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ORIGINAL ARTICLE

Using the Periapical Index to evaluate the healing of periapical lesions after root canal treatment

ABSTRACT

Aim: *Root canal treatment serves to prevent or cure periapical periodontitis. The aim of our study was to evaluate the remission of periapical lesions radiographically in patients who had undergone root canal treatment.*

Materials and Methods: *We conducted an observational, longitudinal study of patients in the endodontics clinic of the Autonomous University of the State of Mexico. Using an ambispective (retrospective and prospective), comparative (before and after) approach, we analyzed 19 patients. We monitored the progress of their treatment from February to June 2017 by means of periapical x-rays, and compared the results of the final vs. the initial radiographs. To evaluate the periapical root status of patients, we employed the Periapical Index (PAI) created by Ørstavik et al. in 1986.*

Results: *The mean age of our study sample was 40.31 ± 12.75 years, and 63.2% of participants were female. The mean interval between the initial and control radiographs was 618.42 ± 102.38 days. A comparison between the initial and final periapical states of all teeth yielded favorable results, with positive outcomes observed in the periapical lesions of all participants (p=0.0001).*

Conclusions: *In our study sample, root canal treatment proved highly successful in reducing apical periodontitis; it secured the full recovery of the periradicular tissues in the dental organs. In developing countries such as Mexico, root canal treatment demonstrates effectiveness at two years. Its use is recommended as an optimal means of preserving teeth among the Mexican population.*

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Introduction

The purpose of root canal treatment is the preservation of teeth while maintaining their full function in the oral cavity. As the choice of last resort for this purpose, it seeks to prevent, or failing that, to cure periapical periodontitis (1). Periapical lesions, the most common pathology in the alveolar bone, expose the dental pulp to bacteria and their byproducts. These, in turn, act as antigens; they produce both nonspecific inflammatory and specific immune responses in the periradicular tissue, ultimately causing periapical lesions (2). In the root canal system, pulpal tissue infection caused by caries or other pathways is the main cause of apical periodontitis (3). It has been demonstrated that necrosis and periradicular inflammation develop in the pulps of rats when they are exposed to oral microorganisms, contrary to laboratory pulps kept free from microorganisms (4).
Clinical diagnoses of periapical inflammatory diseases are based primarily on clinical signs and symptoms, the duration of the disease, pulpal sensitivity tests, percussion, palpation and a radiological study. By contrast, histological diagnoses rely on morphological and biological profiles of the cells and the extracellular matrix of diseased tissue. However, these can only be performed after the organ has been extracted from the oral cavity. While clinical diagnoses are provisional and are based on symptoms, signs, and test results, histological diagnoses are definitive and relate to diseased tissue. The absence of clinical symptoms and periapical signs on radiographs does not necessarily indicate the absence of apical periodontitis. Similarly, the clinical success of endodontics – that is, the absence of either signs and symptoms or radiological periapical signs after nonsurgical treatment of the root canal system – does not necessarily imply that a periapical lesion has been histologically cured. It has thus been recognized that the clinical diagnostic methods commonly employed such as percussion, palpation and pulp tests (based on cold, heat and electricity) are not sufficiently sensitive to either pinpoint the stage or provide a histological diagnosis of inflammatory periapical diseases (5).
In 1986, Ørstavik et al. (6) created an index for the radiographic evaluation of the periapical state of roots (PAI) which has proven useful and reliable. Based on radiographic evidence, the PAI has been validated through histological diagnoses. It uses an ordinal scale of 1 to 5, where 1 denotes optimal health and 5 evident periapical disease. Studies conducted in numerous countries have used the PAI (7-10). Our work was aimed at evaluating the remission of periapical lesions radiographically in patients having received root canal treatment.

Materials and Methods

Our study used an observational, longitudinal approach with an ambispective (retrospective and prospective) and comparative (before and after) design. Based on convenience sampling, we analyzed a group of patients from the Center for Research and Advanced Studies in Dentistry of the Faculty of Dentistry in the Autonomous University of the State of Mexico. To this end, we retrospectively reviewed the clinical records of all endodontics patients treated between February and June 2015 (n=73). A sample size of 22 participants was established according to the following criteria: a proportion of 98% for estimates, a 95% confidence interval and 5% precision. A total of 19 patients with periapical lesions met the following inclusion criteria: they (1) were of both sexes, (2) had undergone root canal treatment at the endodontics clinic between February and June 2015, (3) had submitted a radiograph showing a periapical lesion, and (4) signed an informed consent letter. Exclusion criteria referred to patients who (1) submitted an initial radiograph that was defective or could not be evaluated, (2) were unreachable, (3) refused to undergo radiographic follow-up, (4) were pregnant, or (5) suffered from a systemic disease. We conducted the

follow-up evaluations between February and June 2017. Our dependent variable included the final PAI scores of the patients, while the independent variables pertained to age, sex, type of tooth, the initial PAI scores, and the number of days that had elapsed after treatment.

Radiographic Material
All radiographs – both initial and follow-up – were performed with the same X-ray equipment, using 70 kV (X-mind ac, Satelec, Italy). Exposure was 0.40 s for anterior teeth, 0.50 s for premolars and 0.60 s for molars. We utilized the long cone paralleling technique with XCP positioners (Rinn Co., Elgin, IL, USA). The periapical radiographs were size #2 for adults (IP21 Insight, Kodak/Carestream Health Inc. NY, USA). All radiographs were revealed manually in a dark room using liquid developer (Kodak Dental READYMATIC, NY, USA).

Radiographic evaluation
Periapical root condition was evaluated using the Periapical Index (PAI) created by Ørstavik et al. (1986). This approach involves the use of reference radiographs which have been corroborated by histological diagnosis. The PAI includes five categories of disease progression represented on an ordinal scale as follows: (1) normal periapical structures; (2) small changes in the periapical bone or bone structure; (3) changes in the periapical bone structure with mineral loss, characteristic of apical periodontitis; (4) demineralization of the periapical bone within a well-defined radiolucent area; and (5) demineralization of the periapical bone with exacerbations and expansion in bone structure.
The radiographs were interpreted by a previously trained and standardized evaluator: a second-year resident in endodontics at the Autonomous University of the State of Mexico. The evaluator analyzed the radiographs using a standardized method involving work in a dark room, using a lightbox and magnification loupes (3.5×).
For purposes of statistical analysis, we established the following cutoff points to categorize the PAI values: 1 denoted no disease and values from 2 to 5 indicated the presence of periapical disease. We termed this variable "health-disease".

Statistical analysis
We created a database using the Excel program. Univariate analysis consisted of calculating the frequencies and percentages of qualitative variables as well as the mean and standard deviations for the quantitative variables. For the bivariate analysis, we calculated chi-square statistics and ran the Wilcoxon test (with related samples) to explore the differences between the initial and final radiographic measurements. All estimates were performed with the Stata 11 statistical package.

Ethical considerations
We conducted all procedures in accordance with both the institutional and national chapters of the corresponding committee on human experimentation and the Declaration of Helsinki 1975, as revised in 2008. The study protocol was approved at the Dr. Keisaburo Miyata Center for Research and Advanced Studies in Dentistry of the Faculty of Dentistry at the Autonomous University of the State of Mexico. Prior informed consent was obtained from all patients included in the study.

Results

Table 1 shows the results of our univariate analysis. We examined 19 patients, focusing specifically on ten molars, six premolars and three anterior teeth each. The average age of participants was 40.31 ±12.75 years, and 63.2% were women. The average number of days between the initial and final radiographs was 618.42 ±102.39. In the initial PAI distribution, most patients (47.4%) exhibited stage 4 periapical lesions. The final PAI evaluation yielded the following results: eight teeth (42.1%) obtained a value of 1, ten teeth (52.6%) a value of 2, and one tooth (5.3%) a value of 3. For purposes of statistical analysis, we dichotomized the health-disease variable

Table 1
Descriptive characteristics of participants

	Mean ± SD	Min–Max
Age	40.31 ± 12.75	18–64
Days between initial and control radiographs	618.42 ± 102.39	476–771
	Frequency	**%**
Sex		
Men	7	36.8
Women	12	63.2
Type of tooth		
Anterior	3	15.8
Premolar	6	31.6
Molar	10	52.6
Initial periapical evaluation		
Stage 3	7	36.8
Stage 4	9	47.4
Stage 5	3	15.8
Final periapical evaluation		
Stage 1	8	42.1
Stage 2	10	52.6
Stage 3	1	5.3
Final periapical status		
Healthy	8	42.11
Diseased	11	57.89

n=19, SD: Standard Deviation

and found that, after root canal treatment, 42.1% of teeth were healthy. In analyzing the final periapical status, we found no significant differences by type of tooth (Table 2). Broken down by sex, women showed a slightly higher percentage of periapical improvement than did men (p=0.061). Wilcoxon testing for related samples (Table 3) indicated a positive change between the initial and final periapical conditions of all participants (p<0.001), demonstrating that root canal treatment was consistently successful.

Discussion

Our study, performed at a university clinic, found that all periapical lesions showed positive radiographic changes following root canal treatment. In developing countries such as Mexico, where tooth extraction in the population is a treatment of choice for dental caries (11, 12), root canal treatment demonstrates effectiveness two years after it is performed; it thus offers patients the possibility of keeping their teeth for a longer period. Previous studies have reported success rates ranging from 88% to 97% (13,14) in the absence of apical periodontitis prior to root canal treatment. When apical periodontitis *does* exist, the success rate varies between 73% and 90% (15, 16). As suggested by Prati in 2018, it would be worthwhile extending the follow-up period beyond that used in this study (less than two years). In a cohort study at 20 years follow-up, Prati reported that 80% of teeth with root canal treatment survived in the oral cavity, while 20% were lost for non-endodontic reasons such as periodontal disease or caries.
During Phase III of the famous Toronto study, it was observed that only 43% of teeth with periapical lesions showed im-

Table 2
Results of bivariate analysis: periapical health status by sex and type of tooth

Variable	Healthy	Diseased	p-value
Sex			
Men	1 (14.3)	6 (85.7)	
Women	7 (58.3)	5 (41.7)	0.061*
Type of tooth			
Anterior	2 (66.7)	1 (33.3)	
Premolar	2 (33.3)	4 (66.7)	
Molar	4 (40.0)	6 (60.0)	0.622*

**Chi-square test*

Table 3
Changes in stage of periapical lesions

	Observed	Expected	
Positive	19	95	
Negative	0	95	
Without change	0	0	**0.0001****

***Wilcoxon test*

provement or reduction in lesion size at 4 and 6 years follow-up (24). This contrasts with the results of our study, in which 100% showed improvement in less than two years (618 days on average). In the Toronto study, treatments were performed by graduate students supervised by qualified specialists; in our study, treatments were carried out by graduate students in endodontics. However, it should be noted that the concentration of sodium hypochlorite used was 2.5% in the Toronto study vs 5.25% in the university clinic where we conducted our study.

The design of this study differed from that of previous studies on periapical status (17-19). According to the European Society of Endodontics (20), four years of observation are required for evaluating periapical status. However, in our study, an average of only 618 days proved sufficient. Other similar studies have been conducted at two years follow-up (21-23). The Toronto study, performed in several phases, supported these conclusions: it found that the attrition rate for patients was greater with longer follow-up (24, 25).

As regards methodology, conventional periapical radiographs were used for radiographic evaluation both initially and at follow-up, as has been done in other studies (26, 27). Orthopantomography has also been used in previous research initiatives (28-30). However, those studies have employed this technology to evaluate other aspects in addition to periapical status, thus avoiding unnecessary patient exposure to additional radiation. Another important feature of our study was using the PAI for evaluation of periapical radiographs instead of orthopantomographies. It is important to note that cone beam computed tomography (CBCT) offers greater sensitivity in the diagnosis of apical periodontitis compared to conventional radiographs, but the latter has shown excellent efficacy in advanced periapical pathological processes (8). Future research projects should consider additional variables. These could include the type of root canal treatment used to shape the root canal, the obturation and restoration techniques selected, and the number of appointments held with patients. This complementary information would enhance our understanding of the outcomes of root canal procedures and provide an indication of the difficulties encountered in the various cases treated.

Our study had a number of limitations. Among these were the lack of standardization in clincal procedures such as those utilized in the instrumentation and obturation techniques. The lack of standardization also applied to the irrigation protocols and the sealant, as root canal treatments were performed by different professionals. It must be underlined that these variables can affect the prognosis for the treated teeth. For example, as Chiara reported in 2018, using a thermoplasticized filling technique yielded a success rate of 85% at ten years evaluation. Another limitation concerned the fact that our PAI cutoff point for health differed from the cutoffs used in previous studies. For final evaluation purposes, we dichotomized the health-disease variable such that 1 denoted healthy teeth and higher values indicated the presence of disease, whereas other authors (10, 11) have generally set cutoff for health at 2. Kirklevang reported in 2014 that using the conventional PAI

cutoffs offered a higher diagnostic value. Our study provided no prognoses for the teeth in our sample of participants. One final limitation was that we were unable to contact several patients, significantly reducing our sample size and thus directly affecting our analysis.

Conclusions

In conclusion, we found that the techniques for root canal treatment aimed at preventing or reducing apical periodontitis were effective in all cases evaluated in our sample of Mexican adults.
Additional studies and larger samples involving follow-up treatments are required to obtain definitive results. Expanding the study to include multiple clinics would also represent an improvement on our study design.

Clinical Relevance

In conjunction with clinical parameters, PAI is an important tool in evaluating the success of root canal treatment.

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Conflict of Interest

The authors declare no competing interests.

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