Giornale Italiano di Endodonzia (2016) **30**, 14—21

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ORIGINAL ARTICLE/ARTICOLO ORIGINALE

Periapical tissue evaluation: analysis of existing indexes and application of Periapical and Endodontic Status Scale (PESS) in clinical practice

Valutazione delle lesioni periapicali: analisi degli indici esistenti ed applicazioni cliniche del Periapical and Endodontic Status Scale (PESS)

Tadas Venskutonis *

Department of Dental and Oral Diseases, Lithuanian University of Health Sciences, Eiveniu 2, Kaunas LT-50009, Lithuania

Received 17 November 2015; accepted 21 March 2016
Available online 21 May 2016

KEYWORDS
Cone-beam computed tomography;
Dental radiography;
Diagnosis;
Follow-up;
Periapical index;
Treatment quality assessment

Abstract
Aim: To compare different indexes used for periapical pathology investigation and to apply them in clinical practice.
Methodology: PAI, CBCT-PAI, and PESS indexes were analyzed in detail using existing literature. Two cases were evaluated using CBCT-PAI and PESS index.
Results: Utilization of PESS index gives the possibility to see the status and changes in periapical tissue with more details. Also, using ETTI part of the index helps to understand the possible causes (filling length, condensation, and complications) of the disease and exact number of roots involved.
Conclusion: PESS index is complex and different from all other indexes already present in the literature. It permits to evaluate not only the status of periapical tissues, but also endodontic treatment quality. Furthermore, the COPI periapical index has prognostic value due to its suggested AP treatment risk degrees. PESS can be used in epidemiological studies and clinical

* Correspondence to: Sauletekio 20, Domeikava 54350, Lithuania. Tel.: +370 61209694.
E-mail: tadasvens@gmail.com.

Peer review under responsibility of Società Italiana di Endodonzia.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.gien.2016.04.002

practice. Future research must validate it. Finally, if universally adopted, this system of evaluation might allow groups worldwide to calibrate and build powerful combined data.

PAROLE CHIAVE
Cone-beam computed tomography;
Radiologia dentale;
Diagnosi;
Follow up;
Indici periapicali;
Valutazione della qualità del trattamento.

Riassunto
Obiettivo: Confrontare diversi indici utilizzati per valutare la patologia periapicale e di applicarli nella pratica clinica.
Materiali e Metodi: Gli indici PAI, CBCT-PAI e PESS sono stati analizzati in dettaglio attraverso la letteratura esistente. Due casi sono stati valutati e confrontati utilizzando CBCT-PAI e l'indice PESS.
Risultati: L'utilizzo dell'indice PESS dà la possibilità di visualizzare lo stato e le modifiche nel tessuto periapicale con maggiori dettagli. Inoltre, utilizzando una parte dell'indice denominata ETTI, questa aiuta a capire le possibili cause della patologia (lunghezza di riempimento, condensazione, complicanze) e il numero esatto di radici coinvolte.
Conclusione: L'indice PESS è complesso e diverso da tutti gli altri indici già presenti in letteratura. Permette di valutare non solo lo stato dei tessuti periapicali, ma anche la qualità del trattamento endodontico. Inoltre, l'indice periapicale COPI ha valore prognostico nell'indicare il grado di rischio di trattamento delle periodontiti apicali. L'indice PESS può essere utilizzato in studi epidemiologici e nella pratica clinica, mu ulteriori ricerche dovranno convalidarlo. Infine, se universalmente adottato, questo sistema di valutazione potrebbe consentire ai gruppi di tutto il mondo di calibrare e combinare tutti i dati ottenuti.

Introduction

Evaluation of periapical tissue is important, it lets clinicians to diagnose the disease, to see progression or regression of the disease and to assess treatments outcome.

Radiographic examination represents an essential part of the contemporary management of endodontic problems, from diagnosis and treatment planning to outcome evaluation. Based on these needs and methods available, various diagnostic indexes for periapical tissue evaluation were proposed using radiographic examination.[1] Orstavik et al. (1986) developed the most popular periapical index (PAI), in which periapical lesions were classified into five scores based on the use of reference periapical radiographs of teeth with confirmed histological diagnosis.[2] Unfortunately, PAI is based on two-dimensional (2D) periapical radiographs, which attempt to analyze a complex three-dimensional (3D) human anatomy; superimposition of anatomical structures may result in geometric distortion of the area and anatomic noise that can hide the region of interest. Cone-beam computed tomography (CBCT), on the other hand, is a 3D imaging modality, which can provide clinically relevant additional information not found in the periapical radiographs or orthopantomograms.[3] Estrela et al. (2008) was the first to develop periapical index (CBCTPAI) based on criteria established from measurements corresponding to periapical radiolucency interpreted on CBCT scans.[4]

Endodontic status and technical quality of the root canal filling scale was developed by Eckerbom and Magnusson.[5] The main criteria of technical quality of the root canal filling are determined by length and homogeneity of the root canal filling of visible tooth roots.

All above-mentioned scales analyze separate non-systematized parameters of the patient's periapical and endodontic status. Furthermore, some parameters are expressed as morphological changes of bone tissue but do not indicate the size of the lesion,[2] or, on the other hand, give only the periapical bone lesion size in mm,[4] which has only limited diagnostic and prognostic value.

Recently, Venskutonis et al. (2015) introduced Periapical and Endodontic Status Scale (PESS) based on periapical bone lesion and endodontic treatment quality evaluation using CBCT.[6] This scale, propose one system to analyze both, periapical pathology with surrounding tissues, and endodontic treatment quality evaluation.

The aim of this article is to analyze and compare these three indexes.

Materials and methods

PAI, CBCT-PAI, and PESS indexes were analyzed in detail using existing literature. Two cases were evaluated using CBCT-PAI and PESS index.

PAI

The most popular and commonly used periapical scoring system for assessment of apical periodontitis was developed by Orstavik et al. (1986). It consists of five categories:
1. Normal periapical structures.
2. Small changes in bone structures.
3. Change in bone structure with mineral loss.
4. Periodontitis with well-defined radiolucent area.

5. Severe periodontitis with exacerbating features.

Score 1 and 2 — healthy, score 3—5 — diseased.

The periapical radiographs of the teeth are compared to reference radiographs with known histological diagnosis from Ingrid Brynolf (1967) study,[7] and then assigned to the category by these criteria:

1. Find the reference radiograph where the periapical area most closely resembles the periapical area you are studying. Assign the corresponding score to the observed root.
2. When in doubt, assign higher score.
3. For multi-rooted teeth, use the highest of the scores given to the individual roots.
4. All teeth must be given a score.

The main drawbacks of this index are that the original study was performed only on upper front teeth, and it might not be correct to apply it to the lower jaw or molar multi-rooted teeth. It is also known that even apical periodontitis is not present on the radiograph, and it might be recorded clinically.[8,9] 2D images properties, acquiring technique, morphologic variations of the roots, and bone density around the roots might influence periapical radiograph analysis.[10,11]

CBCTPAI

After development of CBCT technology, there was a need of development of a new periapical tissue evaluation index. CBCTPAI was the first periapical index developed by Estrela et al. (2008), which was based on CBCT technology.[4]

Periapical bone destruction in CBCT is measured in three planes (buccopalatal, mesiodistal, and diagonal) using dedicated software. CBCTPAI score is determined by the largest extension of the lesion. CBCTPAI consists of five categories plus two additional variables (Table 1).[4]

Both indexes do not take in to account number of root and lesion, and their relation with surrounding anatomical tissues. Analysis is only performed to find periapical pathosis; endodontic treatment quality is not assessed.

PESS

PESS is based on two indexes: Complex Periapical Index (COPI), which is designed for radiological identification and classification of periapical bone lesions in case of apical periodontitis, and Endodontically Treated Tooth Index (ETTI), which is designed for endodontic treatment quality radiological evaluation. COPI is composed of three parameters that are related to the characteristics of the periapical lesion: (1) size of the lesion (S), which may be directly related to endodontic treatment outcome results[12,13]; (2) relationship between root and lesion (R), which is an important pre-treatment factor, because the outcome of endodontic lesion treatment on multi-rooted teeth is worse[14,15]; (3) location of bone destruction (D), which can be related to more complicated endodontic or surgical treatment due to the contact of radiolucency with important anatomical structures or destruction of cortical bone.[6,16,17]

Table 1 Cone-beam computed tomography periapical index scores.[4]

Score	Quantitative bone alterations in mineral structures
0	Intact periapical bone structures
1	Diameter of periapical radiolucency 0.5—1 mm
2	Diameter of periapical radiolucency 1—2 mm
3	Diameter of periapical radiolucency 2—4 mm
4	Diameter of periapical radiolucency 4—8 mm
5	Diameter of periapical radiolucency >8 mm
E	Expansion of periapical cortical bone
D	Destruction of periapical cortical bone

ETTI is derived from 4 endodontic treatment assessment explanatory parameters, which are important to the prediction of treatment outcome: (1) length of the root canal filling (L), which is measured in terms of the distance between the apical end of the visible filling material till the radiographic terminus of the root[5,18,19]; (2) homogeneity of the root canal fillings (H), which is an important factor in judging filling condensation[5,19]; (3) coronal seal (CS), which may play a role in improving treatment outcome[12,19,20]; (4) presence of complications/failures (CF) can significantly influence the prognosis.[6,12,19,20] Detailed COPI and ETTI parameters are listed in Tables 2 and 3.

Results

Fig. 1 is an example of case with large periapical lesion around tooth number 11. Fig. 1a and b is a CBCT taken during the treatment, and Fig. 1c and d is taken one year after the treatment. COPI of the tooth number 11 is expressed as S3R1D2; it means that size of the large well-defined periapical radiolucency is more than 5 mm, lesion involved one root and the bone destruction is close with important anatomical structures (incisive canal); this is considered as high treatment risk (Fig. 1a and b). CBCT-PAI score for the same tooth would be 4E (lesion size 4—8 mm, plus cortical bone expansion). Because the endodontic treatment was already started, the ETTI score is not written. The patient came for the surgery one year later and the periapical lesion was almost resolved. The COPI score for the same tooth is S1R1D1; it means that size of the small well-defined periapical radiolucency is up to 3 mm, lesion involved one root and the bone destruction is only located in the apical part; this is considered as mild treatment risk (Fig. 1c and d). There was no need for surgery. The CBCT-PAI after follow-up was 1 (lesion size 0.5—1 mm). The ETTI after one-year follow-up was expressed as L3H1CS1CF5; it presents a homogeneous root canal filling extending over the apex, an adequate coronal restoration and the root canal is associated with a radiolucent lesion (Fig. 1c and d).

Fig. 2 presents the same tooth periapical radiographs before the treatment (Fig. 2a) and after one-year follow-up (Fig. 2b). Fig. 3 is an example of a tooth number 27 with COPI score before the treatment S3R2D3; it means that size of the large well-defined periapical radiolucency is more than 5 mm and lesion involved more than one root, with destruction of cortical bone; this is considered as high treatment risk (Fig. 3a—c). CBCTPAI would be 5D (lesion more than 8 mm with bone destruction. The ETTI score for Palatal canal is L1H2CS1CF5, for disto-buccal is L1H2CS1CF0, for mesio-buccal is L1H2CS1CF5, and for mesio-buccal2 it is L4H2CS1CF2,5; it means that tooth has adequate coronal restoration and obturation of all canals is incomplete, ending 0—2 mm from

Table 2 The Complex Periapical Index (COPI) designed for identification and classification of periapical bone lesions in case of apical periodontitis: S, R, and D evaluation scale.[6]

S (Size of the radiolucent lesion)	
S0	Widening of the periodontal ligament not exceeding two times the width of the lateral periodontal ligament
S1	Diameter of small well-defined radiolucency up to 3 mm
S2	Diameter of medium well-defined radiolucency 3-5 mm
S3	Diameter of large well-defined radiolucency >5 mm
R (Relationship between root and radiolucent lesion)	
R0	No radiolucency,whenwidening of the periodontal ligament is not exceeding two times the width of the lateral periodontal ligament
R1	Radiolucent lesionappearson one root
R2	Radiolucent lesion appears on more than one root
R3	Radiolucent lesion with involvement of furcation
D (Location of bone destruction)	
D0	No radiolucency,whenwidening of the periodontal ligament is not exceeding two times the width of the lateral periodontal ligament
D1	Radiolucency around the root
D2	Radiolucency is in contact with important anatomical structures
D3	Destruction of cortical bone

radiographic apex, except mesio-buccal2, which was not found. All canals are associated with lesion, except disto-buccal canal. After one-year follow—up, the COPI score of the same tooth number 26 is S3R1D2; that means the lesion reduced in size, but is still big, more than 5 mm, but only on one root, and is in contact with sinus; there is no cortical bone destruction and treatment risk is still high (Fig. 3d—f). CBCTPAI has a score of 4 (lesion size 4—8 mm). The ETTI score for Palatal canal is L3H1CS1CF0, for disto-buccal is L3H1CS1CF0, for mesio-buccal is L3H1CS1CF5, and for mesio-buccal2 it is L3H1CS1CF5; that means all canals have sealer extrusion, are completely filled, coronal seal is good, and only mesio-buccal and mesio-buccal2 canals are associated with lesions (Fig. 3d—f). Fig. 4 presents periapical radiographs of tooth number 27 before the treatment (Fig. 4a) and after one-year follow-up (Fig. 4b).

Table 3 The new Endodontically Treated Tooth Index: L, H, CS and CF evaluation scale.[6]

L (Length of the root canal filling)			
L1	0—2 mm from radiographic apex		
L2	>2 mm from radiographic apex		
L3	Overfilling (extrusion of material through the apex)		
L4	Filling material visible only in pulp chamber		
L5	Filled canal of a surgically treated root		
H (Homogeneity of the root canal fillings)			
H1	Complete obturation (homogenous appearance of the root canal filling)		
H2	Incomplete obturation (voids and porous appearance of the root canal filling)		
CS (Coronal seal)			
CS1	Adequate (coronal restoration appears intact radiographically)		
CS2	Inadequate (detectable radiographic signs of overhangs, open margins, recurrent caries, or lost coronal restoration)		
CF (Complications/failures)			
CF0	No complications	CF3	Root resorption
CF1	Root perforation	CF4	Root/tooth fracture
CF2	Root canal not treated/missed	CF5	Endodontically treated root with radiolucency

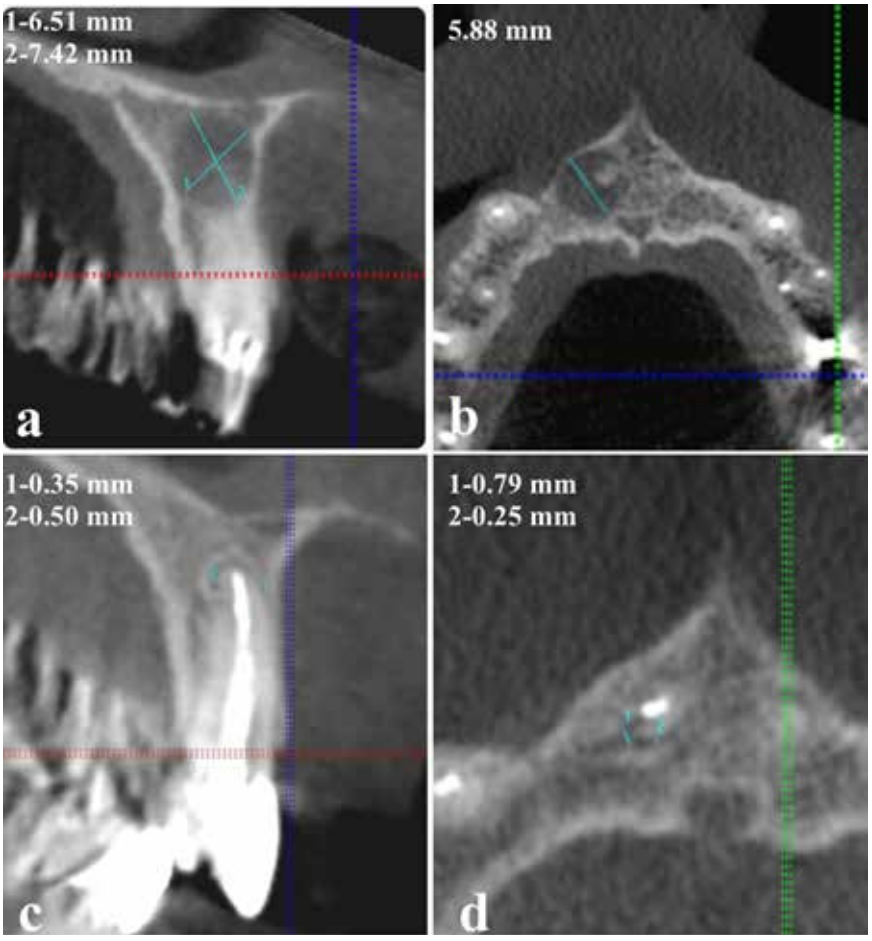

Figure 1 Cone-beam tomography scans, tooth 11: (a) big periapical lesion in sagittal plane, during the treatment; (b) big periapical lesion in axial plane, during the treatment; (c) small periapical lesion in sagittal plane, at one-year follow-up; (d) small periapical lesion in axial plane, at one-year follow-up.

Figure 2 Periapical radiographs, tooth number 11: (a) before the treatment; (b) one-year follow-up.

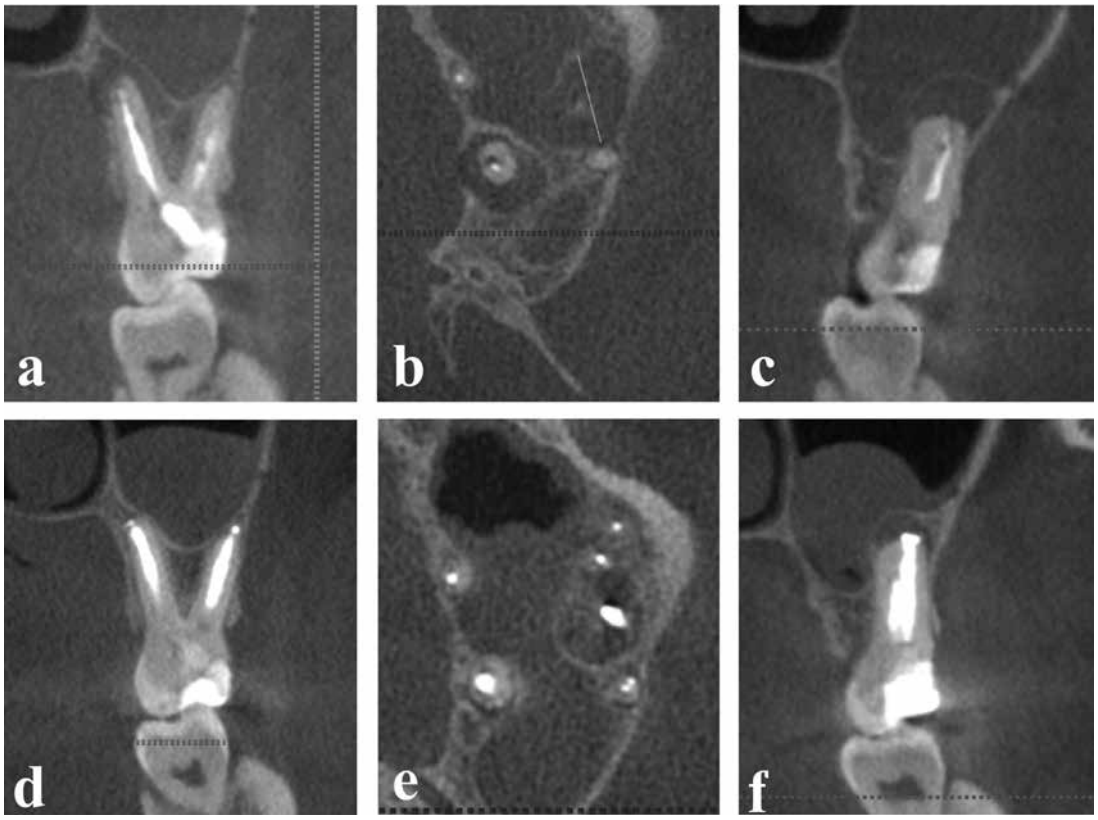

Figure 3 Tooth number 27: (a) frontal plane, disto-buccal and palatal roots before the treatment; (b) axial plane, two large periapical lesions around palatal and mesiobuccal roots before the treatment; (c) frontal plane, mesiobuccal root, missed second mesiobuccal canal, and large periapical lesion before the treatment; (d) frontal plane, disto-buccal and palatal roots at one-year follow-up; (e) axial plane; periapical lesion resolved around palatal and reduced around mesiobuccal root, at one-year follow-up; (f) frontal plane; mesiobuccal root, at one-year follow-up.

Discussion

AP is a disease; its main symptom is bone destruction. AP may be detected with conventional radiography only 15—30 days after the development of the disease.[21,22] However, with new technologies like CBCT, it is possible to detect AP as soon as 7 days after it develops.[21] AP detection and characterization represents an important pre-operative factor that may influence the outcome of root canal treatment; thus, early diagnosis is essential. If AP is present on several roots in a multi-rooted tooth, the outcome might be different.[15] The location and severity of the lesions, such as expansion or destruction of cortical bone, as well as contact with the sinus or the mandibular canal, are also more easily missed using conventional radiology.[16,17]

The most popular periapical index (PAI) is based on a 2D radiology method and cannot be applied to 3D imaging; furthermore, the original study was done only on upper front teeth and is not based on clinical outcomes, and thus the prognostic value is unknown. Tooth type, number of roots, size and number of lesions, and their location are known to influence treatment prognosis,[12—16,23,24] but these parameters cannot be assessed using PAI. The other index, called CBCTPAI and developed by Estrela, is based on 3D image interpretation, but only lesion size, plus two additional variables of cortical bone expansion and destruction are analyzed[4]; some previously mentioned important parameters are not assessed. There is no such index that implements the all-important aspect of periapical pathosis; moreover, there is a lack of a complex index in which radiological treatment results can be accessed. It is known from previous studies that length of root canal filling, homogeneity, coronal seal, and existing complications all influence endodontic treatment outcome,[5,12,18—20] and the parameters proposed by Eckerbom and Magnusson for endodontic treatment evaluation are not complete.[5]

Most important pre-operative, intra-operative, and post-operative parameters included in PESS study were gathered from previous scientific studies. A pilot study was conducted to evaluate which parameters were possible to evaluate using CBCT and the results were compared with the control methods (digital orthopantomograms and periapical radiographs); also COPI index parameter was grouped into three different treatment risks: mild (green color), moderate (yellow color), and high (red color) (Table 2).

PESS gives more information about the disease over CBCTPAI. ETTI part of the index helps to understand the possible causes (filling length, condensation, and complications) of the disease and exact number of roots involved (Table 3).

Figure 4 Periapical radiographs, tooth number 27: (a) before the treatment; (b) one-year follow-up.

Conclusion

The newly developed PESS index described in Venskutonis et al. (2015) study is complex and different from all other indexes already present in the literature.[6] It permits to evaluate not only the status of periapical tissues, but also endodontic treatment quality. Furthermore, the COPI periapical index has prognostic value due to its suggested AP treatment risk degrees. PESS can be used in epidemiological studies and clinical practice. Future research must validate it. Finally, if universally adopted, this system of evaluation might allow groups worldwide to calibrate and build powerful combined data.

Conflict of interest

The author denies any conflicts of interest related to this study.

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