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Original Article / *Özgün Araştırma*

Comparative Evaluation of Periapical Lesions Using Periapical Index Adapted for Panoramic Radiography and Cone Beam Computed Tomography

Panoramik Radyografi ve Konik Işınlı Bilgisayarlı Dental Tomografiye Uyarlanmış Periapikal İndeks ile Periapikal Lezyonların Karşılaştırılarak Değerlendirilmesi

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Abstract

Objective: The aim of this retrospective study was to comparatively evaluate periapical lesions using the periapical index adapted for panoramic radiography and cone beam computed tomography (CBCT-PAI).

Methods: The study group consisted of pre-existing panoramic radiographs and CBCT records of 200 individuals (100 women and 100 men). In this study, panoramic radiographs were evaluated using the PAI scoring system, which uses a scale from 1 to 5 with an increasing radiographic periapical status degree. CBCT images were evaluated using the CBCT-PAI scoring system, which includes two additional variables that indicate any possible expansion or destruction of the cortical bone. During statistical evaluation, the relationship between PAI and CBCT-PAI was investigated by Spearman's rho correlation analysis.

Results: In our study, there was no significant difference between the mean ages according to gender (p>0.05). Moreover, there was no significant difference between the numbers of teeth with lesions according to gender (p>0.05). A significant and positive correlation was found between PAI and CBCT- PAI scores in all samples in coronal, sagittal, and axial planes (p<0.01).

Conclusion: It was confirmed that CBCT provides more accurate information about the extension and dimensions of periapical lesions.

Keywords: Periapical lesions, cone beam computed tomography, radiography, panoramic

Öz

Amaç: Panoramik Radyografiye Uyarlanmış Periapikal İndeks (PAI) ve ortaya konan yeni skorlama sistemi "konik ışınlı bilgisayarlı dental tomografiye uyarlanmış periapikal indeks (CBCT-PAI)" ile periapikal lezyonların retrospektif olarak karşılaştırılarak değerlendirilmesi çalışmanın temel amacıdır.

Yöntemler: Çalışma grubunu 100 kadın 100 erkek olmak üzere 200 hastanın panoramik radyografi ve konik ışınlı bilgisayarlı tomografi (CBCT) görüntü kayıtları oluşturmaktadır. Çalışmada panoramik radyografide periapikal lezyonlar "Periapikal İndeks Skorlama Sistemi (PAI)" olarak adlandırılan ve radyogramlar üzerinde apikal lezyonları, artan radyografik görüntü derecesine göre 1'den 5'e kadar bir skala kullanarak değerlendiren bir sistem ile değerlendirilmiştir. CBCT'de görüntüleri ise PAI skorlamasına kortikal kemik ekspansiyonu ve dekstrüksiyon parametreleri ilave edilerek modifiye edilen CBCT-PAI skorlaması ile değerlendirilmiştir. Çalışmada skorlar arasındaki ilişkilerin incelenmesinde Spearman's rho korelasyon analizi kullanılmıştır.

Bulgular: Çalışmamızda cinsiyetlere göre yaş ortalamaları arasında istatistiksel olarak anlamlı bir farklılık bulunmamaktadır (p>0,05). Cinsiyetlere göre lezyonlu diş sayıları arasında istatistiksel olarak anlamlı bir farklılık saptanmamıştır (p>0,05). Tüm olgularda PAI skorlaması ile koronal, sagital ve aksiyal düzlemlerdeki CBCT-PAI skorlaması arasında aynı yönlü ve istatistiksel olarak anlamlı bir ilişki bulunmaktadır (p=0,001; p<0,01).

Sonuç: Çalışmamızda CBCT ile periapikal lezyonların değerlendirilmesinde daha güvenilir sonuçlar elde edildiği saptanmıştır.

Anahtar Kelimeler: Periapikal hastalıklar, konik işınlı bilgisayarlı tomografi, radyografi, panoramik

INTRODUCTION

The field of radiology shows continuous development in order to improve the image quality and to reduce the patient radiation dose. At present, conventional radiography is replaced with digital radiography (DR) because of emerging radiographic technologies (1-4).

Dental radiographic imaging is a significant tool to achieve an accurate diagnosis. Traditional radiographic methods such as panoramic radiography (PR) provide adequate information; yet, these radiographic techniques provide a two-dimensional (2D) representation of 3-dimensional (3D) structures. Their limited film size, image distortion, magnification, and 2D view restrict their use in this field. To overcome the limitation, medical computed tomography (CT) began to be used for dental applications in the mid-1980s; however, due to the level of radiation exposure during image acquisition, this device received some criticism. Recently, cone beam computed tomography (CBCT) systems have become available for 3D visualization of the craniofacial complex (5).

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Cone beam computed tomography is an imaging technique, which is available to dentists for examining hard tissues in the dental and maxillofacial areas. CBCT gives a 3D view of the anatomy and pathology (6). CBCT is based on a volumetric tomography technique, which uses a 2D detector combined with a single 360° scan-providing 3D X-ray beam. The projection data are used for generating a 3D volumetric dataset to provide reconstructed images in coronal, sagittal, and axial planes, which are referred to as orthogonal planes (7).

Periapical lesions are considerably common in dentistry, and if untreated, they can lead to tooth loss. As a result of vital or necrotic origin inflammation, a response occurs against the causative agent in the periapical region and an acute or chronic form of bone resorption process occurs (8). The diagnosis and localization of periapical lesions and assessment of the endodontic treatment plan are important in dentistry. An essential component of the management of endodontic problems is radiographic examination. The periapical index (PAI) scoring system, which has been introduced by Ørstavik et al. (9), who also applied PAI to clinical trials, demonstrates a scale of 5 scores ranging from no disease to severe periodontitis with exacerbating features. The index is based on the evaluation of periapical radiographs of teeth with a known histological diagnosis. At present, this scoring system is commonly used in epidemiological studies in the literature (10, 11).

Gençoğlu et al. (12) studied periapical lesions of root-filled teeth (RFT) of 400 patients belonging to the Turkish population (138 men and 262 women, age 38.70±13.80 years) using PR. Out of 890 RFT, it was reported that 658 (73.9%) RFT had periapical lesions. It was reported that periapical lesions can be evaluated using PR.

Marques et al. (10) evaluated periapical lesions with panoramic radiographs of 179 patients with an age range 30–39 years. They reported that 27% of patients had periapical lesions. In total, 4446 teeth were evaluated, and 47 (26%) patients had 1 or more teeth with a periapical lesion, which were detected using PR. Thus, PR provides accurate data for detecting periapical bone lesions.

Archana et al. (11) also evaluated periapical lesions using PR in 30,098 teeth of 1340 patients aged older than 18 years. It was stated that 865 patients (1759 teeth) had a periapical lesion. Moreover, periapical lesions were diagnosed in 462 RFT. The authors concluded that periapical lesions can be diagnosed using PR in cases in which no destruction or the expansion of the bone cortex is present.

For several clinical and investigational purposes, CBCT has been used in endodontics (13-15). The specific endodontic applications of CBCT include the diagnosis of pathosis from endodontic and nonendodontic origins, assessment of root canal morphology, evaluation of root and alveolar fractures, analysis of internal and external root resorption, and presurgical planning in root-end surgeries. In addition, various studies have revealed that cysts could be distinguished from periapical granulomas by CBCT because of the fact that a difference in density can be observed between granulomatous tissue and the content of the cyst cavity. Therefore, noninvasive diagnosis is favored (16, 17).

CBCT-PAI is suggested to be used in the evaluation of periapical lesions with CBCT due to the limitations of the PAI scoring system. Therefore, Estrela et al. (18) demonstrated a new PAI (CBCT-PAI) based on CBCT for periapical status identification. The lesions in the case groups were measured using the software application on CBCT scans in 3 different planes: coronal, sagittal, and axial. The final CBCT-PAI was obtained from the largest measurement on a given lesion in the planes presented. Moreover, 2 additional variables, expansion of the cortical bone and destruction of the cortical bone, were added to the 6-point (0–5) scoring system (Figure 1). It has also been reported that this new scoring system provides more reliable data for the detection of periapical lesions (13, 19, 20).

The aim of this study retrospective study was to comparatively evaluate radiographically diagnosed periapical lesions in 200 patients with images of PR and CBCT of each patient using PAI and CBCT-PAI.

METHODS

The study was approved by Marmara University Health Sciences Institute Ethical Committee (protocol number: 119). The retrospective image records of 100 female and 100 male patients were selected from the archive in Department of Oral Diagnosis and Radiology at Marmara University Dental Faculty, Turkey. Each subject was asked to sign a consent form. The first inclusion criterion was an available CBCT (Planmeca Promax SD Mid, Helsinki, Finland) and PR (Morita Veraviewepocs, Kyoto, Japan) imaging of the patients. Inclusion criteria were patients older than 20 years, having at least 8 remaining teeth, and having 1 periapical lesion present in any of their root-filled teeth (RFT). All projections in the study were performed with the same radiographic equipment. The same technician performed all tomographic evaluations and panoramic radiographies. The images were exported and saved as single-frame DICOM files for CBCT and JPEG files for panoramic images.

To ensure a professional and efficient evaluation, an oral diagnosis and radiology clinician and specialist evaluated the clinical images. During the meetings of the pilot study, the clinician and radiology specialist were trained to evaluate the panoramic and tomographic images by the specialist who had an experience of 15 years or more. The evaluators showed agreement on the objective criteria for the evaluation of images.

The PR images were evaluated using the PAI scoring system by Ørstavik et al. (9). According to the index, each tooth was categorized as having a normal periapical structure (score 1), small changes in bone structure (score 2), changes in bone structure with some mineral loss (score 3), periodontitis with well-defined radiolucent areas (score 4), or severe apical periodontitis with exacerbating features (score 5).

Cone beam computed tomography images were evaluated using the CBCT-PAI scoring system. According to CBCT-PAI, in terms quantitative bone alterations in mineral structure, each tooth was categorized as having intact periapical bone structures (score 0), diameter of periapical radiolucency>0.5–1 mm (score 1), diameter of periapical radiolucency>1–2 mm (score 2), diameter of periapical radiolucency>2–4 mm (score 3), diameter of periapical radiolucency>4–8 mm (score 4), and diameter of periapical radiolucency>8 mm (score 5). In addition score (n)+E corresponds to the expansion of the periapical cortical bone and score (n)+D corresponds to the destruction of the periapical cortical bone.

Figure 1. Schematic representation of incisors and molars using CBCT-PAI
CBCT-PAI: periapical index adapted for cone beam computed tomography

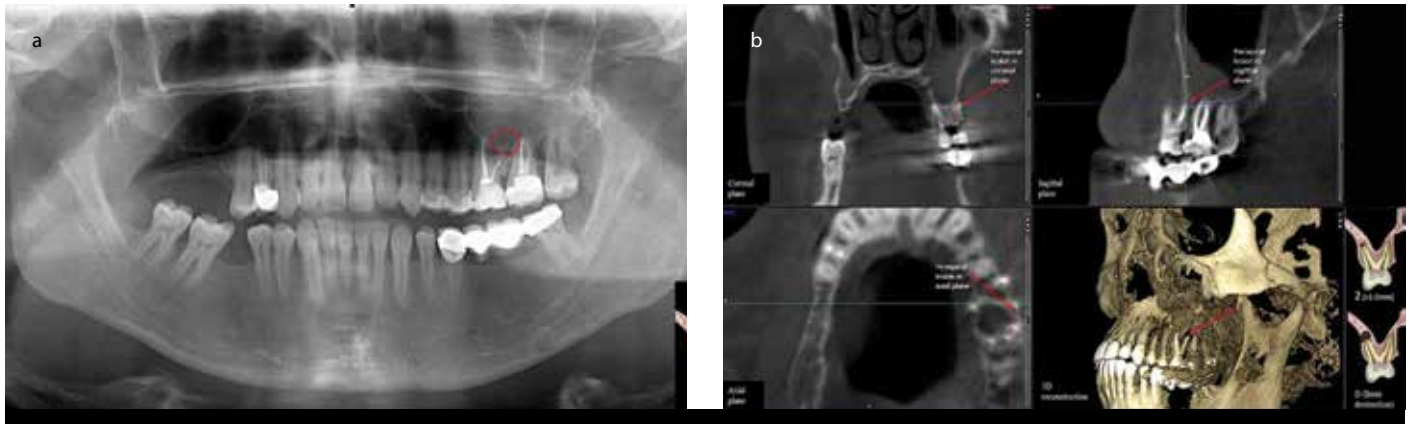

Figure 2. a, b. PAI scoring for tooth 26 using panoramic radiography: 1 (red circle) (a) CBCT-PAI scoring for the subject in Figure 2: coronal: 3+D, sagittal: 3+E, axial: 3+D (b)
PAI: periapical Index; CBCT-PAI: periapical index adapted for cone beam computed tomography

Periapical lesions were evaluated in coronal, sagittal, and axial planes, and 3D reconstruction was performed using the Planmeca Romexis software "Explorer" tool. When there was more than 1 periapical lesion, the largest lesion was selected to be evaluated in CBCT and PR images (Figure 2a, b). The largest diameter of periapical lesions detected in the maxilla and mandibula was measured using "measure" tool in 3 orthogonal planes with 0.40 mm slice thickness.

In addition, a new imaging mode, Planmeca Romexis endodontic module, which is specially designed for endodontic studies, was also used; it enables the visualization of anatomical root details of the teeth evaluated in the study.

Table 1. Evaluation of parameters according to gender

	Male	Female	p
[1]Age Mean±SD	36.91±11.40	39.01±12.05	0.207
[2]Number of teeth Mean±SD (Median)	25.85±4.59 (26)	23.96±5.64 (25)	0.028*
[2]No of teeth with lesions Mean±SD (Median)	3.08±1.80 (3)	2.73±1.82 (2)	0.094
[2]No of RFT Mean±SD (Median)	2.77±1.92 (2)	3.44±2.16 (3)	0.014*
[2]No of RFT with lesions Mean±SD (Median)	1.72±0.96 (1)	1.95±1.24 (1)	0.303

[1]Student t test, [2]Mann-Whitney U test. *p<0.05. SD: standard deviation; RFT: root filled teeth

Table 2. Distribution of CBCT-PAI scoring

	CBCT-PAI score		
Case	Coronal, n (%)	Sagittal, n (%)	Axial, n (%)
1	7 (3.5)	3 (1.5)	1 (0.5)
2	34 (17)	39 (19.5)	29 (14.5)
3	69 (34.5)	72 (36.0)	75 (37.5)
4	36 (18)	52 (26.0)	37 (18.5)
5	4 (2)	10 (5.0)	6 (3)
2+D	2 (1)	0 (0)	0 (0)
3+E	4 (2)	1 (0.5)	6 (3)
3+D	8 (4)	3 (1.5)	6 (3)
4+E	7 (3.5)	2 (1)	6 (3)
4+D	10 (5)	5 (2.5)	18 (9)
5+E	11 (5.5)	6 (3)	6 (3)
5+D	8 (4)	7 (3.5)	10 (5)

CBCT-PAI: periapical index adapted for cone beam computed tomography

Table 3. Correlation between PAI and CBCT-PAI scoring

	PAI					
	Male		Female		All cases	
CBCT-PAI	r	p	r	p	r	p
Coronal	0.534	0.001*	0.495	0.001*	0.525	0.001*
Sagittal	0.632	0.001*	0.602	0.001*	0.626	0.001*
Axial	0.550	0.001*	0.581	0.001*	0.571	0.001*

Spearman's rho correlation analysis. * p<0.01. PAI: periapical index; CBCT-PAI: periapical index adapted for cone beam computed tomography

Statistical Analysis

Statistical analysis was performed using IBM Statistical Package for Social Sciences Statistics 22 program (IBM SPSS Statistics, Armonk, NY, USA). The suitability of the parameters for normal distribution was evaluated by Kolmogorov–Smirnov test. Student t test was used in descriptive statistical methods (mean, standard deviation) as well as in quantitative data comparisons between two groups of parameters in normal distribution. Mann–Whitney U test was used in the comparison of parameters that do not show normal distribution between two groups. The significance level was set at p<0.05.

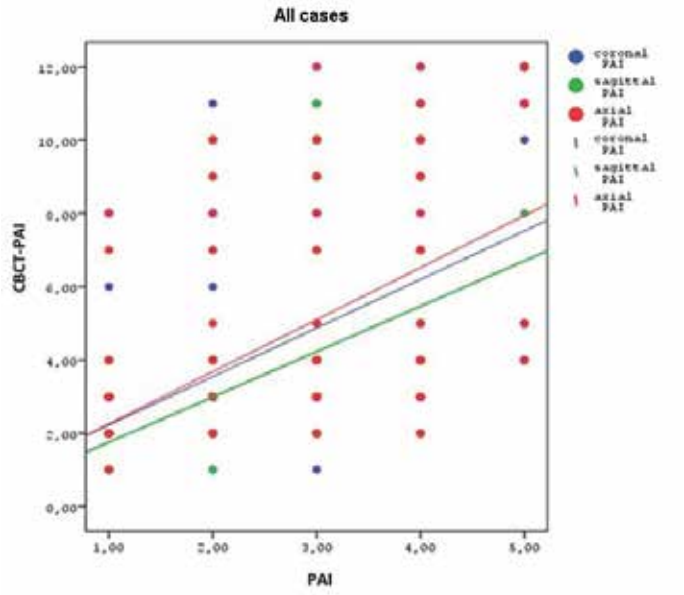

Figure 3. Correlation between PAI and CBCT-PAI scoring in 3 orthogonal planes in all cases
PAI: periapical Index; CBCT-PAI: periapical index adapted for cone beam computed tomography

RESULTS

The sample consisted of 200 subjects [100 men (50%) and 100 women (50%)] aged 20–67 years (mean age 37.96±11.74 years). In our study, there was no significant difference in terms of age between both the groups.

The number of teeth with lesions was significantly higher in men than in women (p<0.05). The number of RFT was significantly higher in women than in men (p=0.014; p<0.05) (Table 1).

The distribution of PAI scoring reveals that 14% of samples in the case group had normal periapical structures and 27% of the samples had small changes in bone structure. Changes in bone structure with some mineral loss were reported in 30% of the samples. Further, 20% of the samples in the case group had periodontitis with a well-defined radiolucent area. Severe periodontitis with exacerbating features were also affirmed in 9% of the samples in our study. The most common PAI score was score number 3.

The distribution of CBCT-PAI scoring in coronal, sagittal and axial planes is shown in Table 2. The most common CBCT-PAI score was score number 3 in all the 3 planes (Table 2).

When the correlation between the 2 scoring indexes in all the cases was analyzed, there was a significant relationship among the 3 orthogonal planes (p=0.001; p<0.01) (Figure 3, Table 3).

DISCUSSION

Radiography is an important tool in the diagnosis of periapical pathologies located in the oral cavity. An essential component of the

management of endodontic problems is radiographic examination (17, 21-23).The prevalence of periapical lesions has been reported in various populations with different radiographic methods (periapical radiography and PR) used in cross-sectional and epidemiological studies (24-26). It has been reported that when the progression of bone destruction occurs, periapical lesions can easily be diagnosed with PR (27-29).

Yıldırım et al. (30) studied a total of 19,625 patients belonging to the Turkish population with panoramic radiography. They diagnosed periapical lesions in 2287 patient and in 87 teeth with insufficient root canal treatment. In conclusion, their study revealed that root canals and possible periapical lesions can be evaluated using PR.

In another study, Jersa and Kundzina (31) investigated RFT and periapical lesions in the Latvia population (312 patients, age range 35–44 years) using PR and the PAI scoring system. Periapical lesions were diagnosed in 224 patients with a total of 342 insufficient root canal treatments. They reported that the detection of periapical lesions using PR and the PAI scoring system is conceivable in endodontic treatment planning.

It is not possible to observe any destruction or expansion of the bone cortex using 2D radiography techniques. Therefore, researchers emphasize on the use of CBCT and CBCT-PAI in the diagnosis of periapical lesions, particularly when bone destruction and expansion are present (14-16).

Low et al. (19) compared periapical radiographic techniques (using the F-speed film) using CBCT. In their study, 45 patients (19 women and 26 mean, mean age 51 years) and 156 teeth were evaluated. All 109 lesions were located at the apices of premolar and molar teeth; yet, 34% of these lesions were not identified with periapical radiographs. The authors stated that CBCT is certainly more accurate for detecting periapical lesions and leads to definite endodontic treatment planning.

Christiansen et al. (20) also compared periapical radiography and CBCT for assessing periapical bone defects after root resection. The study included 50 patients (24 men and 26 women, mean age 55 years) and 58 teeth with root tip resection. They stated that the detected periapical lesions were 10% smaller than those in CBCT images. The detection rate of periapical lesions in the coronal plane was 67%, and only 5% of the lesions were diagnosed with periapical radiographs. In conclusion, Christiansen et al. (20) reported that that more periapical lesions are diagnosed using CBCT than using periapical radiography.

In 2008, Estrela et al. (18) evaluated a total of 1014 images with periapical radiographs and CBCT scans taken from 596 patients using CBCT-PAI scoring. They reported that approximately 61% of the periapical lesions in their study were diagnosed using this new scoring system, whereas only 40% of the periapical lesions were diagnosed using periapical radiographs. CBCT-PAI is suggested to be used in the evaluation of periapical lesions with CBCT because of the limitations of the PAI scoring system. It has also been reported that this new scoring system provides more reliable data for the detection of periapical lesions.

Pope et al. (13) compared periapical radiography and CBCT and used two indices together, which is quite similar to the procedure in our study. Unlike our study, they used periapical radiography instead of PR and they did not include the two additional variables, i.e., E (expansion) and D (destruction), which are originally present in the CBCT-PAI scoring index, due to the fact that these variables were not relevant to the objective of their study. Similar to our study where we compared both periapical lesion scoring indices, the use of CBCT is also highlighted in their study.

CONCLUSION

In our study, PR and CBCT were used together to evaluate and compare PAI and CBCT-PAI scoring systems accurately. When both scoring indices were examined, we found a significant correlation between PAI and CBCT-PAI scorings defined for scores 2, 3, 4, and 5. However, for score 1, we found that CBCT-PAI, more reliable scores are obtained in the coronal plane. Thus, the superiority of CBCT and CBCT-PAI scoring in the early detection of periapical lesions was demonstrated in our study. Moreover, with the use of the Planmeca Romexis Endodontics module for displaying 3D root canal morphology, an advantage was observed in the evaluation of periapical lesions. Eventually, more reliable results were obtained using CBCT and CBCT-PAI than using PR and PAI in our study. The studies that include both periapical lesion scoring indices are extremely limited in the literature. Further studies are needed to elucidate the superiority of CBCT and CBCT-PAI over PR in the detection of periapical lesions.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Marmara University Health Sciences Institute (26/11/2013, Protocol number: 119).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – G.F.K., F.N.P. Design – G.F.K., F.N.P.; Supervision – F.N.P.; Resources – G.F.K., F.N.P.; Materials – G.F.K., F.N.P.; Data Collection and/or Processing – G.F.K., F.N.P.; Analysis and/or Interpretation – G.F.K., F.N.P.; Literature Search – G.F.K., F.N.P.; Writing Manuscript – G.F.K.; Critical Review – F.N.P.

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Hasta Onamı: Yazılı hasta onamı bu çalışmaya katılan hastalardan alınmıştır.

Hakem Değerlendirmesi: Dış bağımsız.

Yazar Katkıları: Fikir – G.F.K., F.N.P. Tasarım – G.F.K., F.N.P.; Denetleme – F.N.P.; Kaynaklar – G.F.K., F.N.P.; Malzemeler – G.F.K., F.N.P.; Veri Toplanması ve/veya İşlemesi – G.F.K., F.N.P.; Analiz ve/veya Yorum – G.F.K., F.N.P.; Literatür Taraması – G.F.K., F.N.P.; Yazıyı Yazan – G.F.K.; Eleştirel İnceleme – F.N.P.

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