus, this study aimed to assess the sensitivity, specificity, PPV, NPV and accuracy of two CBCT systems for detection of strip perforation in the mesial root of mandibular molar teeth. Although periapical radiography greatly helps in detection of procedural errors, this 2D modality has limitations due to geometric distortion and provides limited data regarding the size, extension and location of defects (3). Inaccuracy of periapical radiography for detection of root perforation has been previously discussed (3).
Limitation of periapical radiography in detection of root perforations may be related to the location of perforation as well, since the perforation may be masked if it is located in the root surface concavity.
Thus, several imaging modalities have been suggested for enhanced detection of root perforations. CBCT has been specifically designed to provide undistorted 3D images of the maxillofacial region, the teeth and their surrounding structures (17).
Thus, CBCT was used in the present study. The results showed no significant

difference in diagnostic accuracy of the two CBCT systems for detection of strip perforation in root canals filled with gutta-percha and AH26 sealer with lateral compaction technique. The reason may be no penetration of root filling materials into the perforation site in lateral compaction technique. However, in soft gutta-percha technique, gutta-percha penetrates into the perforation site and enhances the detection of perforated region (9). Evidence shows that the lateral compaction technique has lower efficacy in providing lateral seal in the canals compared with the warm gutta-percha technique (18).

On the other hand, evidence shows that presence of root canal filling material decreases the efficacy of CBCT scans for detection of vertical root fractures (11). Radiopaque materials such as gutta-percha and AH26 sealer create streak artifacts on CBCT slices and mimic the fracture lines (19, 20). These artifacts can complicate the detection of perforations and prevent definite diagnosis of strip perforation.

A previous study showed significantly higher sensitivity, specificity and accuracy of CBCT in detection of strip perforations in empty canals. In the obturated root canals, the sensitivity of CBCT was significantly lower than that of periapical radiography (21). Although our study did not compare CBCT with periapical radiography, the results showed that the sensitivity, specificity and accuracy of both CBCT systems for detection of strip perforation were low, which was probably due to the presence of root filling materials in the canal.

Not eliminating the smear layer and dentinal debris during root canal preparation and also after perforation in this study might have resulted in penetration of dentinal debris and smear layer into the perforation site, and subsequent prevention of the entry of root filling material into the perforated region.

This would decrease the visibility of perforation site, which can consequently decrease the sensitivity of both CBCT systems for detection of strip perforation. Moreover, strip perforations were artificially created by the use of Gates-Glidden drills in the mesiolingual canal of molar teeth in our study; thus, the results cannot be generalized to the clinical setting since strip perforations that occur in the clinical setting may be of different sizes (9). Evidence shows that CBCT, irrespective of the presence of root filling materials, can detect medium-size and large perforations significantly better than smaller perforations. Low sensitivity, specificity and accuracy of the two CBCT systems in detection of strip perforations in the mesiobuccal canals of mandibular molar teeth in our study may be due to the small size of perforation.

Conclusions

The results of this ex vivo study revealed no significant difference in sensitivity, specificity, PPV, and NPV of Acteon and NewTom CBCT systems for detection of strip perforation in the mesiobuccal canal of obturated mandibular molars, and the accuracy of both systems was found to be low for detection of strip perforations.

Clinical Relevance

The results of this study showed that cone beam computed tomography (CBCT) is not a suitable tool for detection of strip perforation of endodontically treated mesial root of mandibular molars.

Conflict of Interest

The authors deny any conflict of interest related to this study.

Acknowledgement

The authors would like to thank the Research Deputy of Zahedan University of Medical Sciences for financially supporting this project. The authors have no conflict of interests to declare.

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Available online at www.giornaleitalianoendodonzia.it

ORIGINAL ARTICLE/**ARTICOLO ORIGINALE**

Comparison of Reciproc, Wave One, Protaper, and One Shape rotary instruments in reduction of bacterial load in root canals

KEYWORDS
Endodontics, Bacteria, Root canal therapy

PAROLE CHIAVE
Endodonzia, Batteri, Terapia canalare

Confronto della capacità di riduzione della carica batterica in canali radicolari degli strumenti Reciproc, Wave One, Protaper e One Shape

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Received 2020, November 4

Accepted 2020, February 27

Abstract

Aim: *To compare the effectiveness of Reciproc, Wave One, Protaper, and One Shape rotary instruments in reduction of E. faecalis in root canals.*
Methodology: *In this in-vitro study, after initial stages of canal enlargement and irrigation, a suspension containing Entrococcus faecalis was inoculated into the root canals of 84 extracted single-canal premolars. The samples (apart from two positive and two negative controls) were randomly assigned into four groups according to rotary instruments used: Reciproc, Wave One, One Shape, Protaper. Each group was then subdivided to two groups based on irrigating solutions of normal saline and NaOCl. After instrumentation, the root canals were filled with brain-heart infusion (BHI) broth. Finally bacterial colony forming units (CFU) were counted.*
Results: *Reduction in number of bacterial colonies before and after instrumentation and irrigation was not significantly different in different rotary instrument systems (P=0.128, F=1.955). However, NaOCl was more effective in reduction of bacterial load compared to normal saline (P<0.001, F=15.528).*
Conclusions: *All rotary instruments used in the study are effective in reduction of the bacterial load.*

Obiettivo: *confrontare la capacità di riduzione dell'E. Faecalis in canali radicolari degli strumenti Reciproc, Wave One, Protaper e One Shape.*
Materiali e Metodi: *in questo studio in vitro, dopo una fase iniziale di allargamento e irrigazione dei canali, 84 premolari estratti con singolo canale sono stati inoculati con una sospensione di Enterococcus Faecalis. I campioni (oltre a due controlli positivi e due controlli negativi) sono stati assegnati a quattro gruppi a seconda dello strumento utilizzato: Reciproc, Wave One, One Shape, Protaper. Ogni gruppo è stato a sua volta suddiviso in due gruppi a seconda che si utilizzasse come irrigante soluzione Salina o NaOCl. Dopo la strumentazione i canali radicolari sono stati riempiti di brain heart infusion (BHI). Successivamente sono state calcolate le unità formanti colonie (CFU).*
Risultati: *la riduzione nel numero di colonie batteriche prima e dopo strumentazione e irrigazione non è risultata statisticamente significativa fra i diversi sistemi di strumenti utilizzati (P=0.128, F=1.955). Comunque l'NaOCl è risultato più efficace nella riduzione della carica batterica confrontandolo con la soluzione salina (P<0.001, F=15.528).*
Conclusioni: *tutti gli strumenti utilizzati nello studio sono efficaci nella riduzione della carica batterica.*

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Peer review under responsibility of Società Italiana di Endodonzia
10.32067/GIE.2020.34.01.10

Introduction

It is known that bacteria and their byproducts are the main etiologic factors in pulpal and periapical disease (1). Bacterial biofilms have been found in most teeth with apical periodontitis (2). The primary goal in endodontic treatment is elimination of bacteria from the root canal system by mechanical and chemical means (3). Also persistent infection is the main reason of failures of endodontic treatment (4). *Enterococci* are facultative anaerobic bacteria. *Enterococcus faecalis* is the most common bacteria isolated from endodontically treated teeth (5). This microorganism can penetrate the dentinal tubules and resist mechanical and chemical debridement and intracanal medicaments thus causing reinfection of the root canals (6).
Various techniques are suggested for debridement of root canal system. Mechanical instrumentation removes the infected dentin from root canal walls. Irrigants solve the organic debris in the canal and remove the microorganisms. However, regardless of technique and material complete disinfection of root canal system is not possible (7, 8). In modern endodontics, engine-driven instrumentation by rotary Nickel-Titanium (NiTi) files has been recruited increasingly for preparation of root canals as it reduces procedural error, preparation time, and operator fatigue compared to manual instrumentation (9, 10). Reciproc (RC, VDW, Munich, Germany) and Wave One (WO, Dentsply Maillefer, Ballaigues, Switzerland) files are made of a special NiTi alloy called M-wire created by an innovative thermal treatment process (11). This alloy provides increased flexibility of the instruments and improved resistance to cyclic fatigue (12). Moreover, the reciprocating motion in these two systems which necessitates the use of special motors, leads to less stress accumulation in the file and makes the instrument less susceptible to separation (13). Universal Protaper (PT, Dentsply Maillefer, Ballaigues, Switzerland) rotary system has a modified cross-sectional design similar to that of K-file. This design allows the instrument to cut the dentin more electively and thus reduces torsional loads (14). One Shape (OS, Micro-Mega, Besancon, France) is another rotary instrumentation system with a non-working safety tip that ensures effective apical progression avoiding obstructions which can lead to instrument separation (15).
Based on our knowledge, no previous study has compared the effectiveness of the aforementioned rotary systems in reduction of bacterial load from root canals. Therefore, the aim of the present study was to compare the effectiveness of RC, WO, PT, and OS rotary instruments in reduction of *E. faecalis* in root canals.

Materials and Methods

84 extracted single canal premolars with complete apices which were extracted for orthodontic reasons were selected. Radiography was used to confirm that only one root canal exists. The crown of the teeth is cut to achieve a root length of 15 mm. The point of termination of root canal preparation was the apical foramen. After debridement, the root canals were filled with EDTA 17% solution for 1 min and then irrigated by sodium hypochlorite (NaOCl) 1% and sterile water to remove the smear layer. Then the apical end of the teeth was sealed with composite resin and the outer surface of the roots was covered with epoxy resin in order to prevent from bacterial leakage. The teeth were then individually mounted on gypsum blocks for better handling during instrumentation. Thereafter, they were packed and sterilized in an autoclave (121 ˚C, 30 min, 15 psi). Two of the teeth were not sterilized as negative controls. Bacterium used in this study was *Entrococcus faecalis* (ATCC29212). The bacterium was cultured on brain-heart infusion (BHI) medium reaching the 1.5x108 colonies and a bacterial suspension was prepared. Eppendorf tubes containing sterile teeth were placed under laminar flow hood and inoculated by the bacterial suspension using a sterile pipet. Fresh BHI medium was added to the sam-

Table 1

Logarithm of number of bacterial colonies before and after instrumentation and irrigation

		Before		After	
File	**Irrigant**	**Mean**	**SD**	**Mean**	**SD**
Reciproc	NaOCl	1320	469.61	158	50.29
	Saline	1624	391.90	546	192.54
Wave One	NaOCl	1338	409.82	164	69.15
	Saline	1366	478.80	679	229.45
Protaper	NaOCl	1375	589.85	271	138.33
	Saline	1228	930.62	207	110.76
One Shape	NaOCl	1214	392.68	328	135.71
	Saline	1094	416.14	164	89.73
Total	**NaOCl**	**1311**	**457.39**	**230**	**125.29**
	Saline	**1328**	**606.31**	**399**	**273.18**

ples every 1 week and the samples were incubated for four weeks in 37 °C. After the incubation period, the teeth were removed from the tube under laminar flow hood and mounted back on their gypsum blocks. A K-file no.15 was then inserted into the canal and the canal was filed for 10 s. Two teeth were not instrumented as positive controls. The samples from root canals were collected by placement of three paper point no. 20 each placed into the canal for 10 s. then the paper points were transmitted to tubes containing 5 µl BHI medium and vortexed for 30 min for serial dilution. Each dilution was then placed on BHI agar plates and incubated for 48 h in 37 °C. Then the colony forming units (CFU) were counted.

The samples were randomly assigned into four groups each instrumented with a different rotary system; RC, WO, OS, PT each containing 20 teeth. Each group was then subdivided to 2 groups based on irrigating solutions of normal saline and NaOCl 5.25%. The total volume of irrigant was 18 ml. Roots canals were irrigated with 2 ml of irrigating solution each time the instrument was changed with the use of needles attached to 5-ml luer lock syringes. Final rinse was performed by 10 ml of the irrigating solution. Instrumentation was performed using four rotary system based on company instructions:

1. RC: R25 file (tip size 25, 0.08 taper) was gently inserted into the cervical third of the root canal with in-and-out pecking motion. After three movements, the file was removed from the canal to clean the flutes. Then, the file was re-inserted in the same manner for the middle third. Lastly, the file was inserted at WL with a brushing motion against the canal walls.
2. WO: Primary file size 25, 0.08 taper was inserted into approximately two-thirds of the canal length with in-and-out pecking motion. After retrieval of the file, it was inserted again at WL with the same motion.
3. OS: Instrumentation was performed with a slight pecking motion until the WL has been achieved.
4. PT: Preparation was done by crown-down technique using the sequence of SX (at two-thirds of WL), S1 and S2 (at 1 mm short of the WL), and F1 and F2 (at WL) instruments. The files were passively used with in-and-out movements and also lateral brushing motion.

After instrumentation, the root canals were filled with BHI broth. *E. faecalis* can stay in the dentinal tubules and the samples should be filled with BHI broth and recollected after 60 days. Data was statistically analyzed by Statistical Package for the Social Sciences (SPSS, v 22, IBM, NY, USA) using descriptive statistics, Shapiro-Wilk analysis, and two-way analysis of variance. Level of significance was set at α=0.05.

Results

Shapiro-Wilk analysis confirmed the normal distribution of the data (P>0.1). Table 1 depicts the descriptive statistics of number of bacterial colonies before and after instrumentation and irrigation. Based on two-way analysis of variance the number of bacterial colonies before instrumentation and irrigation was not significantly different in the groups with different instruments (P=0.316) and irrigants (P=0.893). Reduction in number of bacterial colonies before and after instrumentation and irrigation was not significantly different in different rotary instrument systems (P=0.128, F=1.955). However, a statistically significant difference was observed in reduction of bacterial colonies between samples irrigated with normal saline and NaOCl (P<0.001, F=15.528) with NaOCl being more effective in reduction of bacterial load. Moreover, the amount of reduction in bacterial load using different irrigants was dependent on instrument type (P<0.001, F=18.551). In RC, PT, and WO systems NaOCl was more effective in reduction of bacteria than normal saline. While, in OS system normal saline showed higher reduction of bacteria compared to NaOCl, although not significant.

Discussion

According to the results of the present study, reduction of bacterial load was not significantly different in root canals treated with different rotary systems. However, use of NaOCl was significantly more effective in reduction of *E. faecalis* than normal saline.

In this study *E. faecalis* was used to evaluate and compare the effectiveness of four rotary systems and two irrigants in reduction of bacteria as a measure of canal disinfection. *E. faecalis* is present in persistent endodontic infections and is resistant to various protocols of root canal preparation and intracanal medicaments (16, 17). Moreover, it can survive in difficult environmental conditions (18). *E. faecalis* can also reside in infected root canals without the synergistic support of other bacteria in contrast to most other endodontic bacteria (19).
Machado et al reported that no statistically significant difference was found between PT and Mtwo rotary instruments in removal of *E. faecalis* from root canals (9).
Moreover, Martinho et al in their study concluded that WO, RC, PT, and Mtwo rotary endodontic systems are equally effective in reduction of endotoxins and cultivable bacteria from primarily infected root canals, although they were not able to eliminate them from all tested root canals (20).
Similar results were also observed by Machado et al in another study (21). These findings are consistent with the results of the present study as examined endodontic systems had similar effectiveness in reduction of *E. faecalis* from root canals.
However, Burklein et al reported that RC and Mtwo rotary systems are more effective in cleaning of the apical region compared to WO and PT (11). As their result was not observed in other similar studies, further evaluation might be needed to elucidate any possible difference between various rotary systems.
Different designs of rotary systems may alter the efficiency of these files in bacterial reduction. More aggressive removal of dentin would eliminate more bacteria from the root canals (22). Also, the size of apical enlargement is important in the amount of reduction of intracanal bacteria (23).
Practitioners must consider that regardless of the endodontic system used for cleaning and shaping of root canals, dentinal walls must be removed and proper apical preparation must be performed to ensure maximal reduction of bacteria from the root canals.
Siqueira et al stated that although both ro-

tary and hand instrumentation techniques were significantly effective in reduction of bacterial population, however, in all cases NaOCl was more effective in elimination of bacterial load from root canals compared to normal saline (24).

This finding is also similar to the results of the present study. Studies suggest that the antimicrobial effect of NaOCl is not significantly different in 0.5% to 5% solutions (25-27).

The frequency and the volume of NaOCl can compensate the differences in solution concentration. However, complete elimination of bacteria may not be possible regardless of concentration, frequency, and volume of irrigants (24).

Although reduction of bacterial load is reported in many studies following the use of hand or rotary instruments, complete elimination of bacteria such as E. faecalis is not possible (28). Therefore, adequate use of irrigants is important when cleaning and shaping is done by any method.

Conclusions

Under the conditions of this study reduction of bacterial load was not significantly different in root canals treated with different rotary systems. However, use of NaOCl was significantly more effective in reduction of *E. faecalis* than normal saline.

Clinical Relevance

Elimination of bacteria from the root canal system is the primary goal of endodontic treatment. Although Reciproc, Wave One, Protaper, and One Shape rotary files used in this study were not significantly different for this purpose, NaOCl was more effective in bacterial reduction compared to normal saline.

Conflict of Interest

The authors deny any conflict of interest.

Acknowledgements

This study was financially supported by Kermanshah University of Medical Sciences (grant number 95560). This study was performed as a partial requirement for obtaining DDS degree for the first author (Ali Azizi) in Kermanshah University of Medical Sciences.

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ORIGINAL ARTICLE/**ARTICOLO ORIGINALE**

Effect of composite thickness over the fiber post on fracture resistance of endodontically treated teeth

Influenza dello spessore del composito sul perno in fibra sulla resistenza alla frattura di denti trattati endodonticamente

KEYWORDS
Composite Resin, Conservative Dentistry, Endodontically Treated Teeth, Fiber Post, Fracture Resistance, Restorative Dentistry

PAROLE CHIAVE
Composito, Odontoiatria conservativa, Denti trattati endodonticamente, Perno in fibra, Resistenza alla frattura, Odontoiatria restaurativa

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Received 2019, November 1

Accepted 2020, February 10

Abstract

Aim: *This study aimed to assess the effect of composite thickness over the fiber post on fracture resistance of endodontically treated teeth.*
Materials and Methods: *This in vitro experimental study was performed on 50 sound human premolars, which were randomly divided into 5 groups (n=10). Teeth in Group 1 remained intact while other specimens underwent root canal treatment with a Mesio-occluso-distal (MOD) cavity preparation, restored with fiber posts with a distance of 1.5 mm to the occlusal surface in groups 2 and 4 and 0.5 mm in groups 3 and 5.24 hours of incubation was applied for groups 1-3 and 1 year of incubation for groups 4 and 5. Thereafter fracture strength measured using a Universal Testing Machine at a crosshead speed of 1 mm/minute. Data were analyzed using Shapiro-Wilk, Two-Way ANOVA and Tukey HSD.*
Results: *The results showed a significant difference in terms of fracture resistance (P<0.05). The difference in fracture resistance between Group 1 and other groups was not statistically significant at 24h (P>0.05). Also, Tukey HSD revealed no statistically significant differences between Group 1 and 4 at one year. However, Group 1 (1255.25±280.61N) exhibited significantly higher fracture resistance than that of Group 5 (855.72±300.20N) at one year (P=0.027). The difference between other groups was not significant at any time point (P>0.05).*
Conclusions: *By covering the fiber post with 1.5 mm thickness of composite resin and cuspal reduction of 2 mm, the fracture resistance of endodontically treated teeth can be increased to the level of sound teeth.*

Obiettivo: *lo scopo di questo studio è di valutare l'influenza dello spessore del composito, posizionato sopra il perno in fibra, sulla resistenza alla frattura dei denti trattati endodonticamente.*
Materiali e Metodi: *questo studio in vitro è stato effettuato utilizzando 50 premolari umani che sono stati suddivisi in 5 gruppi (n=10). I denti del Gruppo 1 non sono stati trattati mentre negli altri campioni è stata preparata una cavità mesio-occluso-distale (MOD) ed è stata effettuata una terapia canalare. I campioni sono stati poi ricostruiti tramite posizionamento di perni in fibra, posti ad una distanza dalla superficie occlusale di 1.5 mm (Gruppo 2 e 4) e di 0.5 mm (Gruppo 3 e 5). I denti dei Gruppi 1, 2 e 3 sono stati incubati per 24 ore, quelli dei Gruppi 4 e 5 per un anno. Successivamente, utilizzando una Universal Testing Machine ad una velocità di 1 mm/min, è stata valutata la resistenza alla frattura dei campioni. I dati sono stati analizzati con i test statistici Shapiro-Wilk, Two-Way ANOVA e Tukey HSD.*
Risultati: *i risultati hanno mostrato una differenza significativa nella resistenza alla frattura (p<0.05). La resistenza alla frattura tra il Gruppo 1 e gli altri gruppi non è risultata statisticamente significativa a 24 ore (p>0.05). L'utilizzo del Tukey HSD non ha mostrato una differenza statisticamente significativa tra il Gruppo 1 e il Gruppo 4 a un anno di distanza. Il Gruppo 1 (1255.25±280.61N) ha mostrato una resistenza alla frattura statisticamente più alta del Gruppo 5 a un anno di distanza (855.72±300.20N) (P=0.027). Non c'è stata differenza statisticamente significativa fra gli altri gruppi (P>0.05).*
Conclusioni: *la resistenza alla frattura di un dente trattato endodonticamente risulta la stessa di un dente integro, effettuando una riduzione cuspidale di 2 mm e coprendo il perno in fibra con 1.5 mm di composito.*

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Peer review under responsibility of Società Italiana di Endodonzia
10.32067/GIE.2020.34.01.11

Introduction

The main goal of dentistry is to preserve the teeth and minimize tooth loss as much as possible (1, 2). Many techniques have been suggested for restoration of severely damaged teeth after endodontic treatment. Evidence shows that the success of endodontic treatment not only depends on the successful completion of all procedural steps of endodontic treatment such as providing an apical seal and removing the necrotic tissue but also depends on the successful restoration of teeth (3). It should be noted that a root canal treatment should not be considered complete until the tooth crown is well restored (4).

Endodontically treated teeth are susceptible to fracture and researchers have long been in search of restorative materials and technique to reinforce the remaining tooth structure.

Considering the recent advances in formulations of composite resins and their affordability, direct composite restorations are suitable for endodontically treated teeth. Panahandeh et al (5) evaluated the effect of composite thickness on stress distribution in a restored endodontically treated premolar with cusp reduction. The results demonstrated that more stress is observed in the tooth without cusp reduction compared to the other models, and cusp reduction resulted in more suitable stress distribution.

Considering the poor retention of restorative materials in endodontically treated teeth that have lost a great portion of their coronal structure, intra-radicular posts are often used in such cases to provide retention for the coronal restoration (6). Fiber posts are increasingly used in dental clinical settings due to their higher flexibility compared to metal posts and having a modulus of elasticity close to that of dentin. They allow relatively uniform stress distribution and decrease the incidence of Catastrophic tooth fracture (7). Torabzadeh et al (8) evaluated the efficacy of using fiber in direct composite restorations and showed that cusp coverage of 1.5 and 2.5 mm in MOD access cavities with or without insertion of resin impregnated fiber had similar fracture rates in the endodontically treated teeth. Further evidence confirmed that cuspal coverage in directly bonded restorations enhanced the fracture resistance of teeth and protected the cusps against fracture (9).

In this regard, the thickness of the core material can significantly affect the fracture resistance of endodontically treated teeth with intra-radicular posts (10). Composite resins are commonly used for reconstruction of the core in endodontically treated teeth and the thickness of composite covering the post can significantly affect load distribution and fracture resistance of teeth (11, 12). However, data are scarce regarding the effect of the composite thickness over fiber posts on fracture resistance of teeth. Therefore, this study was undertaken to assess the effect of composite thickness (0.5 and 1.5 mm) over the fiber post on the fracture resistance of endodontically treated teeth after 24 hours and one year.

Materials and Methods

This in vitro study was performed on 50 sound single-canal human premolars extracted for orthodontic or periodontal reasons during the past six months. The soft tissue residues and calculus were removed from the coronal and radicular surfaces of the teeth using a hand scaler (Gracy Curette SG 17/18; Hu Friedy; Chicago, IL, USA). The teeth were inspected under a stereomicroscope (SZ61; Olympus, Tokyo, Japan) at x10 magnification to ensure the absence of cracks and caries. The teeth were anatomically examined to ensure that they all had normal anatomy and had no anomaly. The teeth were stored in distilled water in a screw-top container at 4 °C until the preparation. The water was refreshed weekly.

Tooth preparation

Figure 1
Silicone impression as an index for the restoration of the crown.

The buccal and lingual height from the cusp tip to the cementoenamel junction (CEJ) and the buccolingual width of teeth at the height of contour were measured by a digital caliper (Mitutoyo, Tokyo, Japan) to select teeth with relatively equal dimensions (for the purpose of standardization of samples). The size of the tooth was calculated by dividing tooth height by tooth width. The teeth (n=50) were randomly divided into 5 Groups of 10. Impressions were made of teeth in Groups 2 to 5 using putty silicone impression material (Speedex putty type I; Coltene, Altstätten, Switzerland) (8).
After polymerization of impression material, it was sectioned occlusoapically by a scalpel to obtain two half-impressions to serve as molds. The teeth were then removed from the impressions. These impressions were used as an index for the restoration of the crown (figure 1).
Teeth in Group 1 remained intact. In Groups 2 to 5, the access cavity was prepared in teeth using diamond fissure burs. A #15 K-file (Mani Inc., Tochigi, Japan). The root canals were cleaned, filed and flared to file #60 using the step-back technique. Saline was used for irrigation. The master file was #35, and the root canals were filled using lateral compaction technique. A #25 spreader, #15 lateral gutta-percha cones and #35 gutta-percha master cone (Aridanet, Tehran, Iran) along with AH26 sealer (Dentsply/DeTrey, Konstanz, Germany) were used for this purpose.
At this stage for post space preparation, gutta-percha in the canal was removed to 5 mm above the apex using #1 and #2 Gates-Glidden drills (Gates Glidden; Dentsply Maillefer, York, PA) and #1 and #2 peeso reamers(Peeso Burs; Dentsply Maillefer, York, PA).
The mesio-occluso-distal (MOD) cavities were then prepared and cusp reduction was performed for teeth in Groups 2-5. The width of MOD cavity at the isthmus was two-thirds of the distance between the two cusp tips. The buccal and lingual walls of the cavity were parallel and the distance from the mesial and distal box floor to the cementoenamel junction was 1 mm.
After cavity preparation, a few reference grooves were created with 2 mm depth on the cusps using a fissure bur with a 1.5 mm diameter and a digital caliper (Mitutoyo, Tokyo, Japan). Using these reference grooves, buccal and palatal/lingual cusp reduction was performed.

Restorative procedures and FRC post placement
Size 1 Reforpost Glass Fiber RX posts

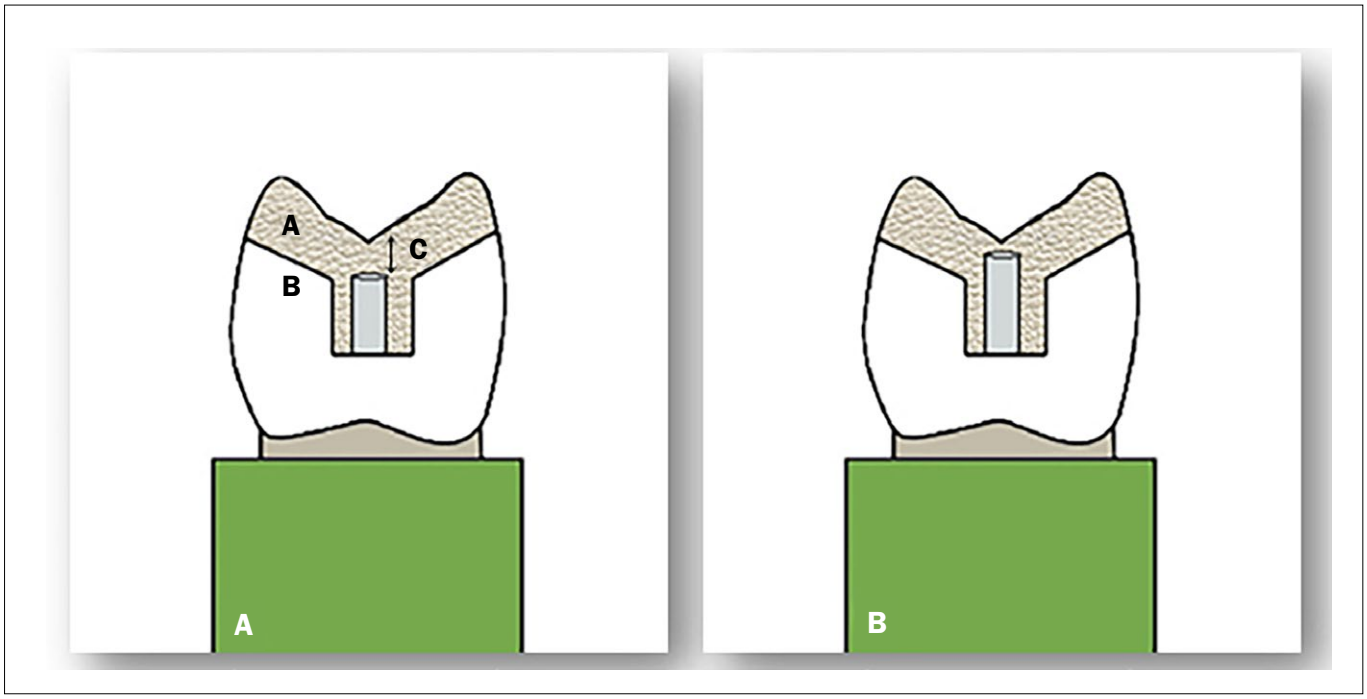

Figure 2
An overview of the relation between the posts to the occlusal surface. **(A)** Composite Build-up Restoration, (**B)** Reducted Cusps, (**C)** Distance between post tip and occlusal surface (a: 1.5 millimeters, b: 0.5 millimeters).

(RfX fiber; Ângelus, Londrina, PR, Brazil) were then used. After cavity and post space preparation, the canal and tooth crown were thoroughly rinsed and the fiber post was inserted into the canal. Next, one half of the previously made silicon impression was placed on the respective tooth. Using a digital caliper, in Groups 2 and 4 the post was marked at 1.5 mm and in Groups 3 and 5, 0.5 mm far from the occlusal surface of the tooth, respectively. Using a high-speed hand-piece, the posts were shortened to the marked points (figure 2). Using the other half of silicon impression and a digital caliper, distance of post from the occlusal surface was checked again and then it was removed from the canal. For the cementation of posts, Panavia F2 resin cement (Kuraray-PAN) was used according to the manufacturer's instructions.

The post was soaked in the cement and introduced into the canal. Light curing was performed using a quartz-tungsten-halogen light-curing unit with 705 mW/cm2 light intensity (SN.851553 Blue Point; AriaLuxe, Tehran, Iran) for 2 seconds. Excess cement was removed and light-curing was continued for another 40 seconds.

After cementation of posts, the teeth were built-up. For this purpose, the remaining tooth structure was etched with 35% phosphoric acid, rinsed and dried. Using a micro-brush, Single Bond (3M ESPE, St. Paul, MN, USA) was applied on etched surfaces, thinned with air spray for 10 seconds from 10 cm distance and light-cured for 20 seconds. Filtek Z250 (shade A2, 3M ESPE, St. Paul, MN, USA) composite was incrementally applied into the cavity using the layering technique until the tooth was completely restored. Each increment had 1 mm thickness and light-cured for 20 seconds. The final increment of composite was applied to the previously made silicon mold and the tooth was then placed in the mold. After removing the excess composite, final curing was performed for 40 seconds.

Compressive test

All teeth were then mounted in acrylic resin to 2 mm below their CEJ (simulating the alveolar crest). The teeth were immersed in distilled water and incubated at 37 °C for 24 hours and 1 year. Next, they were transferred to a universal testing machine (Zwick Roell, Ulm, Germany) and subjected to compressive

stress. The load was gradually increased with a crosshead speed of 1 mm/minute until fracture occurred. The maximum load at fracture was recorded in Newtons (N) and indicated the fracture resistance of tooth.
After the fracture, all samples were evaluated by the naked eye and divided into two groups in terms of the location of the fracture line above or below the CEJ. The percentage of each mode of failure was calculated.
Data were statistically analyzed using SPSS version 22 (SPSS Inc., IL, USA). The mean and standard deviation (SD) of fracture resistance in each group were calculated. The Shapiro-Wilk test showed that the data were normally distributed, therefore, data analyzed by Two Way ANOVA and Tukey HSD test. Statistically significant was defined as $P<0.05$.

Results

Table 1 shows the mean and SD of fracture resistance in the five groups. The highest fracture resistance was noted in Group 1 and the lowest in Group 5. The Shapiro-Wilk test showed that the data were normally distributed in any of the five groups. The Two Way ANOVA test was applied to compare the groups and showed that the groups were significantly different in terms of fracture resistance ($P<0.05$) but no interaction between factors. Thus, the Tukey HSD test was applied for pairwise comparisons, which showed that only the difference between the Groups 1 (control) and 5 (0.5 mm thickness) was significant ($P=0.02$). The difference between other groups was not significant at any time point.
The fracture was evaluated with naked eye and the position of fracture was considered according to the CEJ position. The fracture mode of the specimens is shown in Table 1. Fisher's exact test showed no significant difference among groups in terms of the percentage of modes of failure ($P=0.84$).

Discussion

Since premolars are greatly weakened by the process of access cavity preparation and the prevalence of fracture is high in premolar teeth, reinforcement of these teeth is often necessary. Also, premolars often play a role in a beautiful smile and thus, should be necessarily restored with tooth-colored restorative materials (13). So we used this type of teeth for our research. The teeth were standardized in terms of dimensions because these dimensions dictate the size of the access cavity and according to St-Georges et al (14) cavity depth (which is dictated by the height and size of the crown) is the most critical parameter in tooth fracture. An increase by even 1 mm in depth of cavity significantly decreases the fracture resistance

Table 1

The mean and standard deviation of fracture resistance and mode of failure in the five groups (n=10)

Groups	Time	Composite thickness (mm)	Mean (N)±SD	Mode of failure%	
				Above CEJ	Under CEJ
1	24h	Intact Teeth	1255.25±280.61	80	20
2		1.5	1146.07±301.80	70	30
3		0.5	971.07±261.34	70	30

of teeth. Cavity width is also important. According to Roberson et al (15) if the isthmus width exceeds one-third of the distance between the cusp tips, cuspal coverage should be considered to reinforce the remaining tooth structure. Cuspal coverage is necessary when the cavity width is two-thirds of the distance between the cusp tips, especially in endodontically treated teeth. According to Linn and Messer (16) loss of the two marginal ridges can weaken the tooth structure by 60%; this negative impact is greater on premolars than molars.

Load distribution in tooth structure is an important factor affecting successful restoration of endodontically treated teeth, which depends on the type of post, core material and its thickness over the post (17, 18). The use of fiber posts is increasing due to their optimal esthetics, mechanical properties, and affordability (19).

Studies on the effect of restorative material thickness over the posts are limited. Tarun et al (17) evaluated the effect of the thickness of composite covering the titanium posts on load distribution in endodontically treated teeth. They showed that increasing the thickness decreased the stress applied to the apical third of the root. However, their study was conducted on titanium posts and their results cannot be generalized to fiber posts. In this study, no significant difference was noted in fracture resistance of Groups 1 and 2 but the difference between Groups 1 and 5 was significant. Z250 composite used in our study has a modulus of elasticity close to that of dentin (20). Also, the mechanical properties of Angelus fiber post used in our study are highly similar to those of dentin (21). This may explain relatively similar results obtained in most groups. The head of fiber posts cannot be exposed to the oral environment because of the water sorption of their resin component. Microscopic signs of post surface degradation due to water uptake and a loss of structure due to occlusal wear were seen (22). Thus, 0.5 mm composite was the smallest possible thickness of composite on the post. Differences between Groups 1 and 5 can also be due to the brittleness of composite in lower thicknesses (17). The mode of failure of teeth can affect their restoration or may necessitate tooth extraction.

In all groups in our study, 70% of fractures were above the CEJ, which shows that the thickness of composite over the fiber post does not affect the mode of fracture. In a similar study, Reid et al

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(23) found no significant difference in fracture resistance of teeth restored with quartz, carbon and titanium posts but the type of fracture in teeth restored with fiber post was more favorable. Furthermore, more favorable modes of failure have been reported in teeth restored with direct composite restoration and cuspal coverage. Torabzadeh et al (8) showed that teeth that received cuspal coverage with 2.5 mm thickness had more favorable modes of failure than those restored with 1.5 mm of cuspal coverage. Thus, it may be postulated that teeth restored with direct composite restoration, fiber post placement, and cuspal coverage have modes of failure similar to sound teeth. This study had an in vitro design. Thus, a generalization of results to the clinical setting must be done with caution.
Future studies with larger sample sizes and water storage of teeth are required to assess the behavior of these restorations in the long-term.

Conclusions

The fracture resistance of endodontically treated teeth restored with a fiber post and 1.5 mm thickness of composite over it along with 2 mm of cuspal coverage after 24h and one year is comparable to that of sound teeth. 0.5 mm thickness of composite over fiber post has a significant influence on the reduction of the flexural properties after one year.
It may be concluded that 0.5 mm of composite thickness overlying fiber post seems not to be a reliable choice but 1.5 mm thickness of composite resin covering fiber posts and cuspal reduction of 2 mm, can cause the fracture resistance of endodontically treated teeth to be increased to the level of sound teeth.

Clinical Relevance

The presented article shows that despite the fact that fiber posts have a comparable modulus of elasticity to dentine and composite, minimum coverage of 1.5 mm is necessary for direct restoration of composite resins.

Conflict of Interest

The authors declare that they have no conflict of interests.

Acknowledgments

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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ORIGINAL ARTICLE/**ARTICOLO ORIGINALE**

Use of dynamic navigation with an educational interest for finding of root canals

Uso della navigazione dinamica per un'apertura della camera pulpare minimamente invasiva

KEYWORDS
Cone Beam Computer Tomography, Dynamic Navigation, Endodontics training, Minimal Invasive Endodontic, Pulp Chamber

PAROLE CHIAVE
Tomografia computerizzata a fascio conico, Navigazione dinamica, Pratica endodontica (Endodontics training), Endodonzia minimamente invasiva, Camera pulpare

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Received 2019, November 11

Accepted 2020, January 28

Abstract

Aim: *The aim of this technical note was to evaluate the potential application of dynamic navigation in teaching undergraduate students the opening of the access cavity.*
Methodology: *Extracted human teeth were fixed into a prefabricated phantom model in place of the correspondent teeth and pre-operatively scanned with the marker plate containing the fiducial markers with a cone beam computed tomography, imported on the ImplaNav software (ImplaNav, BresMedical, Sydney, Australia) and obtaining a 3D reconstruction. Open access cavity was performed with a diamond bur in using real-time navigation. This procedure was aimed to directly identify the pulp horns and the root canal entrances with a unique hole for each canal.*
Results: *All access cavities were prepared according to a minimally invasive endodontics approach with the dynamically guided ImplaNav software. No perforations occurred and all the canals were successfully located.*
Conclusions: *Present results demonstrated a possible application of this technology for educational purposes in finding root canals. This protocol may have potentialities in teaching dental students to start their approach in endodontic field.*

Obiettivo: *lo scopo di questa nota tecnica è valutare la potenziale applicazione della navigazione dinamica per un rilevamento minimamente invasivo dei canali radicolari.*
Metodologia: *i denti estratti sono stati fissati in un modello prefabbricato al posto dei rispettivi denti in resina e scansionati pre-operativamente con il marker plate e i rispettivi marcatori, attraverso una tomografia computerizzata a fascio conico, importata sul software ImplaNav (ImplaNav, BresMedical, Sydney, Australia) al fine di ottenere una ricostruzione 3D. La cavità di accesso è stata eseguita con una fresa diamantata utilizzando la navigazione dinamica in tempo reale. Questa procedura aveva lo scopo di identificare direttamente i cornetti pulpari e l'accesso a ogni canale radicolare con un'apertura minimamente invasiva.*
Risultati: *tutte le cavità d'accesso sono state preparate secondo un approccio endodontico minimamente invasivo con il software ImplaNav mediante una guida dinamica. Non si sono verificate perforazioni e tutti i canali sono stati localizzati correttamente.*
Conclusioni: *i nostri risultati hanno dimostrato una possibile applicazione di questa tecnologia nella ricerca dei canali radicolari. Questo protocollo può avere potenzialità nell'insegnamento agli studenti di odontoiatria per iniziare il loro approccio in campo endodontico.*

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Peer review under responsibility of Società Italiana di Endodonzia
10.32067/GIE.2020.34.01.02

Introduction

New strategies are being implemented in clinical practice to overcome traditional difficulties in endodontics (1).
Endodontic cavities' design concerning different tooth types have remained unchanged for decades with only negligible modifications (2). Access cavity preparation is one of the most important factors that influences the quantity of the residual dental substance (3) and, consequently, the fracture strength of treated teeth (4). Indeed, root fracture is one of the most significative events which lead to tooth extraction in the long term (5, 6).
In 2010, Clark and Khademi (7) modified the endodontic cavity design to minimize tooth structure removal.
Inspired by the minimally invasive dentistry concept (8), conservative endodontic access cavity (CEC) preparation was proposed by these authors to preserve maximum tooth structure, while partially maintaining the chamber roof and peri cervical dentin.
Some endodontists have taken this concept a step further, designing "ninja" and "truss" endodontic access cavities (NECs and TRECs, respectively).
A NEC consists of a small occlusal entry that should allow the clinician to find and access all of the root canal orifices (3). On the other hand, a TREC consists of direct access from the occlusal surface to each canal orifice, avoiding removal of the whole pulp chamber roof (9).
One of the most critical aspect in endodontic procedures is the detection of root canal orifices in the pulp chamber. The opening of the pulp chamber is the first invasive step of every root canal treatment and is thus crucial for the outcome, stability and longevity of the tooth (1).
Students' perceptions of the difficulties of endodontic treatment are mainly focused on this first step, thus tutors and teachers are usually involved in trying to simplify the clinical approach to improve pulp chamber preparation and the location of the root canal orifices preventing the destruction of dentinal walls and the perforation of pulp chamber floor (10).
The use of phantoms and other plastic/resin devices to train students is therefore necessary. Unfortunately, some clinical conditions are extremely complex and require an innovative approach to avoid unnecessary risks and damages. Traditionally, a manual approach is required to remove residual dentin-enamel structure and to place the bur close or inside pulp chamber and close to the root orifices. For this reason, studies on new protocols for teaching endodontics are necessary in order to assess the effectiveness of dental care and help with the planning of future dental training (10).
Cone beam computed tomography (CBCT) has been introduced to detect not only periapical (undiagnosed) lesions and anatomy discrepancies, but also to guide the operator in clinical approach when considered difficult (11).
A dynamic navigation system, working on CBCT data and a computer assisted software, able to guide the high-speed handpiece (and bur) to the exact position of orifices may represent a challenging approach. This kind of technology has already been used for dental implantology for several years using the standard drill (12) and it has recently been proposed also with the aid of ultrasonic instruments (13).
The aim of the present research is to evaluate the feasibility of using a dynamic navigation system for minimally invasive Endodontics in addition to presenting an innovative didactical method for the opening of the pulp chamber cavity in order to find the root canal orifices before the endodontic treatment, thus preventing unnecessary alterations of crown morphology.

Materials and Methods

Step 1. Preparation of the tooth model
Three human teeth extracted for orthodontic reasons were selected, cleaned and stored in distilled water at 4° C for 10 days. Samples were fixed with a light cur-

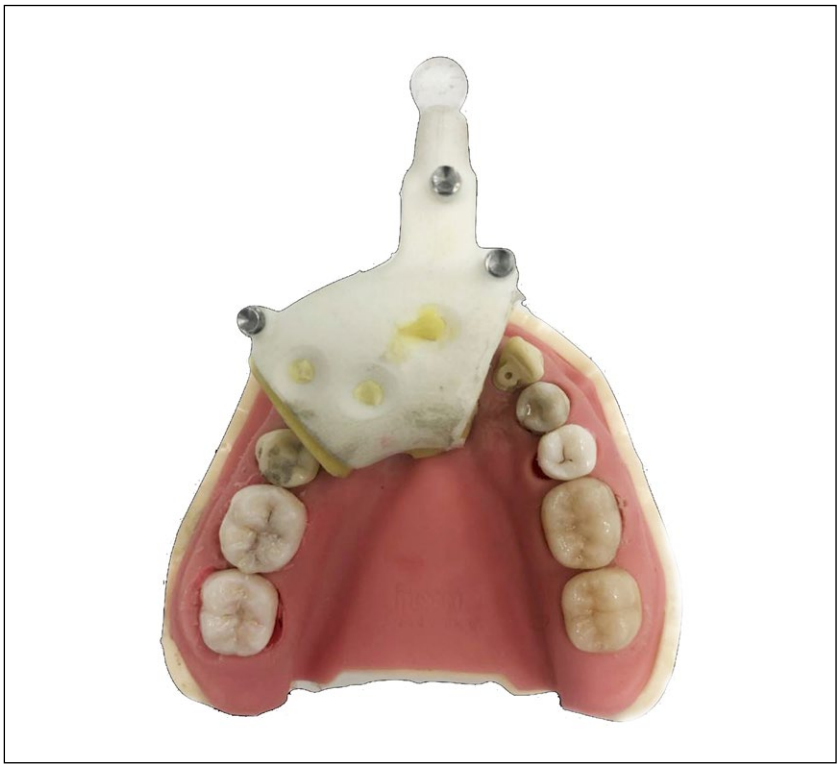

Figure 1
Preparation of phantom tooth model: the marker plate was positioned on the anterior teeth using a silicone mold. The three metal pins were used as reference points to calibrate the dynamic navigation system.

ing resin composite into a prefabricated mouth plastic model (Phantom model) in place of the correspondent resin tooth (figure 1). Out of the extracted teeth, two were lower molars and one was a lower premolar; no one presented previous root canal treatment. A preoperative periapical radiograph of each sample was obtained to verify the dimension of the pulp chamber and the absence of root filling material.

Step 2. CT scan of the custom model
A dental-supported marker plate tray, provided by the Company, was fixed onto the model, before undergoing a cone-beam computed tomography (CBCT scanning). The markers plate tray (MPT), for dental supported procedure, was manufactured with a base similar to an impression tray and contain on the occlusal side the fiducial markers for calibrating the navigation system. The MPT was placed in situ by the use of Putty impression material (Ramitec, 3M ESPE, USA), according to the protocol of the navigation system manufacturer (ImplaNav, BresMedical, Sydney, Australia). A pre-operative CBCT (VGi, NewTom, Verona, Italy) scan (110 kv, 3.00 mA, 0.15 mm, FOV [10×5] HiRes) of the model was taken with the markers plate containing the fiducial markers, in place. CBCT scan of the model was then imported on the ImplaNav software and a 3D reconstruction model was then obtained.

Step 3. ImplaNav Navigation System
The ImplaNav Navigation System was used for this step (figure 2). ImplaNav consists of a software interface running in Microsoft Windows (Microsoft), which processes positional data obtained from a stereoscopic infrared camera. In each frame, the firmware of the camera (NDI Polaris Vicra; Northern Digital) identifies the 3D coordinates of a predefined geometric pattern of reflective spheres, which are segmented on-the-fly in the two-dimensional (2D) image obtained from the frame. Therefore, the reflective spheres are located onto two reference tools (RT) which position is identified in real-time by the camera.
The first reference tool is fixed on the model (patient reference tool: RTp) through a spherical connection present on a prominence on the anterior part of the MPT. This allows the navigation system to know in real time the position of the phantom patient.
In the same way, the position of the handpiece and consequently of the drill is identified via the second reference tool fixed on the handle (handpiece reference tool: RTh) through a screwable connection.
Image-to-world registration of the phantom patient was performed using radiopaque markers embedded in the tooth-supported MPT manufactured in biocompatible plastic.
In the lateral sides of the markers plate tray (MPT) are two definite points and via the touching one of these, on the left or on the right side, the handpiece calibration was done.
The calibration was completed with the patient (model) registration by touching three marker points placed on the MPT directly with the bur tip mounted on the handpiece.
This procedure allowed the system to identify in real time the position of the model.

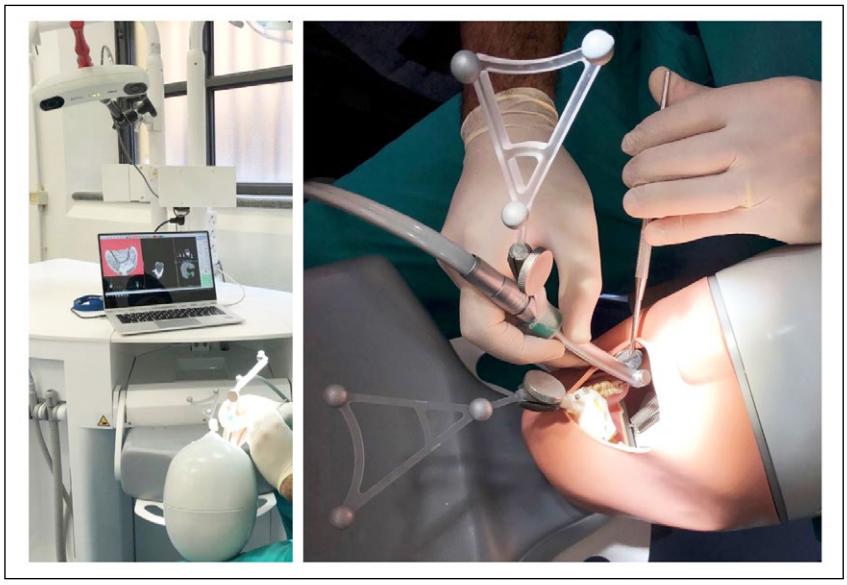

Figure 2
Dynamic guided navigation technique used in the present report.

Step 4. Cavity Preparation and Cavity Navigation
The preparation of the pulp chamber cavity was performed under the supervision of tutors from a Master's Program, by undergraduate students with a diamond bur in a dynamical way by real-time navigation. Rubber dam isolation (Hygienic Dental Dam, Coltène Whaledent, Cuyahoga Falls, USA) was followed before creating the straight-line access.
The image-guided procedure aimed to directly identify the pulp horns and the root canal entrances with a unique hole for each canal. The bur position was virtually followed by the operator on the navigation system screen during all the procedure.
Further preparation was not necessary as the access to the root canals was immediately obtained and verified via the insertion of an endodontic manual instrument. Finally, a postoperative CBCT was taken to radiographically prove the presence of a unique hole for each orifice, from the enamel to the root canal. Different samples were prepared and tested.

Sample 1. A lower premolar was used to create a minimally invasive access cavity by using a diamond bur mounted on a high-speed handpiece.
Operative information (drilling entry point, depth and angulation of bur insertion) of the precise position of tip bur were indicated by a green dot and checked in real-time on the navigation system display (figure 3).

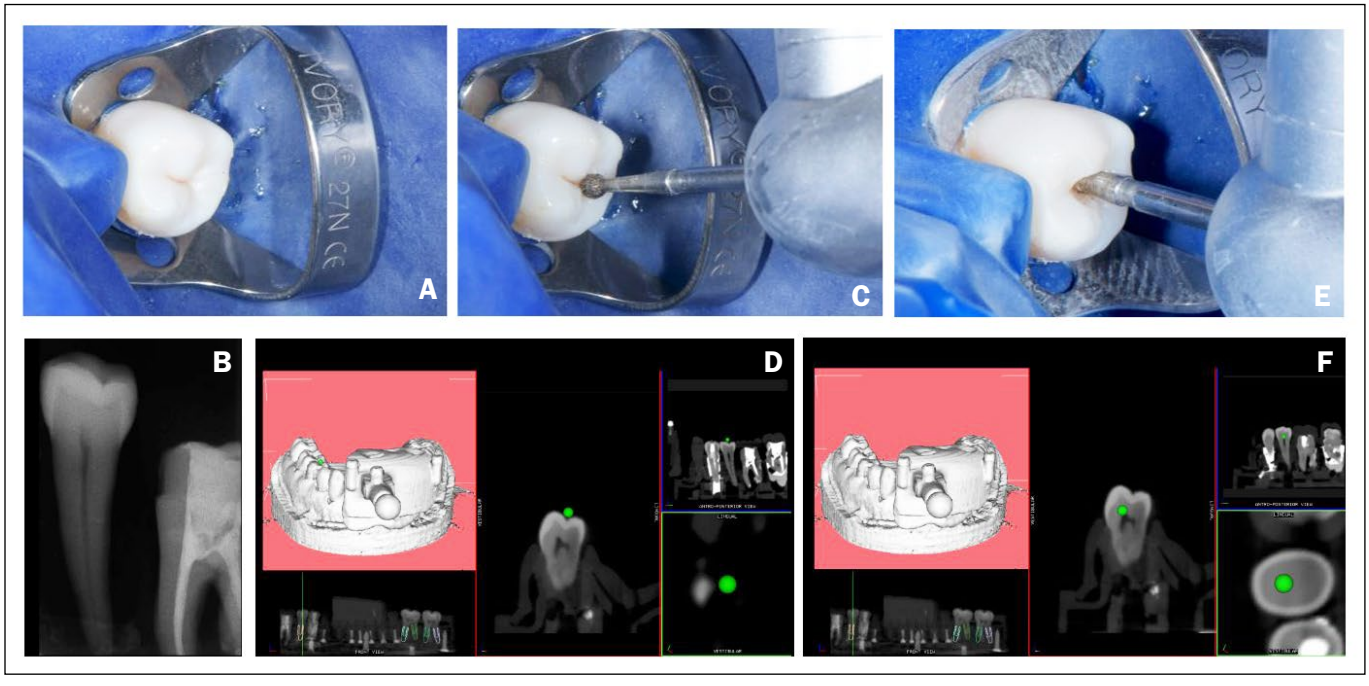

Figure 3
Operative procedures for Sample 1 (premolar tooth). Occlusal pre-operative aspect **(A)** and periapical preoperative radiograph **(B)**. Intraoperative photograph **(C)** and CBCT before access cavity: the green dot represents the tip of the bur in contact with the premolar enamel crown **(D)**. Tip of the bur inside the canal orifices: photograph **(E)** and CBCT **(F)**, respectively.

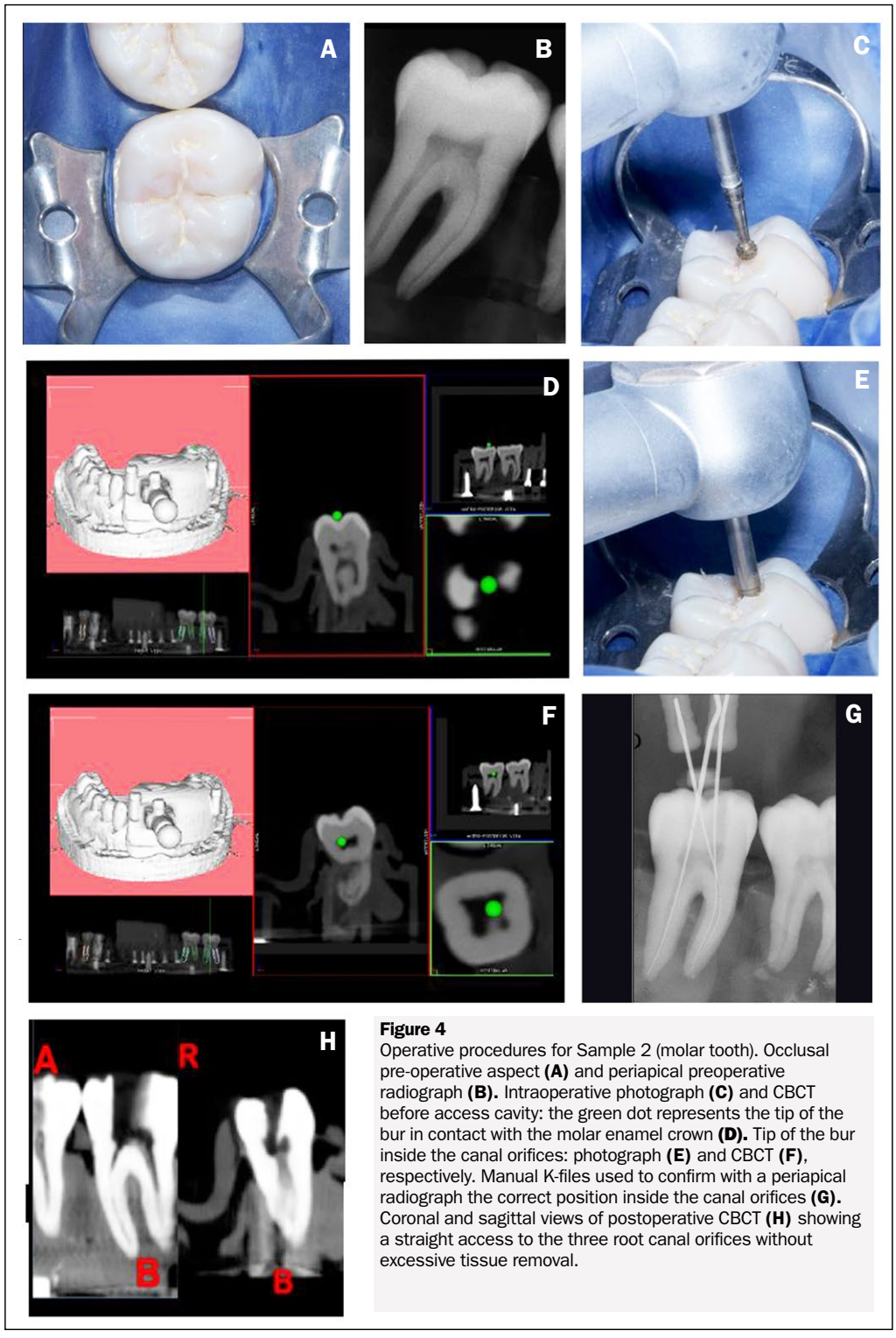

Figure 4
Operative procedures for Sample 2 (molar tooth). Occlusal pre-operative aspect **(A)** and periapical preoperative radiograph **(B).** Intraoperative photograph **(C)** and CBCT before access cavity: the green dot represents the tip of the bur in contact with the molar enamel crown **(D).** Tip of the bur inside the canal orifices: photograph **(E)** and CBCT **(F)**, respectively. Manual K-files used to confirm with a periapical radiograph the correct position inside the canal orifices **(G).** Coronal and sagittal views of postoperative CBCT **(H)** showing a straight access to the three root canal orifices without excessive tissue removal.

The applied movement was a vertical in and out motion to be as much conservative as possible. After achieving the correct depth in the pulp chamber, a manual K-file #10 (Dentsply Maillefer) was used to confirm with a periapical radiograph the correct position inside the canal orifice.

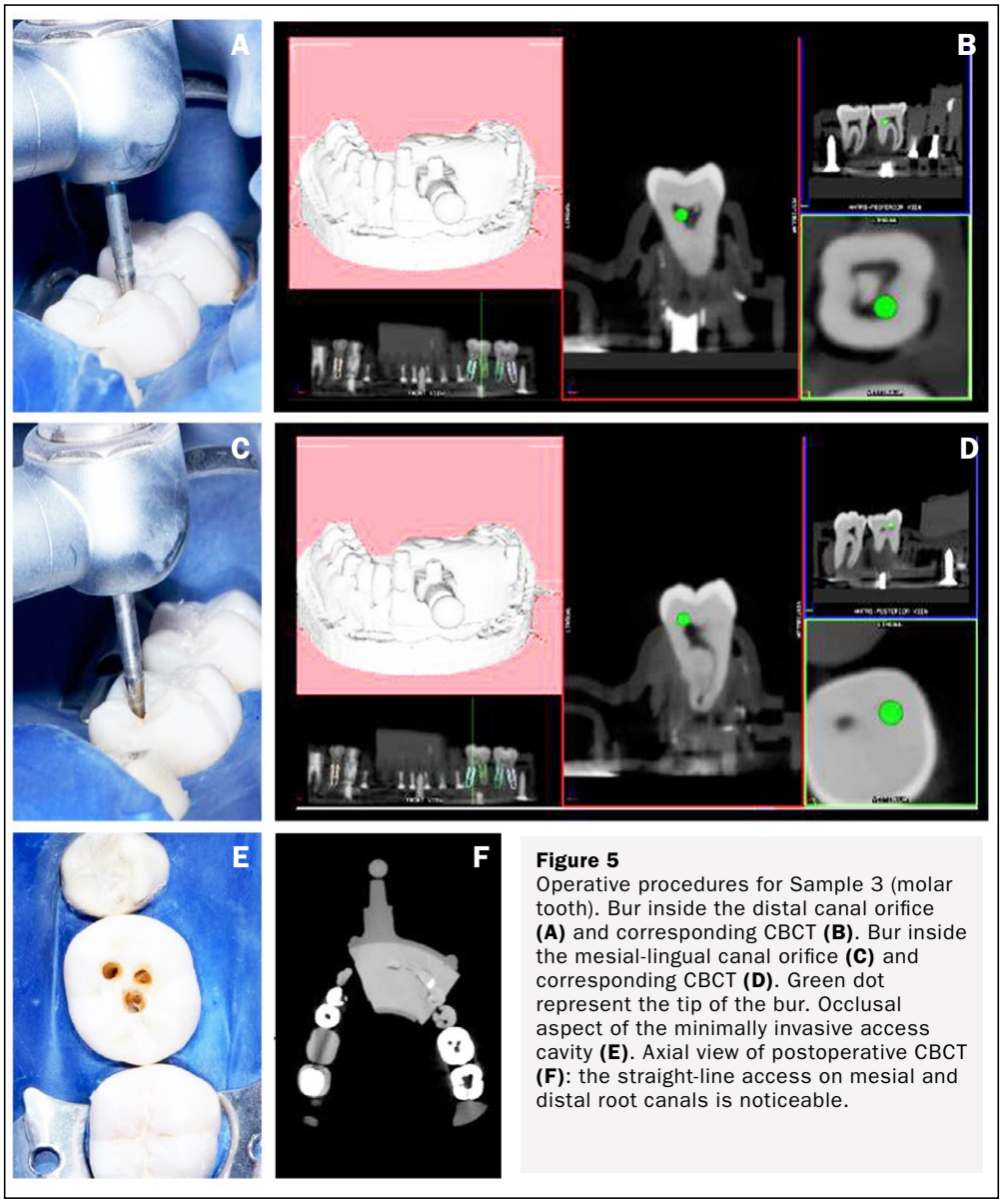

Figure 5
Operative procedures for Sample 3 (molar tooth). Bur inside the distal canal orifice **(A)** and corresponding CBCT **(B)**. Bur inside the mesial-lingual canal orifice **(C)** and corresponding CBCT **(D)**. Green dot represent the tip of the bur. Occlusal aspect of the minimally invasive access cavity **(E)**. Axial view of postoperative CBCT **(F)**: the straight-line access on mesial and distal root canals is noticeable.

Sample 2. A lower molar was used to create a minimally invasive access cavity by using a diamond bur mounted on a high-speed handpiece. The protocol of pulp chamber opening was the same as previously described for Sample 1, with the only difference that the standard cavity design satisfied the presence of three different orifices (mesiobuccal, mesiolingual and distal, figure 4).

Sample 3. A lower molar was used to create a truss access cavity by using a diamond bur mounted on a high-speed handpiece. In this sample, the access to the canal orifices was achieved by removing enamel and dentin in three different points, and creating three different holes on the occlusal surface in correspondence of the three orifices (mesiobuccal, mesiolingual and distal, figure 5).

After gaining the access to the canal orifices, postoperative CBCT scans were acquired for each of the included samples.

Results

A reduced dentinal destruction was noted by observing axial, coronal and sagittal frames.
No perforations were recorded and all the canals were successfully located, by resulting accessible to a K-file. This approach seemed to simplify the pulp chamber opening when the operators were undergraduate students.

Discussion

The present report describes a new method to identify the root orifices via the use of a dynamic navigation system confirming its applicability for educational purposes. The minimal access cavity allowed to preserve the structure integrity and to localize the root canal orifices with a simplified technique. All access cavities were prepared according to a minimally invasive endodontics approach with the dynamically guided ImplaNav software.
Reduction of the pulp chamber due to the formation of physiological or pathological secondary dentine, presence of blood, tissues, tooth rotation and inclination in the mouth may prevent the localization of the root canals. Straight line access to the root canals is preferable in order to preserve tooth structure and prevent instrument fractures. Peculiar root canal anatomies could be present in teeth, especially in molars where variations in the number and shape of root canals are frequent.
A virtually planned and guided minimal invasive access cavity could enhance the preservation of the tooth structure avoiding perforations, which could lead to an improved long-term prognosis, especially for teeth with calcified root canals (14).
Periapical radiographs do not show the real morphology of the root canal system and several studies have identified CBCT as a superior aid in the detection of various endodontic complications (15).
CBCT enables three-dimensional evaluation of teeth and related structures, and therefore could be considered a preferred imaging modality. CBCT is often used in the field of oral surgery for 3D planning of implant cases, to quantify bone level or to visualize anatomic structures such as the mandibular nerve canal (16).
However, CBCT offers a static view of the anatomy system and consequently could not provide immediate advantages during the preparation of the access cavity. Although mechanical properties of dentine compared to the alveolar bone are different and may influence accuracy, the use of this computer-aided technique from oral implantology applied to endodontics could be beneficial in producing a minimally invasive access cavity, locating calcified root canals and in endodontic surgery. Several new approaches have been designed and tested regarding the minimally invasive approach in complex root canal treatments, using guided implantology software (1, 17, 18).
However, these experimental procedures were designed in a static model, creating a resin template which should be adapted first to a dental model, then in the oral cavity and the overall dimension of the template has yet to be considered. Dynamic navigation is the most recent free-hand method for computer-aided surgery via an image-guided procedure. New dynamic three-dimensional technology has already occurred in the dental implantology field (19) and could be now applied to Endodontics in order to reduce the treatment invasiveness and avoiding the use of a bulky resin template. A navigation system could give significant aid when scouting the root canal system intraoperatively.
Dynamic guided endodontics may be challenging in clinical practice because it allows a maximum preservation of the dental structure (20), by reducing the encumbrance to the minimum. The dynamic navigation seems to be a useful device to help students to identify the root canal orifices through a fast moving image guided procedure. Up to date, this kind of technology presents some limits for a full application in the Endodontic field.
First, the accuracy declared by the manufacturer companies of about 0.5 mm needs further evaluation to determine whether or not it is sufficient. Secondly, the possible presence of a metal crown could represent another problem due to the radiographic

artifacts. Our initial evaluation of using dynamic navigation for Endodontics seems promising and a worthy method to be further investigated.
The present report seems to show that the system can be useful to identify the coronal third of the root.

Conclusions

The use of CBCT and the software assisted ImplaNav Navigation System has been tested for the first time in Endodontics at the University of Bologna.
The potentialities of this technique can be identified in teaching the pulp chamber opening and access to the canal orifices in teeth with a modified position (orthodontic reasons) and an altered anatomy.

Clinical Relevance

Utilization of a dynamic navigation in the endodontic field may provide significant advantages in endodontic training as a didactic tool to find the root canals. In addition, this technology would be useful in complex retreatment cases or in presence of sclerotic root canals.

Conflict of Interest

The authors deny any conflicts of interest related to this report.

Acknowledgments

The report was self-funded.

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ORIGINAL ARTICLE/**ARTICOLO ORIGINALE**

Sonic vs Ultrasonic activation of sodium hypoclorite for root canal treatments. In vitro assessment of debris removal from main and lateral canals

KEYWORDS
Root canal irrigation, Sodium hypoclorite, Sonic activation, Ultrasonic activation, Accessory canals

PAROLE CHIAVE
Irrigazione canalare, ipoclorito di sodio, Attivazione sonica, Attivazione ultrasonica, Canali accessori

Attivazione Sonica vs attivazione Ultrasonica dell'ipoclorito di sodio per i trattamenti endodontici. Valutazione in vitro della rimozione dei detriti dai canali principali e laterali

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Received 2019, November 21

Accepted 2020, February 11

Abstract

Aim: *Aim of this study is to evaluate the efficacy of two different sonic and ultrasonic devices in the elimination of debris from artificial main and accessory canals.*
Methodology: *Two different irrigant activator devices were tested: the sonic handpiece EndoActivator (Dentsply Maillefer, Baillagues, Switzerland) and the ultrasonic handpiece Ultra X (Eighteeth, Changzhou Sifary Medical Technology Co., Ltd, Changzhou City, China). Two groups of 18 artificial root canals were analyzed (n=36): main and lateral canals were embedded in a transparent resin model. Canals were filled with organic paste to simulate the necrotic pulp tissues. With both devices, irrigation was performed using 5% sodium hypoclorite and two activation times of 30 seconds each. Sodium hypochlorite was replaced every 30 seconds. After a photographic exam, debris removal was evaluated by a software and assessed in terms of percentage of cleaned canal. Means and standard deviations were calculated and data were statistically analyzed with the Anova test.*
Results: *Under the same experimental conditions (same canal, time and irrigant), both sonic and ultrasonic devices completely cleaned the*

Obiettivo: *la valutazione dell'efficacia di due differenti apparecchiature, una sonica e un'altra ultrasonica, per l'eliminazione dei residui dentinali dai canali endodontici principali e accessori.*
Metodologia: *sono stati testati due diversi attivatori per irriganti endocanalari: il manipolo sonico EndoActivator (Dentsply Maillefer, Baillagues, Switzerland) e il manipolo ultrasonico Ultra X (Eighteeth, Changzhou Sifary Medical Technology Co., Ltd, Changzhou City, China). Sono stati analizzati 18 canali artificiali per ciascuno dei due gruppi presi in esame (n=36): i canali principali e laterali sono stati creati all'interno di blocchi in resina trasparenti.*
È stata introdotta una pasta organica nei canali per simulare la consistenza dei tessuti pulpari necrotici. Con entrambe le strumentazioni sono state effettuate due attivazioni da 30 secondi ciascuna, utilizzando ipoclorito di sodio al 5%. Dopo un esame fotografico, la rimozione dei tessuti è stata valutata attraverso l'uso di un software e riportato in percentuali: sono state calcolate le medie le deviazioni standard e i risultati sono stati analizzati statisticamente attraverso il test Anova.
Risultati: *alle stesse condizioni sperimentali, (stesso canale, tempo di irrigazione e irrigante), entrambi i dispositivi hanno deterso completamente il canale*

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Peer review under responsibility of Società Italiana di Endodonzia
10.32067/GIE.2020.34.01.12

Abstract

main canal. On the contrary, a statistically significant difference was noted in the debridement of lateral canals, with ultrasonic device removing more debris than the sonic one ($p<0.05$). No tested device was able to remove all debris from accessory canals.

Conclusions: *The cordless ultrasonic handpiece Ultra X used with maximum power showed significantly greater efficacy in cleaning accessory canals when compared to the sonic EndoActivator.*

principale. Al contrario, è stata evidenziata una differenza statisticamente significativa nella detersione dei canali laterali, con una migliore performance del dispositivo ultrasonico rispetto a quello sonico ($p<0.05$). Nessun dispositivo è stato in grado rimuovere completamente i residui dai canali accessori.

Conclusioni: *il dispositivo a ultrasuoni Ultra X utilizzato alla massima potenza ha dimostrato un'efficacia significativamente superiore rispetto al dispositivo sonico EndoActivator nella detersione dei canali laterali.*

Introduction

Remains of pulpal debris and bacteria in the dental root canal are the principal cause of endodontic treatment's failure: only a complete disinfection and subsequent obturation of the endodontic space could lead to success (1, 2). Satisfying instrumentation and irrigation are considered mandatory to decrease the amount of bacteria and necrotic tissues within the root canal system (3-5). In the last decades, research was mainly focused on improving shaping of the root canal with many new instruments and techniques (6-11). However, irrigation still plays a fundamental role in the root canal therapy and it should be never underestimated (12-14). Mechanical instrumentation is not able to clean all the root canal system, and remaining biofilms and infected debris can be a possible source of persistent infection and treatment failure (15). The main factors that prevent complete debridement are: the polymicrobial nature of bacteria and their organization in biofilm, the presence of the smear layer produced by instrumentation, but above all, the complex root canal anatomy that hinders the instrumentation and the penetration of the irrigants in unreachable areas of the root canal system, like fins, accessory canals and isthmuses (16). Therefore, the irrigants should be activated inside canals by proper devices to increase the amount of contact with pulp tissue and debris inside canals.

Many articles tested and compared ultrasonic and sonic devices for irrigants activation (17-21): the main function of sonic handpieces is to produce a vigorous movement of the intracanal liquid through "cavitation" and "acoustic streaming". By activating the flow of irrigants, bubbles are produced, so they expand, become unstable and subsequently collapse in an implosion. This can dissolve impurities and penetrate powerfully into the channels, breaking bacterial biofilms and clean surfaces.

Many different sonic and ultrasonic devices have been commercialized during the last decades. Among sonic devices, Endoactivator (Dentsply Maillefer, Baillagues, Switzerland) is the most studied (22-24); ultrasonic devices, using higher frequencies, create vibrations that produce a continuous current close to the file, keeping the irrigant moving continuously. Eighteeth Ultra X (Eighteeth, Changzhou Sifary Medical Technology Co., Ltd, Changzhou City, China) is a new ultrasonic battery operated device. No studies have been published so far on this device.

Aim of this study is to compare the in vitro efficacy of the two above mentioned sonic and ultrasonic devices in the elimination of debris from canal irregularities in artificial root canals.

Materials and Methods

Power analysis was performed to evaluate sample size. A transparent resin model simulating a radicular canal was divided into two parts of equal thickness and adopted for this study (figure 1). Model and testing methodology have been validated in a previous study (12). The dimensions of the resin model were 10 mm length and 2.5 mm width. Both parts were specular, with a depression inside, at the same level, so that once assembled (by means of two screws) each depression overlapped to its counterpart to reproduce the lumen of a root canal. The canals were embedded with three semi-circular cavities, simulating the presence of irregular lateral canals at different levels (coronal, middle and apical). The three semicircles per side were filled with organic paste similar in consistency and density to the dental pulp, simulating the debris accumulated in the non-instrumented areas of the root canal. Organic paste was obtained by crushing bovine dental pulp and add a bit of dark stain (tempera colour) for better visualization.

The same simulator of the root canal was employed for both groups and the test was repeated 3x3 times for each experimental group (18 repetitions in total). The same irrigation procedure was adopted for all the tests: a 2,5 cc Luer-lock sterile syringe with endodontic needle (Navi Tip, Ultradent, Utah, USA) was placed at 1 mm from the working length (WL). 5% sodium hypoclorite (Ogna, Muggiò, Italy) was activated for 1 minute per procedure. The protocol used for both groups tested was the one suggested by the manufacturer in their instructions for use and included the following phases:

1. First irrigation with a disposable sterile syringe with endodontic needle (2,5 cc 5% NaOCl)
2. Activation time 30 sec.
3. Second irrigation with a disposable sterile syringe with endodontic needle (2,5 cc 5% NaOCl)
4. Activation time 30 sec.

For the group 1, the sonic handpiece EndoActivator was used at the maximum power of 10 kHz. The selected activator tip was a 25.04 red insert, used by following manufacturer instructions. For the group 2, the ultrasonic handpiece Ultra X worked at the maximum power of 45 kHz, using the soft and flexible X Silver tip. In both cases, the selected activator tip fitted passively when placed 2 mm short from the working length. The irrigant solution was activated using short vertical strokes for 30 seconds.

Digital photographs of the artificial canals were taken before, during and after the activation, due to record the amount of debridement. The resulting images were viewed and analyzed using a default

Figure 1
The transparent resin block containing artificial canals: block can be split in two halves for better placement of organic material inside and then reassembled.

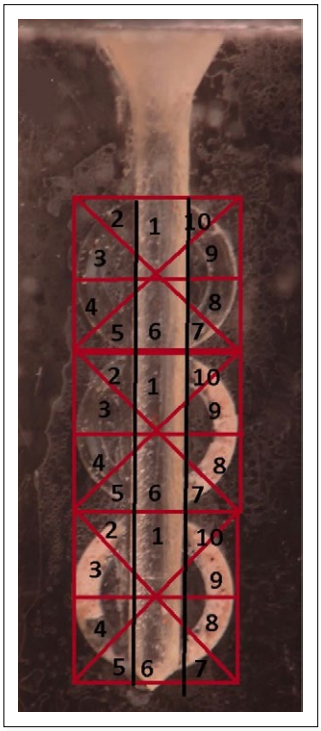

Figure 2
The artificial canal was divided in sectors, allowing more precise and easier visualization of the debridement.

template, realized with a computer-aided technical drawing program (AutoCAD® 2012, Autodesk, San Rafael, USA). The percentages obtained were derived from a graphic interpretation of the results. Specifically, each section in which the artificial channel was divided (coronal, middle and apical third), was further divided into 10 parts, considering both the main channel and the lateral canal irregular extensions (figure 2). At the end of the irrigant activation process, it was made a percentage calculation of the parts that visually appeared to be completely cleaned. Means and standard deviations were statistically analyzed with Anova test to highlight the differences in the ratios of removed debris between groups. The level of significance was set at p=0.05.

Results

Results are shown in table 1. Shapiro-Wilk was performed to verify the normality of data. Both sonic and ultrasonic irrigant activators completely cleaned the main canal of all resin models, while statistically relevant differences have been found in cleaning the lateral canals. Ultrasonic handpiece statistically removed more debris than the sonic one ($p< 0.05$), but none of the tested devices completely removed debris from lateral canals.

Discussion

The majority of ultrasonic handpiece are electric devices with plug-in or handpieces to be connected to the dental unit. The new handpiece is cordless, light in weight, very easy to handle, store, transport and use, even if it is not connnected to a source of irrigating solution. The main advantage of a cordless handpiece is the easier practical use, but there are some concerns about efficacy. More precisely, the power of cordless handpieces is sometimes not predictable, due to problems related to battery and charge. A lower input from battery could easily generate a vibration with reduced frequency, thus reducing the effectiveness of ultrasonic activation. So far, research about improving endodontic irrigation followed two parallel paths: the search for more effective and diffusible irrigants and the search for improved irrigant activation. Different irrigating solutions have been used throughout the years and, among them, sodium hypochlorite has proved to be the best solution (19, 25). Data from literature clearly demonstrated that the increase in temperature has the effect of enhancing the solvent action on the collagen of the hypochlorite, while the bactericidal activity is influenced by the concentration and the time of contact with the bacteria; the optimal concentration is considered to be 5.25% (26). The bactericidal action is carried out in 2-5 minutes, if there is a direct contact between hypochlorite and bacteria. Mechanical activation of sodium hypochlorite is considered capable to increase tissue dissolution and its agitation could provide a continuous flow of renewed chlorine (17, 18).
Disinfection and debridement could be improved by different irrigation delivery devices which use sonic, ultrasonic and negative pressure. In the last decades many new devices and techniques have been proposed for the purpose, but still there is no consensus on which one is the most reliable and efficient for the clinical use (20). Besides the concepts of positive and negative pressure, the differences amongst devices are mainly based on the source and quantity of the released energy, but in similar devices, the conformation of the tip could reach different results.
Aim of this study was to compare the efficacy of sonic and ultrasonic devices for the cleanliness of canal irregularities using the following similar parameters: anatomy, irrigant, activation time and amount of residuals. Results showed that both sonic and ultrasonic irrigant activators completely cleaned the main canal of all resin models, while statistically relevant differences have been found in cleaning the lateral canals. Statistical analysis revealed that the ultrasonic handpiece removed more debris than the sonic one ($p<0.05$). Such difference can be explained by the fact that a more efficient transmission of energy allows a better irrigant activation and progression in endodontic

Table 1

Percentage of debris removal between Endoactivator and Eighteeth experimental groups

Activation	1	2	3	4	5	6	7	8	9	Mean	Std.Dev
Endoactivator (S) main canal	100	100	100	100	100	100	100	100	100	100	0
Eighteeth (US) main canal	100	100	100	100	100	100	100	100	100	100	0
Endoactivator (S) accessory canal	60	58	55	47	64	61	44	58	72	57,66a	8,44
Eighteeth (US) accessory canal	72	69	80	71	82	70	74	68	73	73,22a	4,81

Ultrasonic (US) activation removed a larger amount of debris when compared to sonic (S) one in the accessory canals in all tests. Main canal debris removal was complete in all cases for both groups.
Results showing significative differences are evidenced by upper letter (a).

spaces (like lateral canals, isthmus etc) which are not instrumented or directly reached by the tip of the sonic/ultrasonic device. This experimental condition simulates a clinical situation where tips are inserted in the main canal. A better flow and activation of the irrigant results in increased debridement.

The results showed that there is a significant difference between the sonic and ultrasonic devices, with the last one showing significantly better removal for organic tissues.

A possible explanation is that sonic devices were less efficient, mainly due to their lower power and lower frequency of vibration (25, 27, 28, 29). Typically, a sonic device operates at 1-8 kHz and ultrasonic at 25-40 kHz (30). The efficacy is related to the power of the units. The Eighteeth device has only two selectable values of power and for this study it was used the higher one. The provided power, even if derived from a battery, has proved efficacy, but it should be compared to non-cordless ultrasonic units to appreciate differences, if any. A cordless device makes the handpiece more ergonomic and easy to use, even if special cares have to be paid to ensure that the ultrasonic handpiece is always properly charged.

Efficacy is also related to the possibility to insert the tip in the apical portion of canal. In this in vitro study, artificial main canals were wide and straight, allowing easier placement of tips. All main canals were adequately cleaned by both devices. Clinically in curved canals, efficacy could also be dependant on the flexibility of the files/tips (17).

The current increase of the use of cone beam in endodontic practice, has clearly shown clinically more complex anatomies than expected, underlining the necessity to improve our shaping and cleaning procedures (31, 32).

According to literature, if sonic handpiece is used under 2 mm of the working length it may cause extrusion of irrigant over the apex. Another issue could be evidenced when the size of the apical part of the preparation is too narrow respect to the size of the vibrating tip: once forced by the dentinal walls, the cavitation and movement of the irrigant could be ineffectual (33). However, sonic devices are considered

safer than ultrasonic ones because they are embedded with oscillating plastic point which doesn't stop when in contact with the canal surfaces and it doesn't deform the root canal (12). In fact, ultrasonic files are made of metal alloy, therefore, when they touch the root canal wall, this may cause uncontrolled removal of dentin, with deformation of the root canal morphology (34).
Most of the studies about ultrasounds were performed using electric plug-in devices with cord, while only a few ones investigated cordless handpieces. Due to different power supply cordless and plug-in devices are supposed operate at slightly different frequencies (usually varying from 30 to 50 kHz). A small difference was reported to have no effect on the treatment outcome (35). The two different kind of devices are assumed to operate with similar ultrasonic induced flow patterns. In the ultrasonic instrument oscillation, the pressure waves generate acoustic streaming and cavitation, with the main flow factor appears to be acoustic microstreaming.
The present study is the first one which evaluates and compare in vitro performance of the new handpiece. Ultra X works at 45 kHz, by utilizing acoustic microstreaming, agitation and cavitation. Frequency can be modified by the operator that could optimize the efficacy of the tips during the debridement.
In the present study, two activation times of 30 seconds each were used, according to the clinical protocol established at the beginning of the trial. The test, for the two groups, was conducted under the same conditions and by the same operator, however there are some limitations to keep in mind: the in vitro model used in this study was an artificial root canal with artificial lateral extensions simulating inaccessible areas of the main root canal; the organic

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material present in the real canals was simulated by using a paste with a consistency similar to the pulpal tissues; differently from the natural teeth, plastic canals were poor of irregularities; lateral canals were larger than natural ones and activation was performed always at the same level (12). Another limitation of this study is the fact that the assessment of debridment was only two-dimensional, so it was not possible to precisely measure the amount of residual tissues in all the canal complexities.

Conclusions

Both sonic and ultrasonic activation demonstrated a good capacity for debris removal in the main canal, but in the present experimental model, the Ultra X ultrasonic system significantly removed more debris from lateral extensions than the EndoActivator sonic system.

Clinical Relevance

Endodontic irrigation is mandatory for a successful root canal treatment. Devices for mechanical irrigation could improve the irrigant diffusion through main and accessory canals for a better disinfection.

Conflict of Interest

The authors deny any conflict of interests.

Acknowledgments

The authors would like to thank Eighteeth, Changzhou Sifary Medical Technology Co., Ltd, Changzhou City, China, for providing the Ultra X device for the experimental purposes.

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ORIGINAL ARTICLE/**ARTICOLO ORIGINALE**

Accuracy, sensitivity and specificity of three imaging modalities in detection of separated intracanal instruments

KEYWORDS
Accuracy, CBCT, Nickel Titanium, PSP, Radiography, Separated Instrument

PAROLE CHIAVE
Precisione, CBCT, Nichel-titanio, Radiografia, Strumento separato

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Received 2020, February 15

Accepted 2020, February 25

Precisione, sensibilità e specificità di tre modalità di imaging nel rilevamento di strumenti intracanalari separati

Abstract

Aim: *To compare the accuracy, sensitivity and specificity of CBCT imaging and two dimensional periapical radiography in detection of separated intracanal endodontic instruments with and without root canal filling.*
Methodology: *Eighty (n=80) extracted mandibular molars were randomly divided into four groups (n=20); control, fracture/non-filled, non-fracture/filled, and fracture/filled. Molars were placed in a mandible for imaging. Conventional 2D radiography using D-speed periapical film (SKYDENT, Slovak Republic), semidirect digital radiographs using Soredex Digora Optime system (DIGORAOptime, Soredex, Finland), and cone beam computed tomography using Gendex-GXDP 800 (GENDEX GXDP-800 Kavo, Germany) were acquired. An artifact reduction algorithm was applied. Images were evaluated by three blinded examiners (two endodontists and one radiologist). Qualitative examination for the presence/absence of separated instrument was performed according to a 5-point rank scale (1, definitely absent; 2, probably absent; 3, uncertainty; 4, probably present; and 5, definitely present). Accuracy, sensitivity and specificity were calculated as well as inter-observer reliability. Statistical analysis was performed and significance level was set at 5%.*
Results: *Non-filled groups showed no significant difference between all three tested imaging modalities. Filled groups showed statistically decreased accuracy and sensitivity of CBCT. Good inter-observer agreement was shown.*
Conclusions: *Conventional 2D radiography is a good tool for detection of intracanal separated instruments in filled canals.*

Obiettivo*: confrontare l'accuratezza, la sensibilità e la specificità della CBCT e della radiografia periapicale bidimensionale nel rilevamento di strumenti endodontici intracanalali separati con e senza riempimento del canale radicolare.*
Metodologia: *ottanta (n=80) molari mandibolari estratti sono stati divisi casualmente in quattro gruppi (n=20); controllo, frattura/non riempito, non frattura/riempito e frattura/riempito. I molari sono stati collocati in una mandibola per l'esposizione con radiografia 2D convenzionale con film periapicale D-speed (SKYDENT, Repubblica slovacca), radiografie digitali semidirette con sistema Soredex Digora Optime (DIGORAOptime, Soredex, Finlandia) e tomografia computerizzata a fascio conico con Gendex-GXDP 800 (GENDEX GXDP-800 Kavo, Germania). È stato applicato un algoritmo di riduzione degli artefatti. Le immagini sono state valutate da tre esaminatori (due endodontisti e un radiologo). L'esame qualitativo della presenza/assenza di strumento separato è stato eseguito secondo una scala di 5 punti (1, decisamente assente; 2, probabilmente assente; 3, incerto; 4, probabilmente presente; e 5, sicuramente presente). Sono stati calcolati precisione, sensibilità e specificità, nonché affidabilità inter-osservatore. È stata eseguita un'analisi statistica e il livello di significatività è stato fissato al 5%.*
Risultati: *i gruppi non riempiti non hanno mostrato differenze significative per tutte e tre le modalità di imaging testate. I gruppi riempiti hanno mostrato un'accuratezza e una sensibilità della CBCT statisticamente diminuite. È stato mostrato un buon accordo tra osservatori.*
Conclusionl: *la radiografia 2D convenzionale è un buon strumento per la rilevazione di strumenti separati intracanalali in canali riempiti.*

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Peer review under responsibility of Società Italiana di Endodonzia
10.32067/GIE.2020.34.01.03

Introduction

Although rotary nickel-titanium (NiTi) instruments have the ability to shape root canal systems in a shorter time with less procedural errors, unexpected instrument fracture still does occur (1). The possibility of NiTi instrument separation was shown to range from 0.4% to 4.4% (2).

Sattapan et al (3) identified two modes of fracture; cyclic fatigue and torsional failure. Cyclic fatigue which occurs due to metal fatigue when it rotates freely in a curved canal at the point of maximum flexure (4, 5), while torsional failure happens upon reaching the ultimate shear strength. Many factors influence the occurrence of this mishap including root canal geometry (6), cleaning and shaping techniques (7), debris accumulation (8) sterilization procedures (9), size (5), taper (10), cross section (11), and instrument design (12), as well as the manufacturing technique (13); unfortunately, cyclic fatigue often happens without any visible sign of plastic deformation (2).

Once a separated instrument is observed on a routine radiograph or accidentally happened during root canal treatment, the patient should always be informed (14). From a medicolegal point, it is imperative to accurately diagnose a separated instrument inside a root canal before starting endodontic retreatment procedures. Otherwise, the clinician performing the retreatment might be blamed for it (15). Diagnosis and documentation of separated instruments is deemed mandatory (16).

Intracanal separated instruments may affect the treatment outcome as it prevents adequate root canal disinfection and/or obturation (17). Management of separated instruments includes leaving the instrument inside the root canal after bypassing it, instrument retrieval via orthograde approach, and surgical approach (18). Factors affecting treatment options are the preoperative pulp state, instrument position, remaining radicular dentin thickness, and root canal geometry (18). Proper diagnosis of a separated instrument in a previously filled canal is not that easy because of the continuous radioopaque appearance of the instrument and the root canal filling (19).

Radiation dosage reduction, lack of image processing, and easier manipulation of image contrast, brightness, and sharpness are the main advantages of digital radiography over conventional radiographs (16).

A primary limitation of periapical radiography being a two-dimensional image of a three-dimensional object. Cone-beam computed tomographic (CBCT) imaging overcomes this and allows for accurate assessment of morphology and proper diagnosis (20). Yet, CBCT suffers from metallic artifacts which hinders its ability to accurately diagnose separated metallic instruments (20).

CBCT demonstrated better accuracy than two-dimensional periapical radiography in detecting root perforations, external root resorption, and deviated posts (20). However, CBCT requires a longer scan time, and the patient is exposed to a larger X-ray dose compared to conventional or digital radiography (20). Moreover, contradictory results were reported regarding the detection of separated instruments in filled root canals (21).

Therefore, investigation of the best method to image and diagnosis the presence of instruments in filed root canals was of value. Our null hypothesis is that there is no difference in the accuracy of conventional radiography, digital radiography or CBCT to detect separated instruments in filled root canals.

Materials and Methods

Sample Selection and Classification

The current study was approved from the Research Ethics Committee of Ain Shams University (Cairo, Egypt), (approvation number 07062019).

Eighty sound human mandibular molars extracted for periodontal reasons were selected and used. Teeth were randomly divided into four groups (n=20).

Group I: The control group in which root canals were prepared but left unfilled.

Group II: The fracture/non-filled group in

which root canals were prepared, and files were intentionally fractured.
Group III: The non-fracture/ filled group in which root canals were prepared and filled.
Group IV: The fracture/filled group in which root canals were prepared, files were intentionally fractured, then filled till the level of the separated instruments.

Sample Preparation
Endodontic access cavities were prepared in all teeth. Cleaning and shaping of teeth were performed using the WaveOne Gold primary (Dentsply Maillefer, Ballaigues, Switzerland) in the presence of 2.5% NaOCl. Forty rotary NiTi files size 25 taper 0.06 were weakened by making a notch on each file at 3 mm from the tip. Then, file was inserted into the canal through the apical foramen and twisted to induce intra-canal instrument separation in groups II and IV (2, 30). Groups III and IV were obturated using gutta percha (META BIOMED CO, Republic of Korea) and ADSEAL resin sealer (META BIOMED CO, Republic of Korea) in a cold lateral compaction technique. A dry human mandible was covered with utility wax to simulate soft tissue present in the clinical situation (2). Sockets were minimally modified to fit the teeth in the molar area properly.

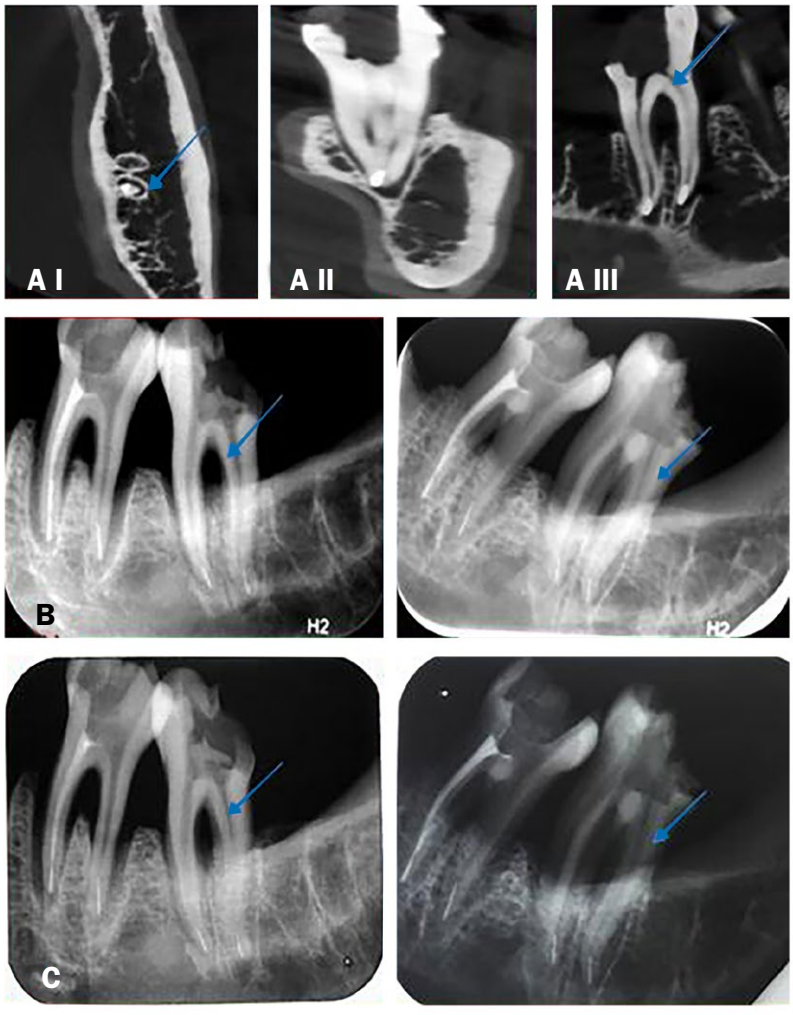

Figure 1
Mesiobuccal canal of lower second molar (blue arrows) radiographed by 3 different Imaging modalities **(A)** CBCT; (I) axial section, (II) coronal section, (III) sagittal section. **(B)** SDDR with two different horizontal angulations and (c) CR with two different horizontal angulations.

Image Acquisition
Conventional Radiography (CR): Rinn-XCP film holder (AZDENT, XCP, film holding system, China) was used to place D-speed periapical film (SKYDENT, Slovak Republic) parallel to the long axis of the tooth and to direct the central beam perpendicular to both. The focus receptor distance was 25 cm. Two radiographs were acquired with two different horizontal angulations (1,2). Image acquisition was performed using FONA-XDC periapical intraoral X-ray machine (FONA-XDC, Assago, Italy) with the following exposure parameters;70 kVp, 7 mA and one second exposure time. Automatic processing was performed using Velopex Extra-X (Velopex Extra-X, Velopex International, England).
Semidirect Digital Radiogarphy (SDDR) were acquired using Soredex Digora Optime system (DIGORAOptime, Soredex, Finland). Photostimulable phosphor imaging plate (PSP) size #2 was held by XCP film holder as for conventional imaging with exposure parameters of 70 kVp,7 mA and 0.04 seconds exposure time.
CBCT Scans: Gendex-GXDP 800 (GENDEX GXDP-800 Kavo, Germany) was used with the following image acquisition protocol: 5*5 FOV, 90 kVp, 5 mA and spatial resolution 0.085 mm.

Table 1

Mean diagnostic values for different imaging methods in the absence of filling material

Imaging method	Accuracy	Sensitivity	Specificity
CBCT	0.889[a]	0.900[a]	0.889[a]
SDDR	0.883[a]	0.900[a]	0.889[a]
CR	0.844[a]	0.833[a]	0.850[a]

Different letters in the same column indicate statistically significance difference (p<0.05).

Image Evaluation

Conventional periapical radiographs were evaluated on a view box. Indirect digital images were viewed on an 18.5 inch HD LED monitor with resolution of 1366x768 using DFW 2.7 software. Zoom, brightness and contrast tools were available for use. CBCT images were analyzed using In Vivo Anatomage 5.3 software on an 18.5 inch HD LED monitor with resolution of 1366x768. A multiplanar reformatted screen was used to evaluate the CBCT scans. Zoom, brightness and contrast tools were also used when required. An artifact reduction algorithm was applied to enhance the image quality and the decrease the imaging artifacts.

Images were evaluated by 3 blinded examiners (two endodontists and one oral and maxillofacial radiologist). Qualitative examination for the presence/absence of separated instrument was performed according to a 5-point rank scale (1, definitely absent; 2, probably absent; 3, uncertainty; 4, probably present; and 5, definitely present) (16).

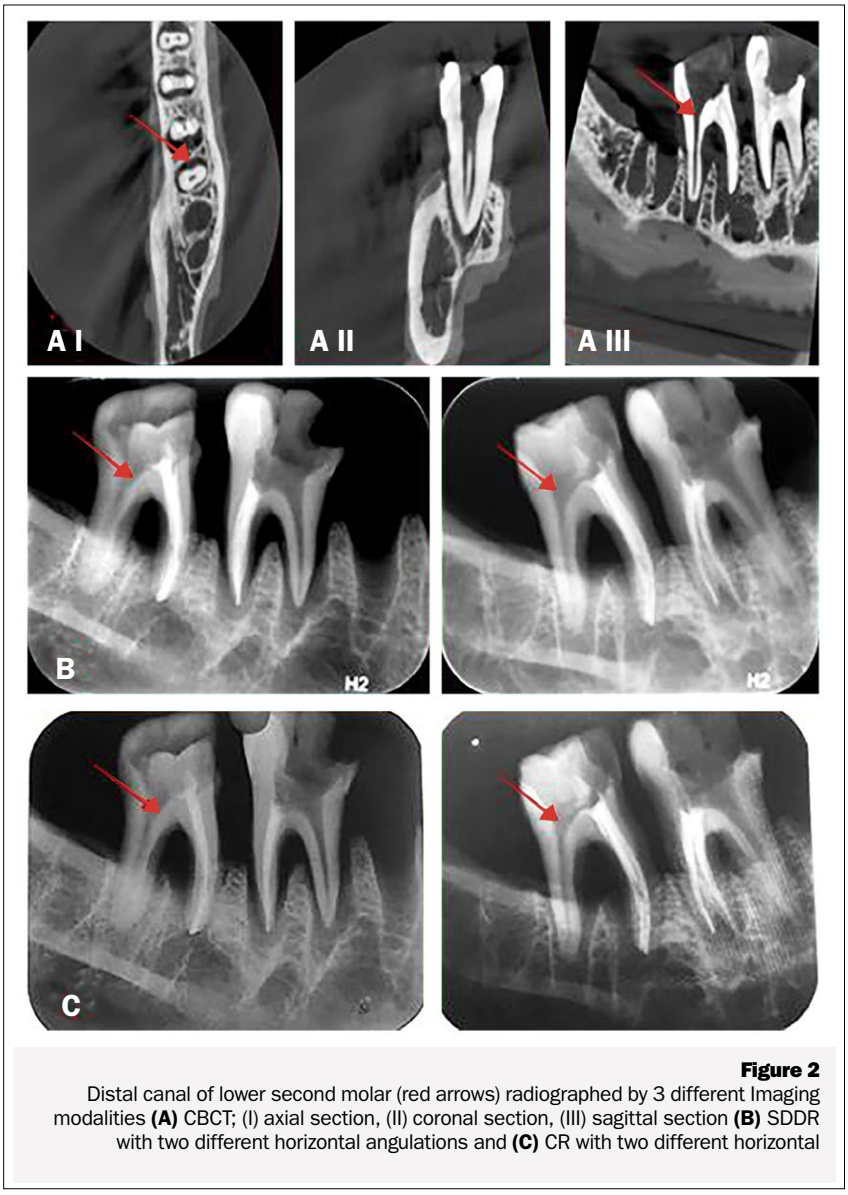

Figure 2

Distal canal of lower second molar (red arrows) radiographed by 3 different Imaging modalities **(A)** CBCT; (I) axial section, (II) coronal section, (III) sagittal section **(B)** SDDR with two different horizontal angulations and **(C)** CR with two different horizontal

Statistical Analysis

Kendall's coefficient of concordance was used to study the inter-rater reliability. Paired comparisons of receiver operator characteristic (ROC) curves were used to assess the diagnostic accuracy of the imaging methods utilized. The significance level was set at 5% for all tests. Statistical analysis was performed using NCSS version 12 for Windows.

Results

Accuracy, Sensitivity and Specificity

For groups I and II, non-filled, diagnostic accuracy (AUC), sensitivity and specificity values for all imaging modalities tested are shown in table 1. No significant difference was shown between all three tested imaging modalities regarding diagnostic accuracy, sensitivity or specificity (figures 1 and 2).

Table 2

Mean diagnostic values for different imaging methods in the presence of filling material

Imaging method	Accuracy	Sensitivity	Specificity
CBCT	0.526[b]	0.300[b]	0.888[a]
SDDR	0.807[a]	0.900[a]	0.722[a]
CR	0.793[a]	0.80[a]	0.666[a]

Different letters in the same column indicate statistically significance difference (p<0.05).

For groups III and IV, filled canals, accuracy, sensitivity and specificity values for all imaging modalities tested are shown in table 2. CBCT showed a statistically significantly smaller AUC and sensitivity values compared to SDDR (P=0.006) and CR (P=0.005). No significant difference was shown between SDDR and CR regarding accuracy, sensitivity or specificity (figures 3 and 4).

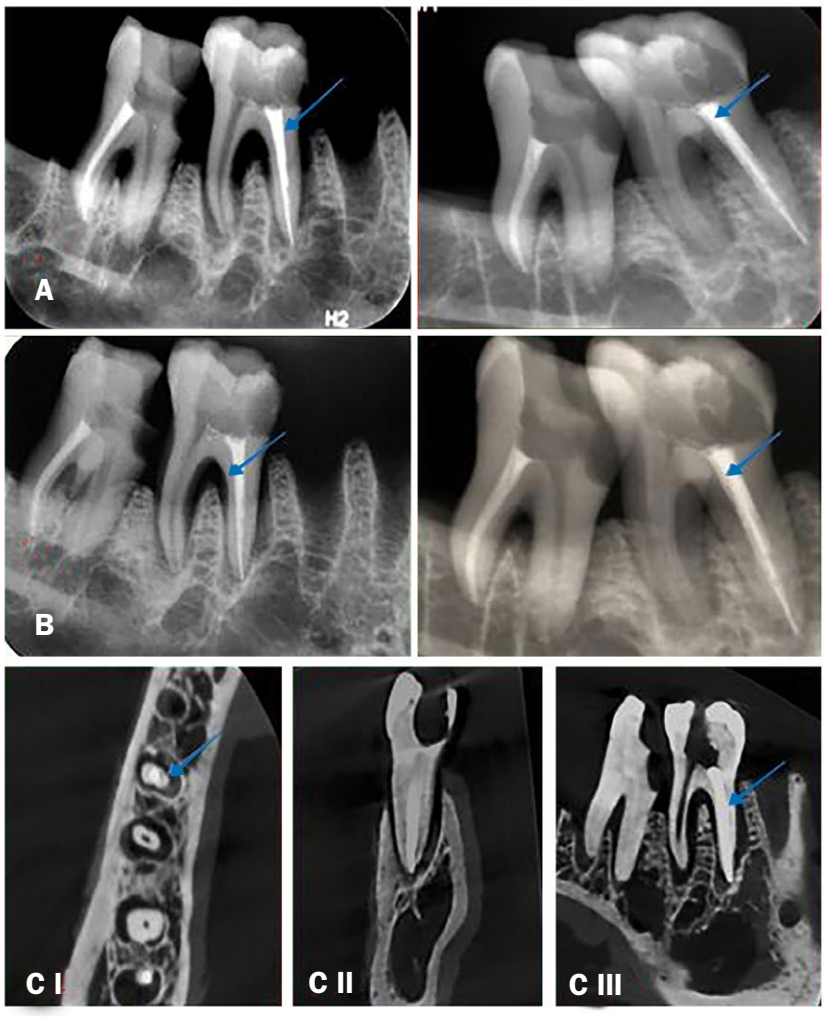

Figure 3
Distal canal of lower second molar (blue arrows) radiographed by 3 different Imaging modalities **(A)** SDDR with two different horizontal angulations **(B)** CR with two different horizontal angulations and **(C)** CBCT; (I) axial section, (II) coronal section, (III) sagittal section.

Interobserver Reliability

There was an overall good agreement between the three observers for all imaging techniques (W=0.813) which was statistically significant (P<0.001). There was a strong agreement for the measurements of CBCT (W=0.878) and CR (W=0.856) which was statistically significant (P<0.001). While for the SDDR, the observers' agreement was excellent (W=0.914) and statistically significant (P<0.001).

Discussion

An intracanal separated instrument may hinder or block the access to the apical part of the canal and compromises the effectiveness of cleaning and shaping procedures. Decision making in the clinical situation to bypass, remove or leave separated instruments will depend on the clinical and radiographic findings (21). Hence, the diagnostic capability of the imaging modality used for assessment of separated instruments should be reliable, especially in the presence of root canal filling materials.
Generally, the ability of radiographs to display high image quality in an image is influenced by spatial and contrast resolution. The spatial resolution, represented as LP/mm, is the ability of radiographs to distinguish fine details in an image (22). With CBCT, images with high spatial resolution are obtained when the high-definition mode and a low voxel size are used for scanning (23). Consequently, CBCT scans with endo mode 0.085 mm voxel

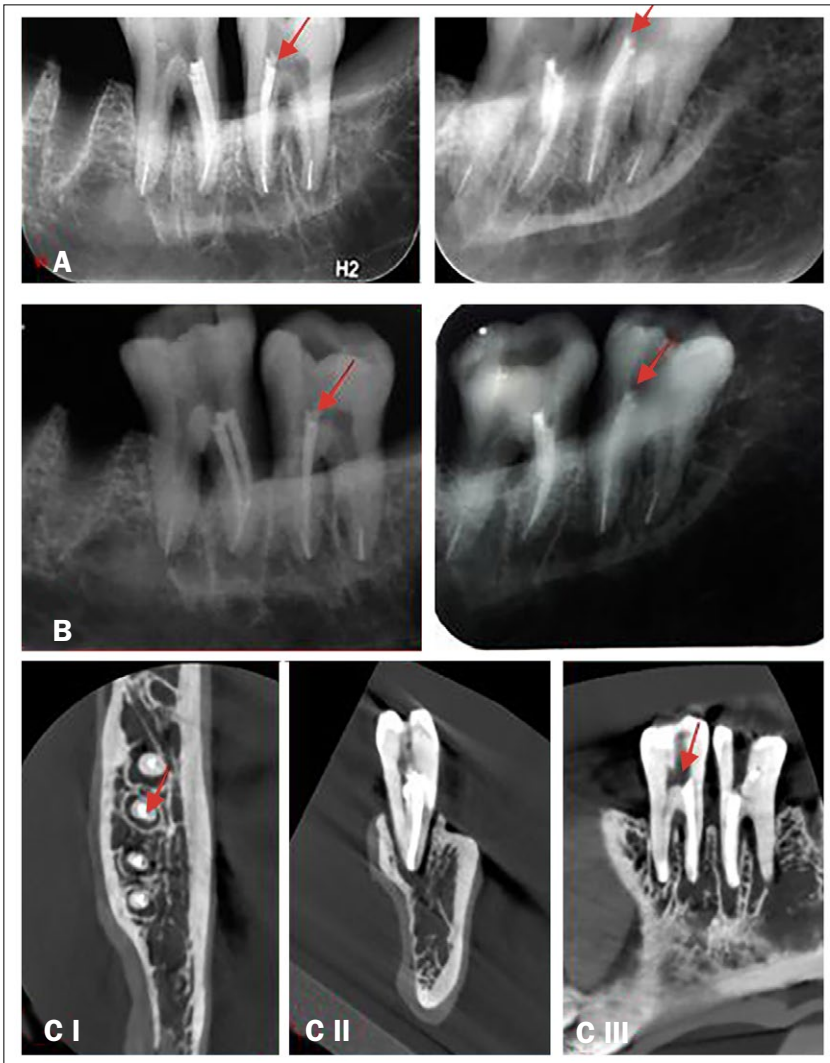

Figure 4
Distal canal of lower second molar (red arrows) radiographed by 3 different Imaging modalities **(A)** SDDR with two different horizontal angulations **(B)** CR with two different horizontal angulations and **(C)** CBCT; (I) axial section, (II) coronal section, (III) sagittal section.

size was selected in the present study.
A limited FOV 5x5 was also used in this study. According to Patel al (25), it is suitable for endodontic purposes as the produced reconstructed images are of high diagnostic power because of the higher spatial resolution than that those of larger FOV scans. Moreover, only the region of interest is irradiated. Thus, the effective dose to the patient is reduced.
Five points scale was used in the present study as it has the advantage of not expecting a simple Yes/No answer from the respondent, but rather allow for degrees of opinion, even in case of hesitation. Therefore, quantitative data could be obtained, which means that the data can be analyzed with relative ease (16).
The interpretation of images with respect to clarity is a subjective judgment of its appearance, which comprises both the technical qualities of the image as well as experience, skill and visual perception of the viewer. There was an excellent inter-observer reliability as their diagnostic scores for all imaging techniques were nearly comparable whether in the presence or absence of the filling material.
PSP plates also have better contrast detectability in addition to the increased exposure latitude in comparison to conventional periapical films, which enable them to distinguish between different densities on the radiographs (16). This explains the high accuracy, sensitivity and specificity of indirect digital radiography used in the current study.
The results of our study showed that the accuracy and sensitivity of CBCT were negatively affected by the presence of gutta percha. This agrees with Khedmat et al (26), who concluded that the presence of gutta-percha reduced the accuracy, sensitivity and specificity of CBCT, and Kobayashi et al (27) who reported that one of the drawbacks of CBCT images was its low contrast resolution which is the ability to distinguish different densities or shades of grey within a radiographic image (21). The decreased accuracy and sensitivity in the present study is not related to the CBCT artifacts but rather to its inherent low contrast resolution. Inherent or induced artifacts caused by the intracanal metallic and non-metallic fillings are considered to be a significant limitation of CBCT (25). Therefore, an artifact reduction algorithm was applied in the present study to enhance the image quality and avoid beam hardening effect from the gutta-percha filling.
The higher specificity value of CBCT in filled canals compared to SDDR and CR may be explained by the evaluators' difficulty in detecting separated instrument. This could be due to proper condensation of the filling material and the absence of the gap between filling material and the separated

instrument. Hence, there was a tendency to answer "probably absent" or "absent", which resulted in a high number of "negative" answers, consequently increasing the number of "true-negative" cases (24).
It should be pointed out that our results were confined and limited to only one type of intraoral digital imaging and CBCT imaging systems. Results may vary if other direct or semi-direct digital systems and CBCT scanners were used. Within limitations of the current study, the null hypothesis is rejected and we conclude that conventional 2D radiography is a useful tool for the detection of intracanal separated endodontic instruments in filled canals.

Clinical Relevance

Conventional two-dimensional radiography is a useful tool for the detection of intracanal separated endodontic instruments in filled canals.

Conflict of Interest

The authors deny any conflicts of interest related to this study.

Acknowledgments

The authors deny any conflicts of interest related to this study.

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ORIGINAL ARTICLE/**ARTICOLO ORIGINALE**

Post removal techniques: a systematic review and meta-analysis

Tecniche di rimozione perni: revisione sistematica e meta-analisi

KEYWORDS
Cast Metal Post, Clinical Chair Time, Post-removal, Glass Fiber Post, Ultrasonics

PAROLE CHIAVE
Perni metallici, Tempo clinico alla poltrona, Rimozione perno, Perno in fibra di vetro, Ultrasuoni

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Received 2018, October 17

Accepted 2020, March 12

Abstract

Aim: *This systematic review aimed to answer what is the best way to remove prefabricated metallic, fiber or cast metal posts.*
Methodology: *An electronic search was conducted in Medline and Scopus databases to identify clinical and in vitro studies that assessed post removal techniques from 1950 to October 2018. Tables were generated to summarize the included studies and reports were assessed for bias using the Cochrane risk of bias tool. A meta-analysis was performed to evaluate the force necessary to remove posts (α=5%).*
Results: *Of the 2,951 studies identified in the initial search, 33 were selected. The duration of using ultrasonic vibrations (and the number of surfaces where the vibration was applied) led to less time spent and less force needed to dislodge a metal post. Dentist's expertise (more than 10 years) was also related to easier post removal. The use of adhesive cements resulted in a more difficult protocol for post removal.*
Conclusions: *Although there is need for more consistent results, the data summarized and meta-analysis points toward the use of ultrasonic energy as the first option to remove posts, with best results for metal posts.*

Scopo: *questa revisione sistematica mira a rispondere a quale sia il modo migliore per rimuovere i perni prefabbricati metallici, in fibra o di metallo.*
Metodologia: *è stata condotta una ricerca nei database Medline e Scopus per identificare studi clinici e in vitro che hanno valutato le tecniche di rimozione dei perni dal 1950 a ottobre 2018. Sono state generate tabelle per riassumere gli studi inclusi e le relazioni sono state valutate per bias utilizzando il rischio Cochrane come strumento di giudizio. È stata eseguita una meta-analisi per valutare la forza necessaria per rimuovere i post (α=5%).*
Risultati: *dei 2.951 studi identificati nella ricerca iniziale, 33 sono stati selezionati. La durata dell'utilizzo delle vibrazioni ultrasoniche (e il numero di superfici su cui è stata applicata la vibrazione) ha comportato un minor dispendio di tempo e una minore forza necessaria per spostare un perno metallico. L'esperienza del dentista (più di 10 anni) era anche correlata alla rimozione del perno più facile. L'uso di cementi adesivi ha comportato un protocollo più difficile per la rimozione dei perni.*
Conclusioni: *sebbene siano necessari risultati più coerenti, i dati riepilogati e le meta-analisi indicano l'uso degli strumenti ultrasonici come prima opzione per rimuovere i post, con i migliori risultati per i perni metallici.*

Introduction

The purpose of an intraradicular post is to increase the retention of restorative materials when the remaining dental tissue is not enough to support the treatment performed (1). While post-retained restorations are known to present good survival, with both indirect and direct restorations (2), the need for removal of an intraradicular post may be necessary (3-5), and many methods can assist in this process. The use of an ultrasound device brings the advantage of decreased force to such removal, since their vibrations act in the cement line, causing its rupture (6). How-

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Peer review under responsibility of Società Italiana di Endodonzia
10.32067/GIE.2020.34.01.09

ever, attention should be paid to water-cooling, as there is the risk of reaching a temperature deleterious to adjacent tissues. Another removal method is to drill out the post (depending on the material) with the assistance of diamond, Gates Glidden or Largo burs, or ultrasound cutting tips. In clinical practice, the technique is usually post-dependent. In both techniques, radiographic assessment is important before starting the procedure to avoid unnecessary loss of tooth structure, root perforations or to be sure that no root fracture already exists.

Also, it may be said that the experience of the dentist will influence the success of a post that is to be removed (7, 8). Yet, it is unknown whether there is a best technique to remove a post considering the various types of posts that may be used in clinical practice. Thus, this study aimed to conduct a systematic review to answer if there is a best technique to remove prefabricated metallic, fiber or cast metal posts. The hypothesis tested was that available post removal techniques would result in distinct times of removal and maintenance of sound dental structure.

Materials and Methods

This review followed the guidelines of the Cochrane Handbook for Systematic Reviews of Interventions (9) and the reporting was based on PRISMA (10).

Eligibility criteria

Is ultrasound device better than burs for post removal in endodontic treated teeth, considering time and maintenance of dental structure?

Any in vitro or in vivo study that involved protocols or techniques for dental posts removal were included. Only English-language articles were selected. Studies that did not use post removal techniques were excluded, as well as the clinical case reports and discussions/reviews on the subject.

Information sources and literature search

Searches were performed in electronic databases (Medline and Scopus) to identify all relevant articles published from 1950 to October 2018. The references of articles included in the review were searched, including hand searching, for additional articles. The literature search strategy is available in table 1.

Table 1

Search strategy for the electronic databases

Database	Search strategy
PubMed	((“Tooth, Nonvital”[Mesh] OR “Nonvital Tooth” OR “Tooth, Devitalized” OR “Devitalized Tooth” OR “Tooth, Pulpless” OR “Pulpless Tooth” OR “Teeth, Pulpless” OR “Pulpless Teeth” OR “Teeth, Devitalized” OR “Devitalized Teeth” OR “Teeth, Nonvital” OR “Nonvital Teeth” OR “Teeth, Endodontically-Treated” OR “Endodontically-Treated Teeth” OR “Teeth, Endodontically Treated” OR “Tooth, Endodontically-Treated” OR “Endodontically-Treated Tooth” OR “Tooth, Endodontically Treated”)) AND (“Post and Core Technique”[Mesh] OR “Post-Core Technic” OR “Post-Core Technics” OR “Technic, Post-Core” OR “Technics, Post-Core” OR “Post and Core Technic” OR “Post Technique” OR “Post Techniques” OR “Technique, Post” OR “Techniques, Post” OR “Post Technic” OR “Post Technics” OR “Technic, Post” OR “Technics, Post” OR “Dental Dowel” OR “Dowels, Dental” OR “Dental Dowels” OR “Dowel, Dental”)
Scopus	ALL (“Tooth, Nonvital” OR “Nonvital Tooth” OR “Tooth, Devitalized” OR “Devitalized Tooth” OR “Tooth, Pulpless” OR “Pulpless Tooth” OR “Teeth, Pulpless” OR “Pulpless Teeth” OR “Teeth, Devitalized” OR “Devitalized Teeth” OR “Teeth, Nonvital” OR “Nonvital Teeth” OR “Teeth, Endodontically-Treated” OR “Endodontically-Treated Teeth” OR “Teeth, Endodontically Treated” OR “Tooth, Endodontically-Treated” OR “Endodontically-Treated Tooth” OR “Tooth, Endodontically Treated”) AND ALL (“Post and Core Technique” OR “Post-Core Technic” OR “Post-Core Technics” OR “Technic, Post-Core” OR “Technics, Post-Core” OR “Post and Core Technic” OR “Post Technique” OR “Post Techniques” OR “Technique, Post” OR “Techniques, Post” OR “Post Technic” OR “Post Technics” OR “Technic, Post” OR “Technics, Post” OR “Dental Dowel” OR “Dowels, Dental” OR “Dental Dowels” OR “Dowel, Dental”)

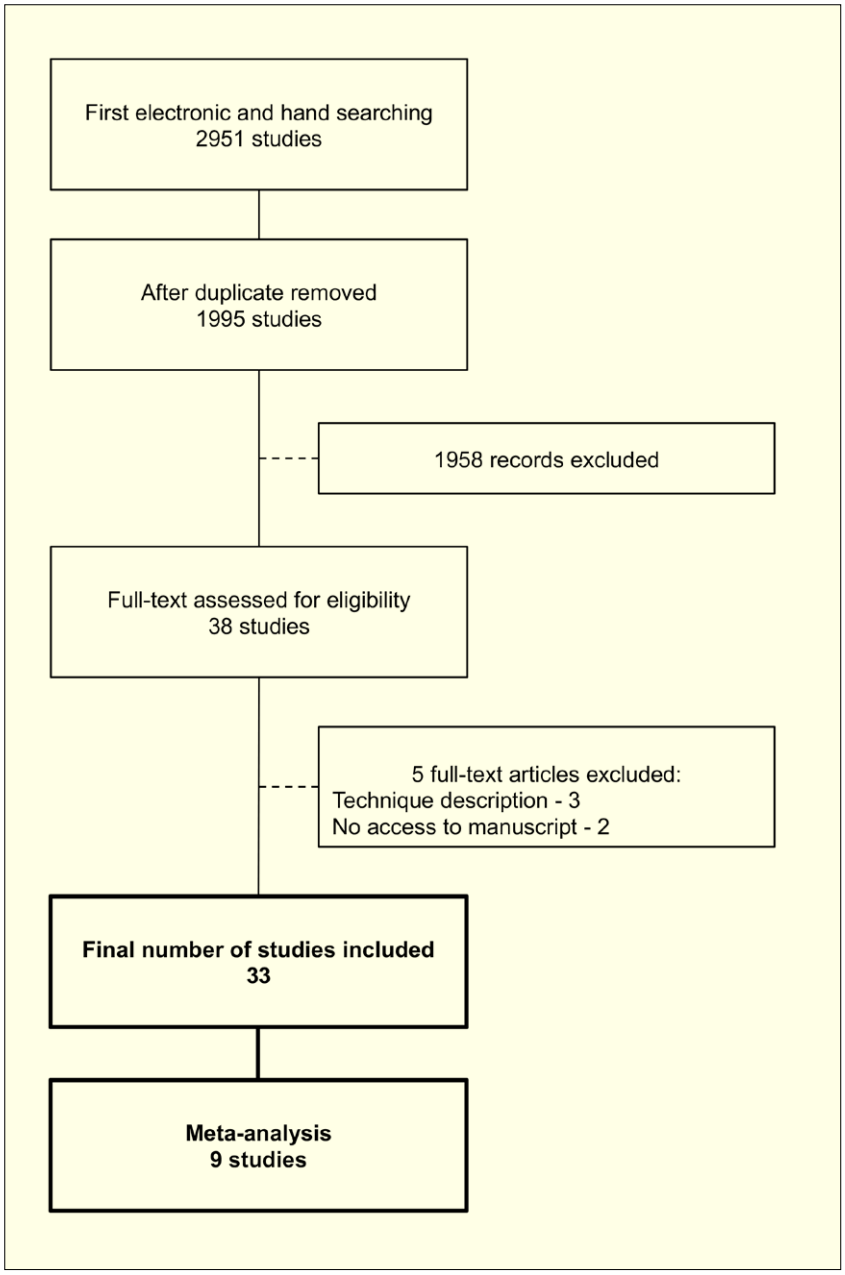

Figure 1
PRISMA flowchart.

Study selection
Literature searches were de-duplicated in the EndNote program. Two independent researchers (LDB and BMV) identified articles by first analyzing titles and abstracts for relevance and presence of the selection criteria listed above. The full-text articles of included and uncertain records were obtained for further eligibility screening by the same two reviewers. Discrepancies in eligibility were resolved through discussion between the two reviewers. In the event of disagreement, the opinion of a third specialist (TPC) was obtained.

Data collection process and data items
Data were collected through Excel (Microsoft Corp, Washington, USA) spreadsheets by the two reviewers, each of them responsible for half of the included studies. A standardized outline was used to extract the main findings of the studies (that is, the results and conclusion) as well as variables as type of technique, type of post and cement were extracted and recorded. The missing data was requested to the authors by e-mail in two attempts. Studies were excluded if there was no reply from the authors or if they did not have the data anymore.

Data synthesis and risk of bias assessment
The estimated effect of pooled data was obtained by comparison of means and was represented by weights between different means ($p<0.05$). The analysis was conducted using Review Manager Software version 5.1 (Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration). Also, a qualitative investigation was made with all papers included. Reports of the studies were assessed for bias using the Cochrane risk of bias tool considering the judgment of the blinding of evaluators, presence of a control group, sample size calculation and sample randomization (9).

Results

Study selection and characteristics
The initial literature search yielded 2,951 studies. After duplicates removal and analysis of titles and abstracts, 38 articles were selected to access the full-text and 33 were included in the review (5 excluded for the following reasons: two studies were not found and three were technique descriptions; PRISMA flowchart – figure 1). All studies were in English. The most used technique was ultrasound removal and bur removal. The characteristics of each included study are presented in table 2.

Table 2
Main characteristics of the included studies

Year	Author	Type of substrate	Endodontic treatment	Post type	Aging /storage	Cement	Groups
2017	Graça et al	Molar	Y	Cast post	Humidity at 37°C for 24h	Zinc phosphate	G1: no cavity/no ultrasonic vibration G2: ultrasonic vibration in the coronal portion G3: cavity in the core G4: cavity in the core and ultrasonic inside the cavity
2014	Abe et al	Canine	Y	Glass fiber	Dry light-protect environment for 30 days	Resin cement	G1: diamond bur and largo reamer G2: ultrasonic insert G3: carbide bur and ultrasonic insert
2013	Ebrahimi et al	Canine and PM	Y	Titanium	Water at 37°C for 7 days	Zinc phosphate	G1: post length 5 mm G2: post length 7 mm G3: post length 9 mm
						Glass ionomer	G4: post length 5 mm G5: post length 7 mm G6: post length 9 mm
						Resin cement	G7: post length 5 mm G8: post length 7 mm G9: post length 9 mm
2013	Feiz et al	Premolar	Y	Alloy Metallic	Thermal cycling machine - 5-55°C 500 cycles 20sec of stay | 10sec transfer time	Resin self-etch	G1: No ultrasonic vibration G2: Ultrasonic vibration
						Resin self-adhesive	G3: No ultrasonic vibration G4: Ultrasonic vibration
2013	Scotti et al	Single-Rooted	Y	G1: Fiber post (D.T. Light-Post)	Humidity at 37°C for 24h	Resin cement	G1: Ultrasonic vibration with one unit without refrigeration
				G2: Fiber post (Hi-Rem)			G2: Manufacturer's instructions
2012	Braga et al	Canine	Y	Copper-aluminum alloy	Distilled water at 37°C for 7 days	Zinc phosphate	G1: control (no ultrasonic vibration)
							G2: device tip positioned close to the incisal edge G3: device tip positioned close to the cementation line
2010	Adarsha et al	Canine	Y	Alloy NiCr	Humidity at room temperature for 3 weeks	Glass ionomer	G1: No ultrasonic vibration (control) G2: Ultrasonic vibration without refrigeration G3: Ultrasonic vibration with refrigeration
						Resin cement	G4: No ultrasonic vibration (control) G5: Ultrasonic vibration without refrigeration G6: Ultrasonic vibration with refrigeration
2010	Davis et al	Canine and PM	Y	Metallic	.	Resin cement	G1: common refrigerant spray for 10s G2: common refrigerant spray for 15s G3: common refrigerant spray for 20s G4: water spray for 10s G5: water spray for 15s G6: water spray for 20s G7: air spray for 10s G8: air spray for 15s G9: air spray for 20s
2010	Lipski et al	Incisor	Y	Prefabricated	.	Zinc phosphate	...
2009	Brito-Júnior et al	Premolar	Y	Alloy CuAl	Humidity at 37°C for 7 days	G1: Zinc phosphate	G1/A: Enac
							G1/B: Profi II
							G1/C: Jet Sonic
						G2: Glass ionomer	G2/A: Enac
							G2/B: Profi II
							G2/C: Jet Sonic

Table 2
Main characteristics of the included studies

2009	Garrido et al	Canine	Y	G1 Core: 5mm Post: 1,3mm	Distilled water at 37°C for 7 days	Zinc phosphate	G1/A: Ultrasonic vibration - 5s on each surface
							G1/B: Ultrasonic vibration with intermittent application of the ultrasonic tip, for 10 s on B and L faces alternately, 10 s on M and D faces in the same way and 5 s on the incisal face
				G2 Core: 1,3x5 mm (DxH) | Post: 1,3mm			G2/A: Ultrasonic vibration - 5s on each surface
							G2/B Ultrasonic vibration with intermittent application of the ultrasonic tip, for 10 s on B and L faces alternately, 10 s on M and D faces in the same way and 5 s on the incisal face
				G3 Core: 1,3x3 mm (DxH) | Post: 1,3mm			G3/A: Ultrasonic vibration - 5s on each surface
							G3/B: Ultrasonic vibration with intermittent application of the ultrasonic tip, for 10 s on B and L faces alternately, 10 s on M and D faces in the same way and 5 s on the incisal face
2009	Soares et al	Canine	Y	Alloy NiCr	Humidity at 37°C for 24h	G1: Zinc phosphate	Burs and tapered diamond burs around the post and Ultrasonic Vibration in all surfaces
						G2: Glass ionomer	
						G3: Resin cement	
2008	Braga et al	Canine	Y	G1/A: Stainless Steel	Distilled water at 37°C for 72h	G1: Panavia F 2.0	Enac OE-5 unit and ST09 tips were applied to the incisal portion of the post, perpendicular to the long axis
				G1/B: Titanium			
				G2/A: Stainless Steel		G2: C&B Cement	
				G2/B: Titanium			
2007	Anderson et al	Single-Rooted	Y	G1: Fiber post (D.T. Light-Post)	100% humidity in opaque bottles individually numbered for 7 days	Resin cement (Duo-Link)	A) D.T. Light-Post kit B) Kodex/Tenax drills C) Diamond and Peeso reamer burs
				G2: Fiber post (ParaPost FiberLux)		Resin cement (ParaCem Universal DC)	A) D.T. Light-Post kit B) Kodex/Tenax drills C) Diamond and Peeso reamer burs
2007	Campos et al	Incisor	N	No post	37°C under 100% humidity for 24 h	Zinc phosphate	G1: control (no post)
				CuAlZn alloy			G2: Carbide bur G3: Ultrasound
				PdAg alloy			G4: Carbide bur G5: Ultrasound
2007	Ettrich et al	Not found	Y	Stainless steel	Water bath at 37°C and 100% humidity	Zinc phosphate	G1: no coolant G2: air-cooled G3: water-cooled
2007	Queiroz et al	Single-Rooted bovine	Y	PdAg alloy	Distilled water at 37°C for 72h	Zinc phosphate	G1: with coronal anatomy reproduced G2: without coronal anatomy reproduced
2006	Braga et al	Canine	Y	G1: Glass-Fiber	Distilled water at 37°C for 72h	Resin cement	G1: Instron 4444
				G2: Alloy CuAl			G2: Instron 4444
2005	Braga et al	Canine	Y	Alloy CuAl	Distilled water at 37°C for 72h	Resin cement	G1: Ultrasonic vibration with one unit for 30s on each surface G2: Ultrasonic vibration with one unit for 60s on each surface G3: Ultrasonic vibration with two units for, for 30s on two opposed surfaces at the same time G4: Ultrasonic vibration with two units for, for 60s on two opposed surfaces at the same time G5: No ultrasonic vibration (control)

Table 2
Main characteristics of the included studies

2005	Dominici et al	Incisor	Y	Titanium	100% humidity for 30 days	Zinc phosphate	.
2005	Lindemann et al	Premolar	Y	G1: ParaPost XH (control)	Wrapped in paper towel moistened with water and stored in plastic bags for 24h	ParaPost Cement	G1 Method 1 Ruddle Post Removal System-PRS with refrigeration G1 Method 2 Diamond burs and Ultrasonic vibration
				G2: ParaPost Fiber White			G2 Method 1 Performed according with the manufacturer's instructions G2 Method 2 Diamond burs and Ultrasonic vibration
				G3: Luscent Anchors			G3 Method 1 Performed according with the manufacturer's instructions G3 Method 2 Diamond burs and Ultrasonic vibration
				G4: Aesthetic-Plus			G4 Method 1 Performed according with the manufacturer's instructions G4 Method 2 Diamond burs and Ultrasonic vibration
2005	Pečiulienė et al	Single-Rooted	Y	Cast Post	.	G1: Zinc phosphate	MasterPiezon 400 (EMS) with a D4 (EMS) ultrasonic tip
						G2: Modified glass ionomer for resin	
2003	Chandler et al	Canine	N	Titanium	Saline bath at 37°C	Resin cement	G1: Control G2: Trephination G3: Ultrasound
2003	Gesi et al	Anterior	Y	G1: Tapered Fiber	Water for 48h	G1: Dual-Cure	G1/A: Kit RDT G1/B: 1 diamond bur and 1 Largo bur
				G2: Glass-Fiber		G2: Excite DSC and Variolink II	G2/A: Kit RDT G2/B: 1 diamond bur and 1 Largo bur
				G3: Carbon Fiber		G3: Duo-Link Cement	G3/A: Kit RDT
							G3/B: 1 diamond bur and 1 Largo bur
2003	Hauman et al	Canine	Y	Parapost (SS)	Saline at 37°C for 14 days	Zinc phosphate	G1: vibration G2: no vibration
						Glass ionomer	G3: vibration G4: no vibration
						Resin cement	G5: vibration G6: no vibration
				Parapost (Ti)		Zinc phosphate	G7: vibration
						Glass ionomer	G8: vibration
						Resin cement	G9: no vibration
2002	Castrisos et al	Single-Rooted	Y	Non-precious alloy	.	Zinc phosphate	G1: 1 mm of dentine thickness G2: 2 mm of dentine thickness
2002	Dixon et al	Canine	Y	Alloy Stainless Steel	Natural water at room temperature for at least 2 months	Zinc phosphate	G1: Instron 444 G2: Spartan Ultrasonic G3: Enac Ultrasonic

Table 2
Main characteristics of the included studies

2001	Bergeron et al	Canine	Y	Titanium	37°C under 100% humidity for 14 days	Zinc phosphate	G1: vibration and Root's 821 Elite Sealer G2: no vibration and Root's 821 Elite Sealer G3: vibration and AH26 Sealer G4: no vibration and AH26 Sealer
						Resin cement	G5: vibration and Root's 821 Elite Sealer G6: no vibration and Root's 821 Elite Sealer G7: vibration and AH26 Sealer G8: no vibration and AH26 Sealer
1996	Johnson	Premolar	Y	Parapost (SS)	37°C and 100% humidity for 30 days	Zinc phosphate	G1: Control (no vibration) G2: Ultrasonic for 4 minutes
							G3: Ultrasonic for 12 minutes G4: Ultrasonic for 16 minutes
1994	Buoncristiani	Single-rooted	Y	Titanium	100% humidity for 24 h	Zinc phosphate	G1: Control (Cavitron ultrasonic) G2: Neosonic ultrasonic G3: Enac ultrasonic G4: Micro mega sonic selaer G5: Densonic sonic sealer

Risk of bias of the included studies
From the 33 studies included, almost all presented unclear risk of bias (figure 2). The parameters considered in the analysis were the presence of a control group, blinding of evaluators, sample size calculation and sample randomization.

Results of individual studies and synthesis of results
Two types of outcomes were extracted from the 33 papers selected: time of post removal (11-21) and force required for post dislodgment or removal. Due to different methodologies and materials employed in those papers, a meta-analysis was only possible to be done with nine studies regarding the force needed to dislodge the intraradicular posts (11, 22-29). The main reasons for the impossibility of gathering data in the meta-analysis were varying types of posts, cements (resin-based, zinc phosphate, glass-ionomer-based) but especially various techniques employed for post removal as ultrasonic vibration with totally different protocols, use of kits for removal or use of diamonds/largo burs. Also, three papers were excluded and could not be included in the meta-analysis as it was impossible to extract the data (data presented in graphs – even after contact with the authors to obtain raw data or not enough data available to run the analysis) (18,30,31). The analysis using a random-effect model showed that the necessary force to remove prefabricated and cast metal posts is decreased in 64.03 N (53.95-74.12; $p<0.00001$, figure 3) when using ultrasonic vibration.

Descriptive analysis
Due to heterogeneous datasets, a descriptive analysis was the only option to describe the results of the other included studies. Not only the type of post and type of luting material were different among the included studies, but also the intervention method to evaluate post removal was also distinct. Even when ultrasonic vibration was assessed, the duration of ultrasonic vibration used (6, 16, 22, 32) and the use or not of water spray (11, 16, 33, 34) were also evaluated, leading to various scenarios that impaired the analysis. Still, it was possible to observe that the longer the duration of using ultrasonic vibrations (as well as the number of surfaces where the vibration was applied), the lower the time or the force needed to dislodge the post.
The influence of the dentist's expertise was also evaluated. Irrespective of the technique used to remove the post, a dentist with more than ten years of expertise in endodontics removed the post in less

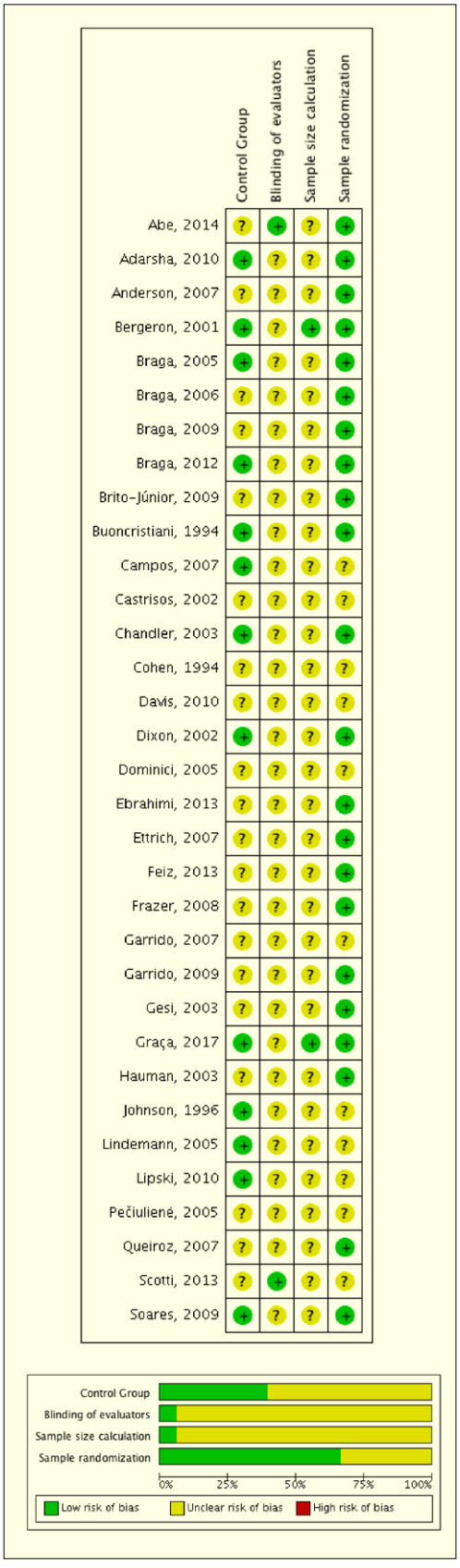

Figure 2
Assessment of risk of bias of included studies.

time compared with an undergraduate student (20). Still, concerning the time spent to remove the post, a comparison regarding the type of material used for cementation was possible. Three studies found that posts cemented with zinc phosphate took less time to be removed when compared to glass ionomer cement irrespective of the method used (14, 19, 35). However, when compared with resin-based cement, both presented lower time needed to remove the post (21, 31, 35). Besides, regarding the force necessary to dislodge the post, one study found no difference between zinc phosphate, glass ionomer and resin-based cements (25), while another study evaluated resin-based and glass ionomer-based cement and concluded that it seems to be technique-dependent (11).
One important clinical issue is the removal of a coronal portion of the post until the cement line is visualized, which could clinically help post removal; however, only two studies reported this issue in the methodology (14, 27).
As for the material of the post, one study considered time needed to remove different types of posts and found that titanium posts took more time to be removed than fiber posts (31). Three studies compared post resistance. Glass fiber posts required more force to be removed compared to cast post (13) while titanium and glass fiber posts removal were dependent on the cement brand used (22). When titanium and stainless steel posts were compared, no difference was found (25).

Discussion

This is the first systematic review comparing various techniques available to remove intraradicular posts and it has shown that time spent to remove a post using an ultrasound device is statistically significantly lower compared to other techniques for cast metal posts.
It seems that ultrasonic energy would be helpful for fiber post removal, but the evidence is not as strong as for cast metal posts. Besides, when considering post removal, a series of actions should be care-

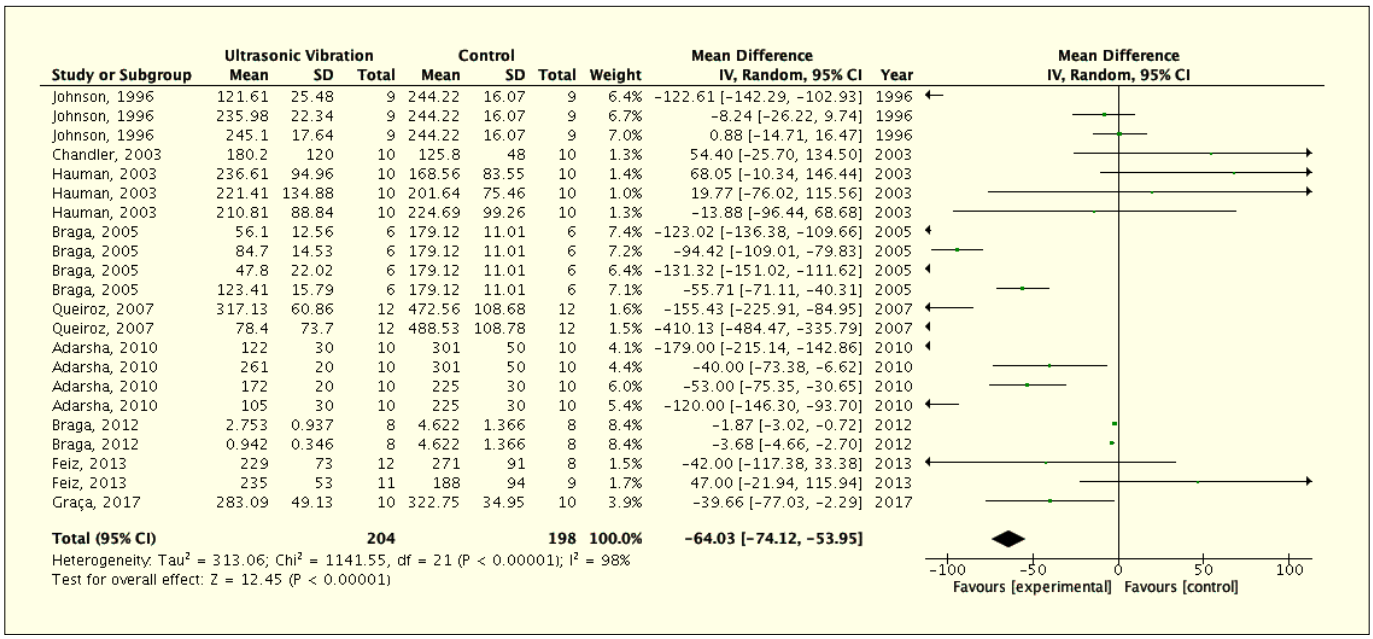

Figure 3
Results of meta-analysis. Best results are shown for ultrasonic vibration group (p<0.00001).

fully planned to avoid iatrogenic perforations or root fractures, including an X-ray. Techniques as use of trephines, hemostats or forceps are less used because of disadvantages as the procedure takes longer time, it removes more sound dental structure, and there is a need of the presence of a coronal structure for the apprehension of the instrument. The use of these specific devices to break the cement and pull out the post is only possible when a passive post has been used as there is a risk of a root fracture in active posts. These techniques, although reported in the literature, were not included in our study, as force is impossible to be measured, but also because no reports were found comparing those techniques.

When drilling out a post with diamond burs, there is sound dental structure removal, but this is lower when compared to the other technique cited above and is a feasible option to be used together with ultrasonic devices. On that situation, there is a difference between metallic and glass fiber posts removal. For the former, the idea is to open space for the post to be dislodged. Also, the technique is to diminish the metallic post diameter and height to expose the cement. Yet, for the fiber posts the technique is intended to drill the post completely.

Ultrasonic energy is effective when used to remove metal posts, as these materials are rigid and present high elastic moduli, allowing vibrations to be conducted along the post, reducing the necessary force for removal. On the other hand, for fiber posts, the use of this technique still remains uncertain, as there is not enough information to draw definitive conclusions. The use of ultrasonic devices present the advantage of less chair time, although it presents higher cost and possibility of generating dentin micro cracks. When the use of ultrasonic device is not enough to dislodge the post, drills may be additionally used for final removal (13, 19, 21, 29). However, when considering glass fiber posts – and their low elastic modulus – the scenario may be different. Glass fiber posts are more difficult to be removed with ultrasonic devices, as not only the elastic modulus will negatively influence on the breaking of cement, but the cement itself is usually a resin-based cement, which neutralizes vibrations, absorbing the energy (21). Thus, it seems reasonable to indicate post drilling when a fiber post is to be removed.

Regarding the bonding agent, zinc phosphate took less time to be removed when compared to glass ionomer cement irrespective of the method used (14, 19, 35). When comparing these two cements with resin-based cements, both demonstrated low-

er time for removal (21, 31, 35). Historically, cast metal posts were cemented with zinc phosphate, which allows easy rupture when ultrasonic energy is used. Resin-based cements available are used to lute any type of post and the difficulty on its removal is possibly due to a better dentin union when compared to zinc phosphate and glass ionomer cements. In contrast, some authors report that the heat of ultrasonic devices would decrease adhesive characteristics of resin-based cements, leading to similar results when compared to the other cements (36).
The impossibility of comparing time difference to remove different post types and cements is one of the limitations from the present study, and it is justified by the high heterogeneity of the present data. There is need of standardized studies, even if they are in vitro. Details as sample size calculation, randomization, use of control/comparison group, measurement of time for post removal, blinding of the operator, when possible, are usually reported in clinical trials and should be present also in in vitro studies. Specifically, the authors must choose a technique and vary the type of cement and type of post or other variables, as presence or not of water-cooling. Considering that cast metal posts, glass fiber posts and resin cements are the most commonly selected materials (37), those must be selected for future studies.
In the present review, no conclusive advice can be given for fiber posts removal in clinical practice, due to limited data regarding it or the lack of standardized studies with this type of post. In addition, if a post is cemented with resin-based cement, glass ionomer and zinc phosphate, the bond strength of the first is higher than the others (36), leading us to believe that if there is a best technique to remove a post cemented with resin cement, probably it will be the best for the other types of cements. Considering the increased use of fiber posts, fur-

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ther research must be conducted for this material. Also, non-destructive techniques as MicroCT and cone beam could be helpful to measure the amount of dentin lost during the removal process.

Conclusions

Based on the findings from the present study, the use of an ultrasonic device seems to be the best technique when removing metal posts, although it seems less predictable for removing non-metal posts. Type of cement, post design, and length are important co-factors. More studies are necessary to draw more precise conclusions.

Clinical Relevance

When there is a need for removal of an intraradicular post, the use of an ultrasonic device is the best technique for metal post, although it is less predictable for non-metal posts. Post design, length, and type of cement are co-factors and should be considered as well.

Conflict of Interest

The authors deny any conflicts of interest.

Acknowledgments

This study was financed in part by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brazil (CAPES) – Finance Code 001, #88882. 346903/2019-01. TPC is partially funded by the National Council for Scientific and Technological Development (CNPq - Brazil) and FAPERGS - PRONEX #16/2551-0000471-4. The funders had no role in the study design, data collection, and analysis, decision to publish or preparation of the manuscript.

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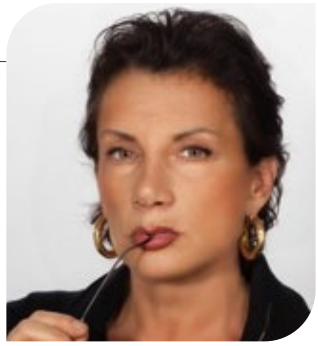

19 anni fa, per l'esattezza, ho fatto il mio ingresso come Socio Attivo della Società Italiana di Endodonzia.
Devo molto alla nostra Società, gli stimoli maggiori sono legati alla ricerca del miglioramento continuo della mia attività clinica e alla necessità di adeguarmi, aggiornandomi e ascoltando i consigli e i suggerimenti di coloro che, da sempre, ho considerato i nostri maestri.
Tutti abbiamo bisogno di migliorare in continuazione e tutti dobbiamo con umiltà riconoscere coloro i quali, in modi diversi, ci hanno aiutato a crescere professionalmente.
La SIE ha assunto in questo modo la forma di una Scuola di diversi pensieri, tutti interessanti e ben supportati.
Durante i miei mandati come Segretario della Regione Liguria ho presentato al Consiglio in carica di allora la proposta di iniziare un percorso di formazione post laurea da svilupparsi a livello regionale: il progetto é stato prontamente approvato ed è stato collaudato dapprima all'interno della nostra Regione e poi esportato nelle altre Sezioni Regionali, con un successo che sicuramente ha superato le mie aspettative.
Il progetto ha dato la possibilità alla nostra Società, negli anni, di condurre una capillarizzazione della formazione endodontica a km 0 conferendole una caratteristica che può essere considerata una nostra esclusiva peculiarità.
Le tecniche moderne supportate da strumentario all'avanguardia hanno reso l'Endodonzia più predicibile e i risultati iconograficamente molto apprezzabili, ma la conoscenza endodontica deve avere un più ampio traguardo.
I giovani odontoiatri devono associare alla manualità un adeguato aggiornamento mediante le letture delle pubblicazioni scientifiche e questo arricchimento dovrebbe essere fatto con regolarità per poter ottenere una buona base culturale, per questo motivo ho pensato e fortemente voluto SIE ACADEMY: il nostro nuovo Socio Attivo deve essere formato e stimolato a una preparazione con più ampia visione dove l'elemento dentale deve essere inquadrato nella giusta integrazione che permetta una considerazione delle diverse patologie odontoiatriche; l'interazione con le varie specialità è necessaria per evitare una compartizzazione alienante della conoscenza professionale, per questo motivo l'aggiornamento attraverso i giornali dedicati deve essere continuo e approfondito.
Per ultimo, ma non ultimo, la mia presidenza, per quanto singolare poiché vicariante, ha finalmente aperto un confine fino a oggi ben chiuso, sono infatti fiera di essere la prima donna a ricoprire questa carica, ma sono anche certa che le mie colleghe più giovani preparate ed estremamente decise nelle "competizioni" con i colleghi, sapranno continuare questo percorso con il successo che meritano.
La nostra Società è in salute e questo risultato deve essere attribuito a un costante impegno da parte di tutti i componenti del Consiglio, ma anche dei soci che veramente si sono dimostrati "Attivi" e che in modo compatto e con entusiasmo hanno ben lavorato dedicando tempo e risorse al bene della Società.
Inoltre, abbiamo una collaboratrice eccezionale nella nostra preziosa Gaia che con competenza ed efficacia conduce la complessa gestione della Segreteria.
È inutile nascondere che i lunghi anni trascorsi mi hanno fatto assistere a diatribe infuocate, più o meno giustificate, ma penso utopisticamente che le battaglie dovrebbero sempre essere condotte con eleganza e con rispetto e che, soprattutto attualmente, esista la necessità di pensare al bene futuro solo e sempre della Società.

SIE per sempre!

Il Presidente SIE
Dott.ssa Maria Teresa Sberna

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Qualsiasi Socio Ordinario, con i requisiti necessari, può presentare la documentazione per ottenere la qualifica di Socio Attivo. Il Socio Aggregato che volesse presentare la documentazione scientifica e clinica a integrazione di quella clinica già approvata dalla CAS per lo status di socio Aggregato, potrà farlo già dall'anno successivo all'ottenimento della sua qualifica.
Un meccanismo a punti è stato introdotto per valutare il candidato a Socio Attivo. Un minimo di 200 punti è richiesto per divenire Socio Attivo.
Nella domanda non potranno essere presentati casi la cui somma superi i 240 punti per la qualifica di Socio Attivo.
La documentazione scientifica potrà essere presentata, a completamento della documentazione clinica, solo per la domanda per divenire Socio Attivo e non potrà superare i 100 punti.
La documentazione clinica dovrà presentare un minimo di sei casi, di cui almeno 4 di molari pluriradicolati con delle precise tipologie: tra questi casi almeno uno deve essere un ritrattamento con lesione visibile nella radiografia preoperatoria e dei restanti tre almeno due devono avere una lesione visibile nella radiografia preoperatoria.
La documentazione clinica non deve presentare più di un caso di Endodonzia Chirurgica Retrograda con immagini e non più di uno senza immagini.
La documentazione scientifica non potrà presentare più di due articoli come coautore.

MODALITÀ DI DOCUMENTAZIONE DEI CASI CLINICI

Criteri e modalità per la valutazione dei casi clinici idonei ad accedere alle qualifiche di Socio Aggregato e di Socio Attivo sono espressi nell'apposita sezione del Regolamento della Società Italiana di Endodonzia (SIE) all'indirizzo web: www.endodonzia.it.

CRITERI DI VALUTAZIONE

I casi clinici verranno valutati nel loro complesso, coerentemente con gli scopi e fini della SIE, e devono essere presentati dai Candidati considerando non solo l'aspetto clinico, ma anche quello formale della documentazione presentata.
La documentazione scientifica verrà valutata considerando la classificazione ANVUR delle Riviste Scientifiche, i documenti scientifici dovranno essere tutti di pertinenza endodontica.

ADEMPIMENTI DEL CANDIDATO

La domanda di ammissione allo status di Socio Aggregato/Attivo, rivolta al Presidente della SIE, dovrà pervenire, insieme alla documentazione di seguito elencata, alla Segreteria della SIE con un anticipo di 20 giorni sulle date di riunione della CAS, sufficiente per poter organizzare il materiale dei candidati. Le date di scadenza saranno rese note sul sito. La domanda dovrà essere firmata da un Socio Attivo in regola con la quota associativa per l'anno in corso, il quale dovrà aver esaminato e approvato la documentazione. Quest'ultimo è responsabile della correttezza clinica e formale della documentazione presentata.

PRESENTAZIONE DEI CASI ALLA COMMISSIONE

La presenza del Candidato è obbligatoria durante la riunione della CAS; è altresì consigliabile la presenza del Socio presentatore.

LA COMMISSIONE ACCETTAZIONE SOCI

La CAS (Commissione Accettazione Soci) è formata cinque Membri di indiscussa esperienza clinica, quattro Soci Attivi con almeno cinque anni di anzianità in questo ruolo eletti a ogni scadenza elettorale dall'Assemblea dei Soci Attivi e Onorari e uno dei Past President della Società incaricato dal CD a ogni riunione. Compito della CAS è quello di esaminare e valutare la documentazione presentata dagli aspiranti Soci Aggregati e Soci Attivi. Per rispetto del lavoro dei Candidati e per omogeneità di giudizio, in ogni riunione CAS verranno valutati non più di 12 candidati a Socio Attivo; resta libero, invece, il numero dei candidati a Socio Aggregato valutabile in una singola riunione. Il Consiglio Direttivo (CD) incaricando la Commissione Accettazione Soci (CAS) la rende responsabile dell'applicazione delle regole descritte nell'articolo 2 del regolamento. Il giudizio della CAS è insindacabile.

MEMBRI DELLA COMMISSIONE ACCETTAZIONE SOCI 2019

Past President della Società
Dott. **Enrico Cassai**
Dott. **Marco Colla**
Dott. **Mario Mancini**
Dott. **Pier Luigi Schirosa**

HYGIENIO: IL SANIFICATORE

L'evoluzione nel campo della disinfezione

Hygienio è l'innovativo metodo di applicazione a caldo del disinfettante sulle superfici, permette una **disinfezione dell'ambiente operativo a 360°**: innumerevoli prove e test di laboratorio hanno certificato un abbattimento della carica microbica superiore al 99,999%.

Hygienio utilizza un **sistema tecnologico brevettato** in grado di miscelare in modo automatico ed equilibrato vapore saturo secco e disinfettante nebulizzato, questa esclusiva tecnologia permette di disinfettare tutte le superfici presenti in un ambiente rapidamente e con **riutilizzo immediato degli spazi e delle attrezzature**.

L'attività di disinfezione diviene **semplice e rapida** grazie ad una pratica lancia irrigatrice ed evita il contatto diretto con le superfici da e verso l'operatore eliminando il rischio di trasporto di cariche batteriche.

La miscela vapore-disinfettante generata da Hygienio a contatto con le superfici condensa per poi asciugarsi rapidamente depositando un sottile strato omogeneo di disinfettante.
La pellicola di disinfettante essendo finissima ed autoestinguente in 18/24 ore, non necessita di risciacqui e quindi garantisce un **effetto batteriostatico duraturo nel tempo**.

Il disinfettante consigliato, **Adantium Plus**, è un preparato di sintesi di ultima generazione a spettro totale di abbattimento: **batteri, micobatteri, spore funghi e virus**, notificato presso l'istituto superiore di sanità italiano (CE0373) e pertanto risponde a tutte le normative vigenti dettate del CEN (Comitato Europeo Normativo).

Adantium Plus risulta **atossico** al 99,999% e **biodegradabile** al 94%, e garantisce quindi l'uso in **totale sicurezza** e conformità ai disposti della Legge sulla Sicurezza (D.lgs. 81/08 e s.m).

Un'adeguata ed integrale disinfezione dello Studio Odontoiatrico è finalmente possibile con Hygienio ed Adantium Plus.

F22ALIGNER
BIOLOGIC TEETH ALIGNER

sweden & martina

L'ultima generazione di allineatori ortodontici

F22 è un sistema di sottili allineatori trasparenti realizzati su misura con un esclusivo materiale plastico super trasparente per guidare delicatamente lo spostamento graduale e progressivo dei denti verso la posizione desiderata.

Tutto il ciclo di fabbricazione del sistema F22, dalla progettazione alla produzione, è interamente **svolto in Italia**. Frutto della ricerca pluridecennale condotta dal team del **Prof. Siciliani** presso l'**Università di Ferrara**, F22 nasce da uno studio sui pazienti che si perpetua negli anni e che ha permesso di analizzare ogni aspetto di questo trattamento, apportando continue evoluzioni fino a renderlo il sistema di **mascherine trasparenti** più avanzato attualmente proposto nel mercato. Gli allineatori sono realizzati a Padova, nel **Centro F22** di Sweden & Martina, mediante stampanti tridimensionali di ultima generazione e sono controllati in ogni fase della lavorazione.

F22 offre ai dentisti il servizio di tutoraggio per tutta la durata del trattamento, consentendo, se desiderato, un confronto diretto e immediato con un team di ortodontisti esperti. Attraverso un esclusivo **visualizzatore 3D** l'odontoiatra può interagire con il team di ortodonzisti dell'Università di Ferrara, e verificare il **piano di trattamento**. Lo stesso visualizzatore consente di illustrare al paziente le aspettative di progressivo spostamento dei denti fino al risultato ottimale pianificato. L'esclusivo materiale stratificato **EvoFlex** con cui è prodotto F22 garantisce elevata flessibilità e rende l'allineatore fino al 17% più trasparente di qualsiasi altro allineatore. L'assenza di difetti strutturali, corretti e verificati manualmente prima della consegna al cliente, permette alla luce di passare fino al 20% in più rispetto a quanto avviene con altri allineatori, per un effetto ancora più naturale. Le ricerche e gli studi pubblicati dimostrano che anche in condizioni estreme la superficie perfettamente liscia e le proprietà del materiale garantiscono assenza di ritenzione di pigmenti: F22 Aligner mantiene inalterata la sua **trasparenza** nel tempo. Grazie al contatto completo tra le mascherine e l'arcata, il controllo dei movimenti dentari è molto preciso e i risultati altamente predicibili. Le forze impresse, seppur leggere, sono trasmesse completamente, per un controllo totale dei movimenti dentari, pertanto l'allineatore F22 è in grado di attivare i movimenti di correzione sin dal primo giorno in cui viene indossato. È più **confortevole** per il paziente, poiché minimizza i possibili dolori durante lo spostamento progressivo dei denti, inoltre protegge dal bruxismo, in quanto elastico. Ha una **resistenza allo strappo** e alla trazione del 300% più alta rispetto alla media di altri materiali. L'allineatore è molto confortevole per il paziente, in virtù dell'**elevata elasticità** e dei margini arrotondati e privi di rugosità. I bordi sono rifiniti a mano con particolare cura attraverso una speciale tecnica messa a punto dalla **Scuola di Specializzazione in Ortognatodonzia di Ferrara**.

Per maggiori informazioni si consulti: www.f22aligner.com

Morita: Modern treatment systems for perfect procedures

Endodonzia Sicura… passo per passo

Il primo passo in ogni trattamento endodontico di successo è **una diagnosi precisa** basata su immagini 3D accurate ad alta risoluzione fornite dalla tomografia computerizzata a cone-beam (CBCT).
Morita supporta questi obiettivi diagnostici con il suo nuovo sistema a raggi X **Veraview X800** per immagini 3D, panoramiche e cefalometriche.

Vantaggi

- Questo apparecchio offre un livello di qualità dell'immagine senza precedenti in un sistema di imaging 2D/3D (risoluzione: 2,5 LP/mm MTF).
- È versatile! Non solo produce immagini rapide e accurate, ma fornisce anche la massima sicurezza per l'operatore e il paziente con dosi minime efficaci (ALARA). Infatti il sistema utilizza il collaudato campo R100 di riduzione della dose con la sua forma Ruleaux (triangolare).
- Esposizioni in modalità di 180 gradi e 360 gradi, esposizioni cefalometriche veloci in soli 3,5 secondi, o una funzione di ricostruzione dello zoom che crea una registrazione di 80 µm da una registrazione voxel 125 µm senza richiedere un Retake.

Morita è inoltre sinonimo di…

Precisione e sicurezza per il canale radicolare: una volta che l'endodontista procede alle effettive procedure intraorali, sono disponibili diversi strumenti di alta qualità per assistere il suo delicato lavoro. Per una comoda preparazione della cavità di accesso, Morita offre le **potenti turbine TwinPower** e i **manipoli della serie TorqTech e Tokyo**; offrendo una coppia massima a piccoli diametri dello strumento, forniscono una buona vista dell'area di lavoro e spazio sufficiente durante il trattamento dei molari.

Nelle fasi successive essenziali del trattamento – misurazione, strumentazione, riempimento e polimerizzazione – Morita offre una soluzione innovativa per tutti questi tre step, **il nuovo motore endodontico TriAuto ZX2 con localizzatore Apicale.**
ITriAuto ZX2 è l'unico sistema del suo genere che integra la localizzazione Apicale e la preparazione del canale radicolare in un unico manipolo: è stato progettato per la massima sicurezza ed è dotato sia della funzione OTR che della nuova funzione ottimale glidepath.
L'OTR cambia la direzione di rotazione del file non appena viene superato il livello di coppia pre-impostato singolarmente. Dopo aver invertito la rotazione di 90 gradi, torna a ruotare nella direzione di taglio; se la coppia è ancora troppo alta, il processo viene ripetuto tre-quattro volte dopo un ulteriore 180 gradi. Questo sistema aiuta a conservare la morfologia originale del sistema dei canali radicolari e facilita la rimozione affidabile dei detriti. Tutti questi fattori si combinano per abbreviare il tempo di trattamento.
L'OGP fornisce una preparazione rapida e automatizzata del glide-path, che è la prima fase di preparazione effettiva, e quindi prepara il canale radicolare per procedure endodontiche sicure. In combinazione con la funzione del dispositivo, il clinico può portare lo strumento endodontico fino alla lunghezza di lavoro senza fratture, ostruzione o formazione di sporgenza. Semplicemente ingegnoso e assolutamente sicuro. Un display LCD fornisce un feedback completo dal canale radicolare mostrando i dati di misura esatti acquisiti dal manipolo, soprattutto la distanza del file dall'apice.
Quindi il TriAuto ZX2 conserva la struttura dentale naturale e rende il trattamento ancora più efficiente perché è richiesto solo un numero limitato di file.
Un'altra caratteristica sorprendente di questo sistema endodontico è la sua **piccola testina e il peso ridotto** (140 g), che lo rende molto maneggevole. Essendo un **apparecchio cordless** migliora significativamente la flessibilità di trattamento e ottimizza il flusso di lavoro clinico. Il funzionamento semplice e intuitivo e le funzioni automatizzate assicurano risultati affidabili e sicuri in ogni momento.

LA MISSION DI MORITA

Morita offre un portfolio completo di prodotti di alta qualità che coprono tutte le fasi del trattamento, dalla diagnosi al controllo, permettendo di lavorare sempre in modo efficiente, ergonomico e sicuro. I dentisti apprezzeranno la convenienza e i pazienti apprezzeranno il comfort di un trattamento migliorato. Il nuovo sistema di imaging Veraview X800 2D/3D e il nuovo motore TriAuto ZX2 endo con localizzatore Apex mettono in primo piano la sicurezza e rappresentano nuovi standard nei loro segmenti. Queste soluzioni sottolineano l'impegno di Morita: rispondere alle esigenze degli utenti e dei pazienti in ogni fase e continuare a fornire il "Gold standard" per il successo del trattamento nella pratica endodontica.

EdgeEndo

PERFORMANCE. PRICE. TECHNOLOGY.

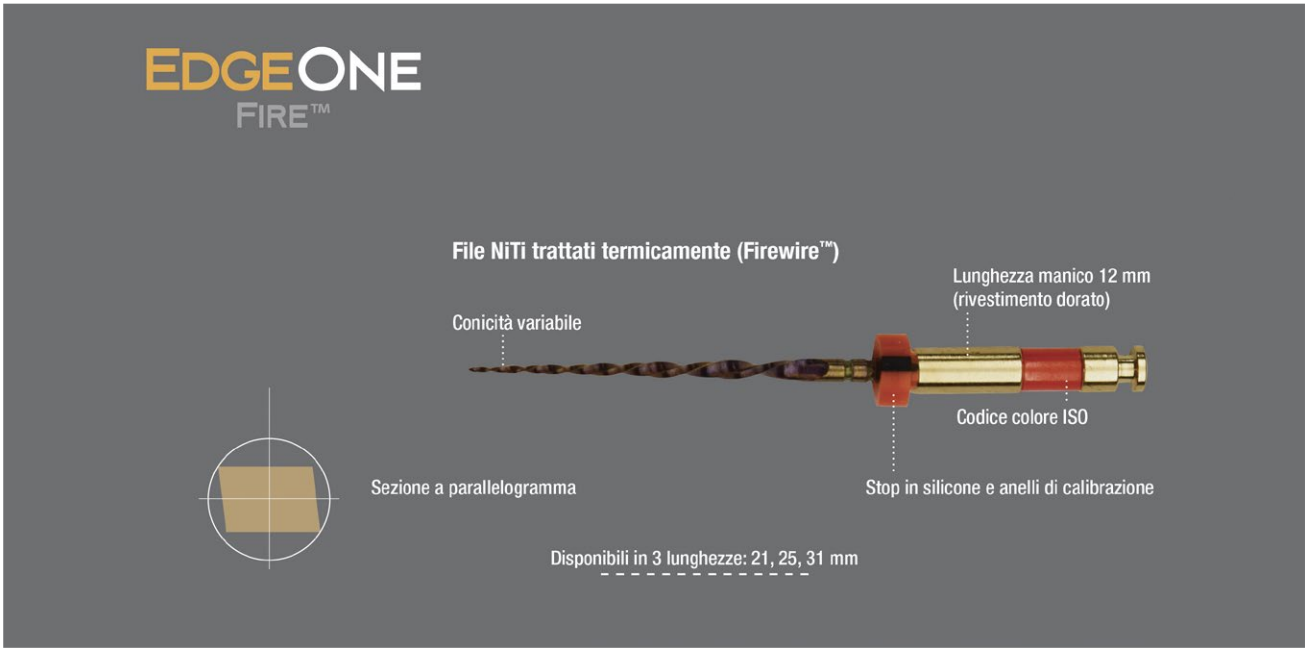
EdgeEndo offre prodotti e soluzioni endodontiche di altissima qualità con tecnologie all'avanguardia e un ottimo rapporto qualità/prezzo.
Con le linee **EdgeTaper, EdgeTaper Platinum, EdgeOne Fire** (reciprocanti) i file EdgeEndo garantiscono velocità e sicurezza nei trattamenti endodontici e grandi vantaggi sia per gli operatori che per i pazienti.
L'applicazione alla strumentazione rotante della nuova tecnologia **FireWire™** rende gli strumenti più flessibili e più resistenti alla fatica ciclica.
Consente altresì un approccio minimamente invasivo sulla dentina, in virtù di un minore ritorno elastico; ciò permette agli strumenti di rispettare meglio l'anatomia originale e seguire il tragitto canalare in modo più semplice, preciso ed efficace.
La linea di file reciprocanti EdgeOne Fire riduce il numero di strumenti necessari per la sagomatura, gli strumenti presentano una conicità variabile, con una riduzione del diametro massimo delle spire (MFD), che facilitano il taglio e minimizzano l'effetto di avvitamento. Inoltre grazie al nuovo trattamento **FireWire™** gli strumenti risultano due volte più resistenti alla fatica ciclica rispetto agli altri.

La parola ai clinici che usano con grande soddisfazione i file EdgeEndo

"Ho recentemente paragonato i file **EdgeEndo NiTi** alle sistematiche da me utilizzate. Sono stato piacevolmente sorpreso dalla loro flessibilità, durevolezza e resistenza alla frattura. Vantaggio più importante per me è stato

poterli utilizzare senza apportare variazioni alla mia tecnica di preparazione, ottenendo risultati altrettanto validi con un significativo risparmio economico. EdgeEndo è entrato a far parte della quotidianità dei miei trattamenti clinici".
Prof. Gianluca Gambarini, Università La Sapienza, Roma

"Utilizzando gli strumenti rotanti **EdgeEndo** ho trovato una sequenza molto semplice anche per i casi più complessi. Gli EdgeEndo Ni-Ti più recenti, ancora più flessibili e resistenti, possono essere utilizzati per più casi ma, allo stesso tempo, essere considerati monouso per il loro costo.
Qualità, semplicità e risparmio: evoluzione per la moderna endodonzia alla portata di tutti."
Dott. Mario Marrone, Odontoiatra, Palermo



Per info
Dental Trey srl | Via Partisani, 3 | 47016 Fiumana-Predappio (FC), Italia
T +39 0543 929111 | F +39 0543 940659 | **www.dentaltrey.it | commerciale@dentaltrey.it**

VITA SOCIETARIA

Moderna Endodonzia tra Tecnologia ed Esperienza

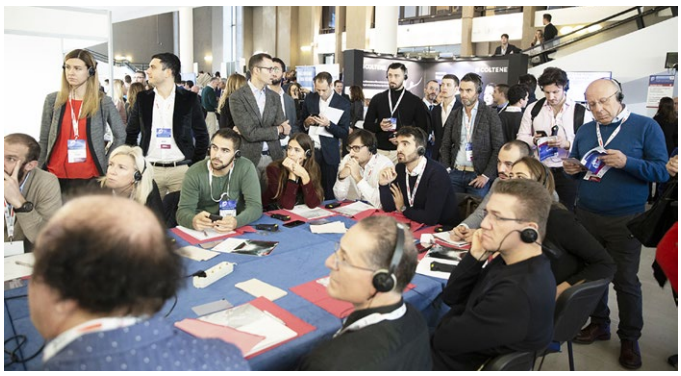
Bologna, 7-9 Novembre 2019
Palazzo della Cultura e dei Congressi

Resoconto del 36° Congresso Nazionale SIE

Nelle giornate di Giovedì 7, Venerdì 8 e Sabato 9 Novembre si è svolto presso il Palazzo della Cultura e dei Congressi di Bologna l'importante Congresso Nazionale della Società Italiana di Endodonzia (SIE), dal titolo **Moderna Endodonzia tra tecnologia ed esperienza.**
Il Congresso è stato accreditato ECM dal CIC Provider e patrocinato dal Comune di Bologna, da FNOMCeO, dal CLOPD - Collegio dei Docenti Universitari di discipline Odontostomatologiche - da ANDI Nazionale e AIO nazionale, dall'Ordine dei Medici e degli Odontoiatri di Bologna, dalle Università di Bologna, Ferrara, Modena-Reggio Emilia e Parma.
L'evento, supportato da ben 26 Aziende sponsor e 3 Media Partner, ha animato l'amata sede di Bologna, sede prestigiosa e facilmente raggiungibile, che, per tre giorni, è diventata la capitale indiscussa dell'Endodonzia.
I lavori hanno avuto inizio Giovedì mattina, nella Sala Europa, con l'**incontro conclusivo dei SIE ENDODONTIC COURSES 2019**: gli iscritti ai vari corsi regionali, con sede a Bari, Brescia, Genova, Spoleto - per i corsi base - e Bologna - per il corso advanced - hanno potuto seguire le relazioni della *Prof.ssa Elisabetta Cotti* e del *Dott. Luca Venuti*, i quali hanno brillantemente approfondito un argomento sempre attuale e ostico: i riassorbimenti radicolari. Al termine della loro splendida relazione dal titolo **Strategie cliniche per la diagnosi e il trattamento dei riassorbenti radicolari patologici** è seguita la consegna delle pergamene di partecipazione da parte del Past President, Prof. Francesco Riccitiello e del Coordinatore Culturale, Dott. Andrea Polesel, in rappresentanza della Società.

Nel pomeriggio, sempre in Sala Europa, tutto esaurito per il classico **CORSO PRE-CONGRESSO:** il nostro Socio Attivo *Dott. Claudio Pisacane* e lo special guest *Dott. Lorenzo Vanini* hanno rapito l'attenzione dei presenti con la loro relazione dal titolo: **Trattamento e prognosi a lungo termine dei traumi dentali,** approfondendo

VITA SOCIETARIA



l'argomento sia dal punto di vista endodontico che ricostruttivo.
La consueta Assemblea dei Soci Attivi chiudeva la prima giornata di lavori.
Venerdì 9, dopo la **Cerimonia di Apertura dei Lavori e del Saluto delle Autorità,** nella cornice di un auditorium gremito di colleghi appassionati di Endodonzia, si è svolta la **prima sessione congressuale** affidata al *Prof. Carlo Prati* e al nostro *Past President Dott. Fabio Gorni;* dopo il break di metà mattina, i lavori venivano ripresi dalla *Dott.ssa Maria Teresa Sberna*, allora Vice Presidente SIE, seguita dal *Prof. Gianluca Gambarini* e dai *Dott. Alberto Mazzocco* ed *Enrico Cassai,* a completamento della **seconda sessione.**
Stessa sala, stessa magica atmosfera, dopo il lunch break, per la terza sessione, quella delle **Master Clinician Session Sponsorizzate** guidate dal *Dott. Italo di Giuseppe* per *Sweden&Martina* e il *Dott. Enrico Cassai* per *Dentsply Sirona*. Le due Master Clinician Session Sponsorizzate sono state intervallate da alcune comunicazioni societarie a cura del Segretario Nazionale, il *Dott. Filippo Cardinali,* che ha introdotto la Presentazione del Consensus intersocietario a cura della *Prof.ssa Elisabetta Cotti* dal titolo: **Lo Screening delle infezioni dentali nel paziente in attesa di chirurgia cardiovascolare** a cui hanno partecipato, oltre alla SIE, anche SIdP, AIE, SIC, SICCH, ANMCO, e il **Position Statement** della *Società Italiana di Endodonzia* a cura della *Prof.ssa Claudia Dettori* dal titolo: **Il trattamento endodontico dei pazienti a rischio di Osteonecrosi dei Mascellari associata all'utilizzo dei farmaci anti-riassorbimento.**
In parallelo, in Sala Italia, **si sono svolte le Sessioni finali dei Premi Riccardo Garberoglio** (9.15-11.00), **Giorgio Lavagnoli** (11.30-13.30) e **Francesco Riitano** (14.30-16.15); fasi finali anche del **Premio Miglior Poster SIE e SESSIONE POSTER AFFISSIONI CARTACEE,** rispettivamente in Sala Verde e Area Espositiva.
Dalle 17.00 alle 19.00 si sono svolti i **14 Teatri Clinici** organizzati dalla SIE e le **10 Tavole Cliniche Sponsorizzate** a cura di Dentsply Sirona, Simit Next, Fotona D.O.O., Sweden&Martina, Septodont, JMorita Europe GMBH, Komet Italia, Acteon, Coltene Italia, Giovanni Ogna & Figli, ciascuno dei quali ripetuti tre volte in modo da dare la possibilità ai colleghi presenti di partecipare a quelli di maggiore interesse per loro.
Tra i Teatri Clinici, al primo piano, in lecture room dedicate, anche i Teatri che hanno visto come protagonisti relatori ospiti in rappresentanza di alcune tra le più autorevoli Società Scientifiche Italiane **(AIC, AIOP, SIdP).**
La graditissima novità di

VITA SOCIETARIA

quest'anno è stata l'introduzione delle **cuffiette**.
Per garantire la resa acustica di ogni Teatro Clinico/ Tavola Clinica infatti è stato predisposto l'utilizzo di cuffiette con 20 canali regolabili e sintonizzabili in base ai Teatri Clinici/Tavole Cliniche frequentati.
La **Cena Sociale**, presso il suggestivo ed elegante **La Porta Restaurant,** ha concluso in maniera rilassata e conviviale una giornata intensa e ricca di contenuti.
Durante la cena, la Dott.ssa Maria Teresa Sberna, allora Vice Presidente SIE, ha omaggiato **i tre nuovi Soci Attivi, il Dott. Gianluca Plotino, il Dott. Pasquale Paone e il Dott. Andrea Lamparelli.**
Sabato 10, terzo e ultimo giorno di Congresso, Sala Europa ancora gremita per seguire le ultime due sessioni, la quinta e la sesta, che vedevano protagonisti rispettivamente i Prof. Maurizio Bossù e Giovanni Olivi e i Dott.ri Italo Di Giuseppe e Franco Ongaro e il Prof. Vito Antonio Malagnino e i Dott.ri Mauro Rigolone, Andrea Polesel e Umberto Uccioli.
Contemporaneamente, le due interessanti **Sessioni di Ricerca Libera** in Sala Italia e le molto apprezzate **Tavole Cliniche sponsorizzate** nell'area espositiva, che hanno intrattenuto i partecipanti, tutti molto interessati e colpiti dall'offerta e dalla possibilità di fare anche workshop pratici a discrezione dell'Azienda.
A seguire, si è proceduto alla nomina dei **Vincitori delle 4 Sessioni Finali dei Premi SIE**.

Premio Riccardo Garberoglio
Effetto antibatterico di due peptidi sintetici di derivazione anticorpale nei confronti di Enterococcus faecalis
Giovanni Mergoni*, Maddalena Manfredi, Pio Bertani, Tecla Ciociola, Stefania Conti, Laura Giovati

Premio Giorgio Lavagnoli
Trattamento di canali calcificati con tecnica di Endodonzia guidata: case series Antonietta Bordone*, Cauris Cauvrechel

VISTO IL PERDURARE DELLA SITUAZIONE CRITICA COVID-19

il nostro IV Congresso Internazionale di novembre 2020 è stato rimandato all'anno venturo (nuove date 11-13 Novembre 2021).

In alternativa, nelle date storiche del Congresso annuale **il Consiglio Direttivo sta organizzando per i propri Soci un innovativo Evento che si svolgerà via Web.**

Seguiranno aggiornamenti!

Premio Francesco Riitano
Valutazione della qualità del sigillo canalare mediante micro-CT: cono singolo con bioceramiche VS onda continua di condensazione VS guttaperca calda veicolata da carrier
Edoardo Moccia*, Alessandro Dell'Acqua, Mario Alovisi, Giorgia Carpegna, Allegra Comba, Damiano Pasqualini, Elio Berutti

Premio Miglior Poster SIE
Morfologia del sistema endodontico negli incisivi laterali inferiori: uno studio in vivo attraverso la tomografia computerizzata cone beam
Linda Quero*, Giovanni Schianchi, Federico Valenti Obino, Massimo Galli, Luca Testarelli, Gianluca Gambarini
Poi si è passati alla nomina dei **Vincitori dei contest.**

Premio Contest #LivingSIE
Eleonora Caroglio*

Premio Contest #MycongresSIE
Stefano Pagnoni*

Premio Sponsor Tour SIE
Andrea Cristini*

L'estrazione e la premiazione del vincitore dello **Sponsor Tour 2019** ha seguito la premiazione dei **contest fotografici, #livingSIE e #mycongresSIE**, da parte del Coordinatore della Comunicazione, la *Dott.ssa Denise I.K. Pontoriero.* I due contest #livingSIE e #mycongresSIE, una novità assoluta di questo Congresso, hanno coinvolto ed entusiasmato i nostri colleghi, specialmente i più giovani, ma non solo, rendendo il nostro evento "virale" anche sui Social Network.
Il Congresso si concludeva con l'intervento finale del Segretario Nazionale, il Dott. Filippo Cardinali, che, davanti a un pubblico rimasto numeroso fino alla fine dei lavori, ha ringraziato i partecipanti a nome della Società.

GUIDELINES FOR AUTHORS

Giornale Italiano di Endodonzia was founded in 1987 and is the official journal of Società Italiana di Endodonzia, SIE (Italian Society of Endodontics) https://www.endodonzia.it/

It is a peer-reviewed journal, only available in electonic format and publishes original scientific articles, reviews, clinical articles and case reports in the field of Endodontology. Scientific contributions dealing with health, injuries to and diseases of the pulp and periradicular region, and their relationship with systemic well-being and health. Original scientific marticles are published in the areas of biomedical science, applied materials science, bioengineering, epidemiology and social science relevant to endodontic disease and its management, and to the restoration of root-treated teeth. In addition, review articles, reports of clinical cases, book reviews, summaries and abstracts of scientific meetings and news items are accepted. Please read the instructions below carefully for details on the submission of manuscripts, the journal's requirements and standards as well as information concerning the procedure after a manuscript has been accepted for publication in Giornale Italiano di Endodonzia. Giornale Italiano di Endodonzia is indexed in Scopus, Science Direct, Embase and published online by Ariesdue, Milan, Italy and hosted by PAGEPress, Pavia, Italy. All articles are available on www.giornaleitalianoendodonzia.it. The Journal is issued twice a year, in June and November.

Authors are encouraged to visit **www.giornaleitalianoendodonzia.it** for further information on the preparation and submission of articles and figures.

Ethical guidelines

Giornale Italiano di Endodonzia adheres to the below ethical guidelines for publication and research.

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Authors submitting a paper do so on the understanding that the manuscript has been read and approved by all authors and that all authors agree to the submission of the manuscript to the Giornale Italiano di Endodonzia. Giornale Italiano di Endodonzia adheres to the definition of authorship set up by The International Committee of Medical Journal Editors (ICMJE). According to the ICMJE, authorship criteria should be based on 1) substantial contributions to conception and design of, or acquisiation of data or analysis and interpretation of data, 2) drafting the article or revising it critically for important intellectual content and 3) final approval of the version to be published. Authors should meet conditions 1, 2 and 3. It is a requirement that all authors have been accredited as appropriate upon submission of the manuscript. Contributors who do not qualify as authors should be mentioned under Acknowledgements.

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The text file must contain the **abstract, main text, references, tables and figure legends**, but no embedded figures or title page. The title page should be provided as a separate file. In the main text, please reference figures as for instance **figure 1, figure 2** etc to match the tag name you choose for the individual figure files uploaded.

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Manuscript Types Accepted

Original Scientific Articles must describe significant and original experimental observations and provide sufficient detail so that the observations can be critically evaluated and, if necessary, repeated. Original Scientific Articles must conform to the highest international standards in the field.

Review Articles are accepted for their broad general interest; all are refereed by experts in the field who are asked to comment on issues such as timeliness, general interest and balanced treatment of controversies, as well as on scientific accuracy. Reviews should generally include a clearly defined search strategy and take a broad view of the field rather than merely summarizing the authors´ own previous work. Extensive or unbalanced citation of the authors´ own publications is discouraged.

Mini Review Articles are accepted to address current evidence on well-defined clinical, research or methodological topics. All are refereed by experts in the field who are asked to comment on timeliness, general interest, balanced treatment of controversies, and scientific rigor. A clear research question, search strategy and balanced synthesis of the evidence is expected. Manuscripts are limited in terms of word-length and number of figures.

Clinical Articles are suited to describe significant improvements in clinical practice such as the report of a novel technique, a breakthrough in technology or practical approaches to recognised clinical challenges. They should conform to the highest scientific and clinical practice standards.

Case Reports or **Case Series** illustrating unusual and clinically relevant observations are acceptable, but they must be of sufficiently high quality to be considered worthy of publication in the Journal. On rare occasions, completed cases displaying nonobvious solutions to significant clinical challenges will be considered. Illustrative material must be of the highest quality and healing outcomes, if appropriate, should be demonstrated.

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Authors should pay special attention to the **presentation** of their research findings or clinical reports so that they may be communicated clearly.

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All manuscripts submitted to Giornale Italiano di Endodonzia should include Title Page, Abstract, Main Text, References, Clinical Relevance, Conflict of Interest and Acknowledgements, Tables, Figures and Figure Legends as appropriate.

Title Page should bear:

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- **Aim:** give a clear statement of the main aim of the study and the main hypothesis tested, if any.
- **Methodology:** describe the methods adopted including, as appropriate, the design of the study, the setting, entry requirements for subjects, use of materials, outcome measures and statistical tests.
- **Results:** give the main results of the study, including the outcome of any statistical analysis.
- **Conclusions:** state the primary conclusions of the study and their implications. Suggest areas for further research, if appropriate.

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Abstract for Mini Review Articles should be non-structured of no more than 250 words, including a clear research question, details of the literature search strategy and clear conclusions.
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- **Methodology:** describe the methods adopted.
- **Results:** give the main results of the study.
- **Conclusions:** state the primary conclusions of the study.

THE STRUCTURE

Main text for Original Scientific Articles

should include Introduction, Materials and Methods, Results, Discussion and Conclusion.
Introduction: should be focused, outlining the historical or logical origins of the study and gaps in knowledge. Exhaustive literature reviews are not appropriate. It should close with the explicit statement of the specific aims of the investigation, or hypothesis to be tested.

Material and Methods must contain sufficient detail such that, in combination with the references cited, all clinical trials and experiments reported can be fully reproduced.
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Conclusions should contain a summary of the findings.

Main Text of Review Articles

should be divided into Introduction, Review and Conclusions.

The **Introduction** section should be focused to place the subject matter in context and to justify the need for the review. The **Review** section should be divided into logical subsections in order to improve readability and enhance understanding. Search strategies must be described and the use of state-of-the-art evidence-based systematic approaches is expected. The use of tabulated and illustrative material is encouraged. The **Conclusion** section should reach clear conclusions and/or recommendations on the basis of the evidence presented.

Main Text of Mini Review Articles

should be divided into Introduction, Review and Conclusions; please note that the **Conclusions section** should present clear statements/recommendations and suggestions for further work. The manuscript, including references and figure legends, should not normally exceed 4,000 words.

Main Text of Case Reports and Clinical Articles

should be divided into Introduction, Report, Discussion and Conclusion. They should be well illustrated with clinical images, radiographs, diagrams and, where appropriate, supporting tables and graphs. However, all illustrations must be of the highest quality.

IMPORTANT TO KNOW

Manuscript that do not conform to the general aims and scope of the Journal will be returned immediately without review. All other manuscripts will be reviewed by experts in the field (generally two referees). Giornale Italiano di Endodonzia aims to forward referees´ comments and to inform the corresponding author of the result of the review process. Manuscripts will be considered for fast-track publication under special circumstances after consultation with the Editor. Giornale Italiano di Endodonzia uses **double blinded review** which menas that the names of the reviewers will thus not be disclosed to the author submitting a paper and the name(s) of the author(s) will not be disclosed to the reviewers. To allow double blinded review, please submit your main manuscript and title page as separate files.

Acknowledgements. Giornale Italiano di Endodonzia requires that all sources of institutional, private and corporate financial support for the work within the manuscript must be fully acknowledged, and any potential conflicts of interest noted. Grant or contribution numbers may be acknowledged, and principal grant holders should be listed. Acknowledgments should be brief and should not include thanks to anonymous referees and editors. Under this section please specify contributors to the article other than the authors accredited. Please also include specifications of the source of funding for the study.

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a. ISI Journal Abbreviations Index (https://www.library.caltech.edu/journal-title-abbreviations);
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Standard journal article
(1) Somma F, Cammarota G, Plotino G, Grande NM, Pameijer CH. The effectiveness of manual and mechanical instrumentation for the retreatment of three different root canal filling materials. J Endod 2008;34:466-9.

Corporate author
British Endodontic Society - Guidelines for root canal treatment. Giornale Italiano di Endodonzia 1979;16:192-5.

Journal supplement
Frumin AM, Nussbaum J, Esposito M () Functional asplenia: demonstration of splenic activity by bone marrow scan (Abstract). Blood 1979;54 (Suppl. 1):26a.

Books and other monographs
Personal author(s)
Gutmann J, Harrison JW Surgical Endodontics, 1st edn Boston, MA, USA: Blackwell Scientific Publications, 1991.

Chapter in a book
Wesselink P Conventional rootcanal therapy III: root filling. In: Harty FJ, ed. Endodontics in Clinical Practice, (1990), 3rd edn; pp. 186-223. London, UK: Butterworth.

Published proceedings paper
DuPont B Bone marrow transplantation in severe combined immunodeficiency with an unrelated MLC compatible donor. In: White HJ, Smith R, eds. Proceedings of the Third Annual Meeting of the International Society for Experimental Rematology; (1974), pp. 44-46. Houston, TX, USA: International Society for Experimental Hematology.

Agency publication
Ranofsky AL Surgical Operations in Short-Stay Hospitals: United States-1975 (1978). DHEW publication no. (PHS) 78-1785 (Vital and Health Statistics; Series 13; no. 34.) Hyattsville, MD, USA: National Centre for Health Statistics.8

Dissertation or thesis
Saunders EM In vitro and in vivo investigations into root-canal obturation using thermally softened gutta-percha techniques (PhD Thesis) (1988). Dundee, UK: University of Dundee.

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The ICMJE believes that it is important to foster a comprehensive, publicly available database of clinical trials.
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For example http://www.clinicaltrials.gov, sponsored by the United States National Library of Medicine, meets these requirements.

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