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)

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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

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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. 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. 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. 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.

Endodontic status and technical quality of the root canal filling scale was developed by Eckerborn and Magnusson. 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, or, on the other hand, give only the periapical bone lesion size in mm, 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. 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, and then assigned to the categ-
    ory by these criteria:
    1. Find the reference radiograph where the periapical area
        most closely resembles the periapical area you are study-
        ing. 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. 2D images properties, acquiring technique, mor-
    phologic 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 dedi-
cated 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 tis-
ues. 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 radiolo-
gical 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 results12,13; (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 worse14,15; (3) location
of bone destruction (D), which can be related to more compli-
cated endodontic or surgical treatment due to the contact of
radioluency with important anatomical structures or
destruction of cortical bone.6,16,17

ETTI is derived from 4 endodontic treatment assessment
explanatory parameters, which are important to the predic-
tion 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 root5,18,19; (2) homogeneity of the root canal
fillings (H), which is an important factor in judging filling
condensation5,19; (3) coronal seal (CS), which may play a role
in improving treatment outcome12,19,20; (4) presence of
complications/ failures (CF) can significantly influence the
prognosis.5,12,19,20 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 peri-
apical radiolucency is more than 5 mm, lesion involved one
root and the bone destruction is close with important anato-
nical 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 peri-
apical radioluency 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 L3H1C51CF5; it presents a homogeneous
root canal filling extending over the apex, an adequate
coronal restoration and the root canal is associated with a
radiolucen 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 destruc-
tion of cortical bone; this is considered as high treatment risk
(Fig. 3a–c). CBCTPAI score would be S5 (lesion more than 8
mm with bone destruction. The ETTI score for Palatal canal
is L1H2C51CF5, for disto-buccal is L1H2C51CF0, for mesio-buc-
cal is L1H2C51CF5, and for mesio-buccal2 it is L4H2C51CF2,5;
it means that tooth has adequate coronal restoration and
obturation of all canals is incomplete, ending 0–2 mm from

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<thead>
<tr>
<th>Table 1</th>
<th>Cone-beam computed tomography periapical index scores.4</th>
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<tbody>
<tr>
<td>Score</td>
<td>Quantitative bone alterations in mineral structures</td>
</tr>
<tr>
<td>0</td>
<td>Intact periapical bone structures</td>
</tr>
<tr>
<td>1</td>
<td>Diameter of periapical radiolucency 0.5–1 mm</td>
</tr>
<tr>
<td>2</td>
<td>Diameter of periapical radiolucency 1–2 mm</td>
</tr>
<tr>
<td>3</td>
<td>Diameter of periapical radiolucency 2–4 mm</td>
</tr>
<tr>
<td>4</td>
<td>Diameter of periapical radiolucency 4–8 mm</td>
</tr>
<tr>
<td>5</td>
<td>Diameter of periapical radiolucency &gt;8 mm</td>
</tr>
<tr>
<td>E</td>
<td>Expansion of periapical cortical bone</td>
</tr>
<tr>
<td>D</td>
<td>Destruction of periapical cortical bone</td>
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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.\textsuperscript{6}

<table>
<thead>
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<th>S (Size of the radiolucent lesion)</th>
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<tr>
<td>S0</td>
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<td>S1</td>
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<td>S2</td>
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<td>S3</td>
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<th>R (Relationship between root and radiolucent lesion)</th>
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<tr>
<td>R0</td>
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<td>R1</td>
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<td>R3</td>
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<th>D (Location of bone destruction)</th>
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<tr>
<td>D0</td>
</tr>
<tr>
<td>D1</td>
</tr>
<tr>
<td>D2</td>
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<td>D3</td>
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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.\textsuperscript{6}

<table>
<thead>
<tr>
<th>L (Length of the root canal filling)</th>
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<tr>
<td>L1</td>
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<td>L2</td>
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<td>L3</td>
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<td>L4</td>
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<td>L5</td>
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<th>H (Homogeneity of the root canal fillings)</th>
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<td>H1</td>
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<td>H2</td>
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<tr>
<th>CS (Coronal seal)</th>
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<tbody>
<tr>
<td>CS1</td>
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<td>CS2</td>
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<th>CF (Complications/failures)</th>
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<tbody>
<tr>
<td>CF0</td>
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<tr>
<td>CF1</td>
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<td>CF2</td>
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<td>CF3</td>
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<td>CF4</td>
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<td>CF5</td>
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</tbody>
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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.
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. However, with new technologies like CBCT, it is possible to detect AP as soon as 7 days after it develops. 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. 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 radiography.

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, 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; 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, and the parameters proposed by Eckerbom and Magnusson for endodontic treatment evaluation are not complete.

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).
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. 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.

References


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