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Assessment of Diagnosis of Apical Root Fractures During Tooth Extraction Using Different Radiographic Techniques: An Ex-vivo Study

Diş Çekimi Sırasında Apikal Kök Kırıklarının Tanısının Farklı Radyografik Teknikler Kullanılarak Değerlendirilmesi: Ex-vivo Bir Çalışma

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Abstract

Aim This study aimed to examine the diagnostic ability of different imaging techniques for apical root fractures that occur during tooth extraction by specialist dentists in different branches.

Material and Method Dry human mandibles used for education at Faculty of Dentistry and teeth extracted for routine treatment were used. After the root lengths were measured using a periodontal probe, the samples were adjusted to different lengths. These specimens were placed on a dry human mandible, and images were obtained and recorded using a periapical device, panoramic device, and computed tomography. Radiographs and recordings were performed by an oral and maxillofacial radiologist. The evaluation process was performed by an oral and maxillofacial radiologist, periodontologist, and oral and maxillofacial surgeon.

Results The diagnosis of 1 mm root presence and absence on periapical radiographs showed significant agreement among all observers. In the presence of 2 mm and 3 mm roots, all observers stated that the roots were present. On the panoramic radiographs, moderate agreement was observed in teeth with a 1 mm root. However, poor agreement between observers was observed for teeth with 2 mm and 3 mm roots. Cone-beam computed tomography (CBCT) was effective for the diagnosis of all observers.

Conclusion Consistent with the literature, the present study showed a higher interobserver agreement in CBCT. However, considering the patient's anxiety during the procedure, the duration of local anesthesia, and the surgeon's fatigue, two-dimensional radiographs are generally preferred over CBCT, which has a longer image processing time. Diagnosis using periapical radiographs was more effective than that using panoramic radiographs.

Keywords Cone-Beam Computerized Tomography; Digital Radiography, Panoramic; Radiography; Tooth Fractures

Özet

Amaç *Bu çalışma, farklı branşlarda uzman diş hekimleri tarafından yapılan diş çekimlerinde meydana gelen apikal kök kırıklarının teşhisi için farklı görüntüleme tekniklerinin tanı yeteneğini incelemeyi amaçlamaktadır.*

Gereç ve Yöntem *Diş Hekimliği Fakültesi'nde eğitim amacıyla kullanılan kuru insan alt çeneleri ve rutin tedavi için çekilen dişler kullanılmıştır. Kök uzunlukları periodontal sonda kullanılarak ölçüldükten sonra örnekler farklı uzunluklara ayarlanmıştır. Bu örnekler kuru bir insan alt çenesine yerleştirilmiş ve bir periapikal cihaz, panoramik cihaz ve konik ışınlı bilgisayarlı tomografi (KIBT) kullanılarak görüntüler alınmış ve kaydedilmiştir. Radyografiler ve kayıtlar bir oral ve maksillofasiyal radyolog tarafından alınmıştır. Değerlendirme süreci bir maksillofasiyal radyolog, periodontolog ve oral ve maksillofasiyal cerrah olmak üzere üç kisi tarafından gerçekleştirilmiştir.*

Bulgular *Periapikal radyograflarda 1 mm kök varlığı/yokluğu konusunda tüm gözlemciler arasında yüksek düzeyde anlamlı uyum olduğu gösterilmiş olup 2 mm ve 3 mm köklerin varlığında, tüm gözlemciler radyografide köklerin görülebildiğini belirtmiştir. Panoramik radyograflarda 1 mm kök varlığı/yokluğu konusunda, tüm gözlemciler arasında orta düzeyde, 2 mm ve 3 mm kök varlığı / yokluğu tanısında ise gözlemciler arasında zayıf bir uyum olduğu gözlenmiştir. KIBT'de ise kök varlığı ve yokluğu tanısında gözlemciler arasında uyum konusunda anlamlı bir farklılık oluşmuştur.*

Sonuç *Literatürle uyumlu olarak, bu çalışma KIBT'de gözlemciler arasında daha yüksek uyum olduğunu göstermiştir. Ancak, işlem sırasındaki hastanın kaygısı, lokal anestezinin süresi ve hekimin yorgunluğu göz önüne alındığında, genellikle daha uzun bir görüntü işleme süresine sahip olan KIBT yerine genellikle iki boyutlu radyografiler tercih edilmektedir. Periapikal radyografiler kullanılarak yapılan tanıların, panoramik radyografiler kullanılarak yapılan tanılardan daha etkili olduğu görülmüştür.*

Anahtar Kelimeler *Konik Işınlı Bilgisayarlı Tomografi; Dijital Radyografi, Panoramik; Radyografi; Diş Kırıkları*

INTRODUCTION

In ideal tooth extraction, complete removal of the tooth with its roots and minimal trauma to the surrounding tissues is one of the most important treatment steps. However, in clinical practice, this goal may not always be achieved and undesirable complications such as fracture of the alveolar bone and/or fracture of the tooth root may occur during tooth extraction.[1] One of the frequently encountered complications during root extraction is root fracture. In such cases, it is the responsibility of the dentist to decide whether to remove the root. The dentist should evaluate the radiation dose required for radiographic follow-up, the distinguishability of the root if left in place, and the potential damage to the alveolar bone and periodontal soft tissues, as well as the resulting problems such as tissue collapse or inability to place implants if the root is extracted. Therefore, dentists should act appropriately.[1-4]

In current literature, it is widely accepted that if the length of the root remaining in the socket after extraction is less than 4-5 mm and the root is not infected or in a superficial position, it can be left in place.[5]

Anatomically, root fractures can be classified as horizontal and vertical root fractures.[6] Radiographic imaging is crucial for the diagnosis and follow-up of root fractures. The periodontal ligament space around the root and changes in trabeculation in the surrounding bone can be determining variables in the diagnosis of root fractures.[7,8] The radiographic diagnosis of horizontal root fractures is easier than that of vertical root fractures. Therefore, several studies have focused on the diagnosis and treatment of vertical root fractures. However, diagnosis of root fractures is challenging. The most affected teeth are mandibular molars and maxillary premolars.[6-8]

This study aimed to compare the diagnosability levels of apical root fractures of different sizes that occur during tooth extraction on periapical radiography, panoramic radiography, and cone beam computed tomography (CBCT) images by dentists with different specialties.

MATERIALS and METHODS

Ethical approval for this study was obtained from the Ethics Boards and Commissions (2022/8104). Dry human mandibles used for educational purposes at the Faculty of Dentistry, Nuh Naci Yazgan University, and extracted teeth with routine treatment indications from patients treated at the same faculty were utilized in the study. The roots of the maxillary anterior, mandibular anterior, and mandibular premolars were used as the jaw locations. With the patient's consent, the teeth were collected and stored in separate containers in neutral-buffered 10% formalin solution. Root lengths were measured using a periodontal probe (Nordent Manufacturing, Inc., IL, USA), and the roots were sectioned using a vibration saw (Dentsply Friadent, Mannheim, Germany) in an aqueous medium. Experimental root segments were created at different lengths, namely, 1, 2, and 3 mm from the apical portion of the extracted teeth. Fifteen root fractures were created for each group. These roots were placed in the edentulous socket in the molar region of the dry human mandible to obtain radiographic images using periapical, panoramic, and CBCT, which were recorded numerically. To mimic the soft tissue, a dry human mandible was coated with wax.

Image acquisition

A film holder was used for periapical radiography, and the recommended dose setting of 60 kVp, 7 mA, and 0.32 seconds of exposure time was applied by the imaging company (KaVo FOCUS, Tuusula, Uusimaa, Finland) (Figure 1). For panoramic radiography, –65-70 kVp, 10 mA, and 16 s exposure was used (Figure 1), and for the CBCT images, a 5 cm × 5 cm field of view (FOV) area was exposed at 80 kVp and 8 mAs using a KaVO OP 3D Pro machine (PaloDEx Group Oy, Tuusula, Finland). Sections with a thickness of 1 mm were obtained for image analysis (Figure 2). The images were evaluated on the same monitor (Dell, 32 inch, color, 1280x1024, 32 bit, LCD) and in the same room.

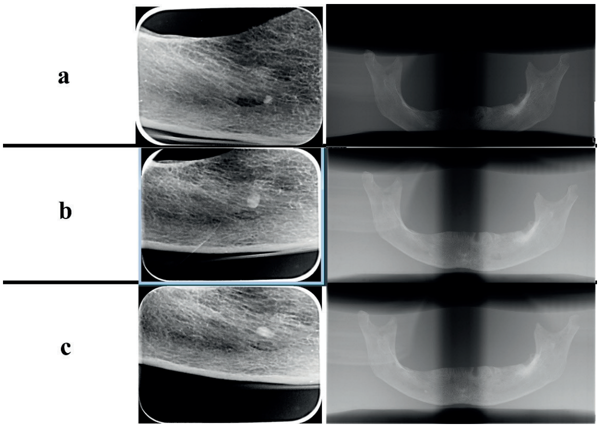

Figure 1. Periapical radiographs of the right third roots of different sizes; Panoramic radiography images of the left third roots of different sizes. a) Presence of 1 mm root (horizontal); b) Presence of 2 mm root (horizontal); c) Presence of 3 mm root (horizontal)

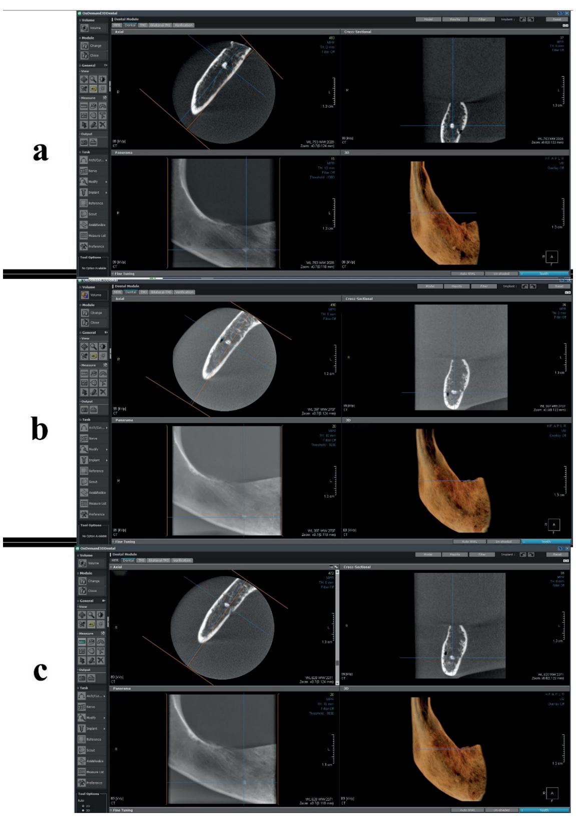

Figure 2. CBCT images of roots of different sizes. a) Presence of 1 mm root (horizontal); b) Presence of 2 mm root (horizontal); c) Presence of 3 mm root (horizontal)

Evaluation of the images

The X-ray imaging procedure and recording were performed by an oral, dental, and maxillofacial radiology specialist, with other observers having no knowledge about the image acquisition process. The radiologist responsible for obtaining the images did not participate in the evaluation. The radiologist who obtained the images did not present the unsuitable images for evaluation to the assessors. Only the images deemed suitable for evaluation were presented to the assessors, and the assessor's response regarding image quality was assessed. The evaluation process was performed by an oral and maxillofacial radiology specialist with 5 years of experience, a periodontics specialist, and an oral and maxillofacial surgeon. All the data were evaluated on the same computer screen in a dimly lit and quiet room. There was a 24-hour time interval between each observer's evaluation of the images. The evaluation criteria were based on the study by Yalda et al.9 The evaluators were asked to make assessments in two categories: the presence or absence of roots. Additionally, their confidence levels regarding the presence of roots were evaluated using a 5-point scale (definitely absent, probably absent, not sure, probably present, and definitely present). Finally, they were instructed to provide one of the three responses regarding image quality: sufficient, borderline, or insufficient. After all evaluations were completed, a random selection of 25% from each sample group was re-evaluated under the same conditions to assess the interobserver reliability.

Statistical analysis

GPower 3.1.9.4 program was used to calculate the sample size. When the effect size was taken as 0.5, α:0.05, β:0.82, the total number of samples for 3 groups was determined as 45.

IBM SPSS software (version 22.0) was used for the statistical analysis of the data. The Fleiss kappa (K) test was used to assess interobserver agreement (Table 1). In the interpretation of the κ statistic, the levels of agreement recommended by Landis and Koch (1977) were used in Table 1.10 A significance level of 0.05 was set for all analyses.

Table 1. Value Ranges for Interpretation of Kappa Statistic	
Kappa Value	Interpretation
<0	Poor agreement
0.01-0.20	Slight agreement
0.21-0.40	Fair agreement
0.41-0.60	Moderate agreement
0.61-0.80	Substantial agreement
0.81-1.00	Almost perfect agreement

Examiner consistency

Five randomly selected images were observed again by the same investigator 2 weeks after the first round of observations. Examiner consistency was assessed for all variables. For three observers, variables were highly similar between the first and second rounds of observations, with correlation coefficients of 0.85–0.96.

RESULTS

There was significant interobserver agreement for the presence or absence of a 1 mm root on periapical radiographs (κ=0.722, p<0.001). For 2 mm and 3 mm roots, all observers reported the presence of roots. The Fleiss kappa values for the diagnosis of root presence on a five-point scale varied by category. The diagnosis of "root definitely present" showed poor interobserver agreement for 1 mm (κ=-0.154, p=0.399) and 2 mm (κ=-0.071, p=0.696) roots, but a significant substantial agreement for 3 mm roots (κ=0.712, p<0.001). The diagnosis of "root probably present" showed poor interobserver agreement for 1 mm (κ=-0.005, p=0.979) and 2 mm (κ=-0.034, p=0.850) roots, and insignificant fair agreement for 3 mm roots (κ=0.259, p=0.156). The diagnosis of "not sure" showed insignificant slight agreement for 1 mm (κ=0.100, p=0.584) and poor agreement for 2 mm and 3 mm roots (κ=-0.034, p=0.850). For the diagnosis of "root probably absent," there was a significant interobserver substantial agreement for 1 mm roots (κ=0.760, p<0.001), but no occurrence of this diagnosis for 2 mm and 3 mm roots. None of the observers reported a "root definitely absent" diagnosis. The image quality of periapical radiographs showed moderate agreement for borderline view and satisfactory view for 1 mm root presence (κ=0.524, p=0.004), fair agreement for inadequate view (κ=0.318, p=0.170), and insignificant slight agreement for satisfactory view (κ=0.050, p=0.785). For 2 mm root presence, all observers reported a satisfactory view, while for the 3 mm root presence, there was a moderate agreement for borderline and satisfactory views (κ=0.464, p=0.011) (Table 2).

Interobserver agreement on panoramic radiography was 1 mm (κ=0.441, p=0.016); moderate agreement in the presence of roots, 2 mm(κ=-0.111, p=0.543), and 3 mm(κ=-0.034, p=0.850) showed poor agreement in the presence of roots. According to the categories on the 5th scale, 3 mm (κ=0.659, p<0.001) in the diagnosis of "root definitely present," the presence of roots showed a significant substantial agreement and became the category with the highest agreement among all categories. The presence of 1 mm (κ=0.457, p=0.012) roots showed moderate agreement, while the presence of 2 mm (κ=0.330, p=0.070) roots showed fair agreement. Two mm(κ=0.365, p=0.046), and 3 mm(κ=0.280, p=0.125) for the diagnosis of "root probably present," a fair agreement was observed in the presence of the root, 1 mm(κ=-0.111, p=0.543)), and there was poor agreement in the presence of roots. For the diagnosis of "not time," 1 mm (κ=0.040, p=0.827), root presence is insignificant, 2 mm(κ=0.-200, p=0.273), and 3 mm(κ=0.-111, p= 0.543), there was poor agreement in the presence of root. The root probably absent "root probably absent" and "root definitely absent" diagnoses have no response for 2 mm and 3 mm, while "root probably absent" diagnosis in the presence of 1 mm root is a poor agreement (κ=-0.111 p=0.543), "root definitely absent" diagnosis was insignificant. (κ=0.464, p=0.011). The image quality of panoramic radiographs was moderate for 1 mm roots, with views of "sufficient" (κ=0.426, p=0.020) and "insufficient" (κ=0.583, p=0.012). "borderline" (κ=0.040, p=0.827) showed insignificant agreement. In 2 mm roots, "insufficient" (κ=0.760, p<0.001) showed significant substantial agreement, "sufficient" (κ=0.330, p=0.070) showed fair agreement, and "borderline" showed insignificant agreement. In 3 mm roots, "sufficient" (κ=0.683 p<0.001) showed significant substantial agreement, while "insufficient" (κ=0.464, p=0.011) and "borderline" (κ=0.441, p=0.016) showed moderate agreement. (Table 3.)

Table 2. Statistical analysis of interobserver agreement for different root lengths on periapical radiographs (Fleiss kappa test)

PERIAPICAL			Root length			
Diagnosis	Yes	Fleiss kappa (%95 CI) p value	1 mm 0.722 (0.711-0.734) <0.001	2 mm All observer	3 mm All observer	Total 0.808 (0.801-0.814) <0.001
	of root	Fleiss kappa (%95 CI) p value	0.722 (0.711-0.734) <0.001	None	None	0.808 (0.801-0.814) <0.001
	Total	Fleiss kappa (%95 CI) p value	0.722 (0.711-0.734) <0.001	None	None	0.808 (0.801-0.814) <0.001
Diagnosis of root (Five point scale)	Root definitely present	Fleiss kappa (%95 CI) p-value	-0.154 (-0.165- -0.142) 0.399	-0.071 (-0.046- -0.060) 0.696	0.712 (0.700-0.723) <0.001	0.661 (0.654-0.667) <0.001
	Root probably present	Fleiss kappa (%95 CI) p-value	-0.005 (-0.016-0.007) 0.979	-0.034 (-0.046- -0.023) 0.850	0.259 (0.248-0.271) 0.156	0.200 (0.193-0.207) 0.058
	Not sure	Fleiss kappa (%95 CI) p-value	0.100 (0.089-0.111) 0.584	-0.034 (-0.046- -0.023) 0.850	-0.034 (-0.046- -0.023) 0.850	0.231 (0.224-0.237) 0.029
	Root probably absent	Fleiss kappa (%95 CI) p-value	0.760 (0.749-0.771) <0.001	None	None	0.788 (0.782-0.795) <0.001
	Root definitely absent	Fleiss kappa (%95 CI) p-value	None	None	None	None
	Total	Fleiss kappa (%95 CI) p-value	0.154 (0.147-0.161) 0.170	-0.053 (-0.062- -0.044) 0.713	0.439 (0.430-0.449) 0.004	0.461 <0.001
Image quality	Insufficient	Fleiss kappa (%95 CI) p-value	0.318 (0.307-0.330) 0.081	None	None	0.451 (0.445-0.458) <0.001
	Borderline	Fleiss kappa (%95 CI) p-value	0.524 (0.512-0.535) 0.004	None	0.464 (0.453-0.476) 0.011	0.586 ,(0.0579-0.592) <0.001
	Sufficient	Fleiss kappa (%95 CI) p-value	0.050 (0.038-0.061) 0.785	All observer	0.464 (0.453-0.476) 0.011	0.466 (0.579-0.592)
	Total	Fleiss kappa (%95 CI) p-value	0.283 (0.275-0.291) 0.030	None	0.464 (0.453-0.476) 0.011	0.499 (0.494-0.504) <0.001
Asymptotic 95% Confidence Interval p<0.05						

Table 3. Statistical analysis of interobserver agreement for different root lengths on panoramic radiographs (Fleiss kappa test)

PERIAPICAL			Root length			
Diagnosis of root	Yes	Fleiss kappa (%95 CI) p value	1 mm 0.441 (0.430-0.452) 0.016	2 mm -0.111 (-0.123- -0.100) 0.543	3 mm -0.034 (-0.046- -0.023) 0.850	Total 0.275 (0.268-0.282) 0.009
	of root	Fleiss kappa (%95 CI) p value	0.441 (0.430-0.452) 0.016	-0.111 (-0.123- -0.100) 0.543	-0.034 (-0.046- -0.023) 0.850	0.275 (0.268-0.282) 0.009
	Total	Fleiss kappa (%95 CI) p value	0.441 (0.430-0.452) 0.016	-0.111 (-0.123- -0.100) 0.543	-0.034 (-0.046- -0.023) 0.850	0.275 (0.268-0.282) 0.009
Diagnosis of root (Five point scale)	Root definitely present	Fleiss kappa (%95 CI) p-value	0.457 (0.446-0.468) 0.012	0.330 (0.319-0.342) 0.070	0.659 (0.648-0.671) <0.001	0.486 (0.479-0.492) <0.001
	Root probably present	Fleiss kappa (%95 CI) p-value	-0.111 (-0.123- -0.100) 0.543	0.365 (0.354-0.377) 0.046	0.280 (0.269-0.291) 0.125	0.275 (0.268-0.281) 0.009
	Not sure	Fleiss kappa (%95 CI) p-value	0.040 (0.029-0.051) 0.827	-0.200 (-0.211- -0.189) 0.273	-0.111 (-0.123- -0.100) 0.543	-0.079 (-0.86- -0.072) 0.454
	Root probably absent	Fleiss kappa (%95 CI) p-value	-0.111 (-0.123- -0.100) 0.543	None	None	-0.304 (-0.04- -0.028) 0.744
	Root definitely absent	Fleiss kappa (%95 CI) p-value	0.464 (0.453-0.476) 0.011	None	None	0.489 (0.482-0.495) <0.001
	Total	Fleiss kappa (%95 CI) p-value	0.202 (0.195-0.209) 0.059	0.219 (0.211-0.228) 0.106	0.372 (0.363-0.381) 0.008	0.277 (0.272-0.281) <0.001
Image quality	Insufficient	Fleiss kappa (%95 CI) p-value	0.583 (0.572-0.595) <0.001	0.760 (0.749-0.771) <0.001	0.464 (0.453-0.476) 0.011	0.640 (0.634-0.647) <0.001
	Borderline	Fleiss kappa (%95 CI) p-value	0.040 (0.029-0.051) 0.827	0.048 (0.036-0.059) 0.794	0.441 (0.430-0.452) 0.016	0.193 (0.186-0.199) 0.068
	Sufficient	Fleiss kappa (%95 CI) p-value	0.426 (0.414-0.437) 0.020	0.330 (0.319-0.342) 0.070	0.683 (0.671-0.694) <0.001	0.480 (0.473-0.487) <0.001
	Total	Fleiss kappa (%95 CI) p-value	0.372 (0.364-0.381) 0.006	0.331 (0.322-0.339) 0.015	0.557 (0.547-0.566) <0.001	0.421 (0.416-0.426) <0.001

Asymptotic 95% Confidence Interval
p<0.05

In CBCT examinations, all observers confirmed the presence of roots in all data, and the image quality was satisfactory.

DISCUSSION

This study provides information on the diagnostic ability of different imaging techniques for apical root fractures during tooth extraction. The results of this study show that dentists can diagnose apical root fractures more accurately on periapical radiographs. However, computed tomography images allow dentists to diagnose apical root fractures more accurately than panoramic radiography and periapical radiography.

Regarding root fractures, we came across the literature on vertical and horizontal root fractures, and radiological studies have focused on the diagnosis of these root fractures.[11,12] When the current literature is examined, no study has specifically focused on retained root fractures and apical root fractures that occur during tooth extraction. The literature primarily consists of in vitro and ex vivo studies that simulate root fractures using mechanical force with a hammer, or consider it as the gold standard.[13] In addition to vertical and horizontal root fractures, tooth roots can also fracture apically during tooth extraction. The clinician must then decide whether to leave the broken root fragment in place or to extract it. The decision to remove root fragments incidentally found on radiographs or those fractured during extraction procedures should be made based on the situation.[14] Although OPG and CBCT are not the first imaging methods applied in the clinical routine, an extra-oral film will be more atraumatic in case of a complication encountered during the procedure, considering both intra-oral bleeding and the patient's agitation.

Dentists and oral surgeons have developed various approaches for dealing with apical fractures that occur during tooth extraction, such as closed surgical techniques, open surgical techniques, the endodontic file technique, the local anesthetic needle technique, the vertical extraction technique, and the Benex device. Radiographic methods are important for analyzing the remaining roots. When dental imaging methods are compared in terms of radiation dose, periapical radiographs have the least radiation dose, while much less radiation dose is used in panoramic radiographs in full mouth imaging. Principles have been developed to reduce the radiation dose in CBCT radiographs. No matter which technique is preferred, movement of the patient during imaging negatively affects the image quality. To prevent this, it is necessary to fix the head. Its use is limited in some dental practices due to the sensitivity and contrast resolution of CBCT devices, artefacts and poor soft tissue image quality, as well as their high cost. Although CBCT with its increasing availability and popularity is more effective in analyzing the specific depth and location of remaining root fragments, traditional two-dimensional radiographs are still primarily preferred.[15-17] In this study, CBCT was found to be effective for diagnosis in all observers by the literature. However, in clinical practice, two-dimensional radiographs are often preferred over CBCT, which has a long image processing time, considering factors such as anxiety in the patient during the procedure, the duration of local anesthesia, and the fatigue of the surgeon. CBCT was compared with these radiographs to reflect clinical reality. Periapical radiographs showed more consistent results in the diagnosis by different observers on two-dimensional radiographs. Although this study tried to reflect soft tissue thickness, the patient factor should be taken into consideration in the clinic and head stabilization should be ensured. Aksever et al. found that CBCT images were more effective than periapical radiographs in an ex vivo study simulating horizontal root fractures.[18] However, no significant difference was found between conventional radiography, digital radiography, and CBCT images in the diagnosis of vertical root fractures in the anterior region of the mandible.[19]

Patient safety and radiation dose issues must be carefully considered when using CBCT. Although it reduces complications and increases patient safety with 3D analysis of anatomical structures, the increase in radiation dose cannot be ignored. Application of low-dose CBCT protocols reduces this disadvantage while maintaining diagnostic performance.[20] Yalda et al. investigated the use of CBCT at different doses for diagnosing root fractures and attempted to develop a radiographic protocol for lower-dose usage. However, due to the ex-vivo model not reflecting soft tissue and anatomical variations seen in clinical settings, it was noted that a standard radiation dose suitable for clinical use could not be established and that reducing the recommended X-ray parameters by 20% would not affect the accuracy of diagnosis.[9] Ex-vivo studies do not reflect clinically ideal results. However, in vivo studies have ethical drawbacks due to excessive radiation exposure.[21] Due to ethical concerns, we could not perform this study in vivo. To minimize soft tissue deficiencies in the ex vivo study, we covered the dry mandible with wax.

In this study, observations of a periodontologist, radiologist, and oral and maxillofacial surgeon were analyzed. Selection bias from observers should also be considered in diagnostic studies. The experience and expertise of the observer can influence the results.[13] For this reason, observers with different areas of expertise and at least 5 years of experience in the field were determined.

The limitations of this study are as follows: The diagnoses may differ from those made in a real clinical setting. The radiographic images used in this study may differ from those obtained in clinical settings. Only the mandibular posterior region with a thick cortical bone was simulated in this study. Therefore, the results may vary among teeth in different regions. Root fractures were created in different sizes; however, different types of root fractures were not evaluated in this study.

CONCLUSION

Complications, such as root fractures, may arise during tooth extraction, and the dentist may have to decide whether to leave or remove the root. In these types of root fractures, CBCT was found to be more effective for diagnosis than two-dimensional radiographs, with periapical radiography being more effective than panoramic radiography.

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Ethical Approval

The ethical approval of this study was approved by the Nuh Naci Yazgan University Scientific Research and Publication Ethics Committee in April 2022 with the decision number 2022/8104.

Peer-review

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Authorship Contributions

Concept: K.Ö., H.C.K.; Design: K.Ö., H.C.K.; Data collection or Processing: H.C.K; Analysis or interpretation: K.Ö., T.E.K., F.A.; Literature Search: K.Ö., F.A.; Writing: K.Ö.,T.E.K,F.A.

Conflicts of Interest Statement

There is no potential for bias or conflict.

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Data Availability Statement

The datasets created and analyzed during the current study are available from the corresponding author upon request.

References

1. El-Kenawy MH, Ahmed WM. Comparison between physics and conventional forceps in simple dental extraction. J Maxillofac Oral Surg. 2015;14(4):949-955. doi:10.1007/s12663-015-0765-6.
2. Ahel V, Cabov T, Spalj S et al. Forces that fracture teeth during extraction with mandibular premolar and maxillary incisor forceps. Br J Oral Maxillofac Surg. 2015;53(10):982-987. doi: 10.1016/j.bjoms.2015.08.007.
3. Kapila S, Kaur T, Bhullar RS et al. Use of physics forceps in atraumatic orthodontic extractions of bilateral premolars: A randomized control clinical study. J Maxillofac Oral Surg. 2020;19(3):347-354. doi: 10.1007/s12663-020-01347-6
4. Krug R, Soliman S, Krastl G. Intentional replantation with an atraumatic extraction system in teeth with extensive cervical resorption. J Endod. 2019;45(11):1390-1396. doi: 10.1016/j.joen.2019.07.012.
5. Yoldaş S, Bodur H, Küçükkurt S. Horizontal kök kırıklı bir dişin dekoronasyon ile tedavisi: olgu bildirimi. Acta Odontologica Tursica. 2016;33(2):91-94. doi: 10.17214/aot.66530.
6. Popescu SM, Diaconu OA, Scrieciu M, et al. Root fractures: epidemiological, clinical and radiographic aspects. Rom J Morphol Embryol. 2017;58(2):501-506.
7. Lustig JP, Tamse A, Fuss Z. Pattern of bone resorption in vertically fractured, endodontically treated teeth. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2000;90(2):224-227. doi: 10.1067/moe.2000.107445.
8. Tamse A, Kaffe I, Lustig J et al. Radiographic features of vertically fractured endodontically treated mesial roots of mandibular molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2006;101(6):797-802. doi: 10.1016/j.tripleo.2005.09.014.
9. Andraws Yalda F, Theodorakou C, Clarkson RJ, et al. Determination of a cone-beam CT low-dose protocol for root fracture diagnosis in non-endodontically treated anterior maxillary teeth. Dentomaxillofac Radiol. 2022;51(2):20210138. doi: 10.1259/dmfr.20210138.
10. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977;(1):159-174. doi: 10.2307/2529310.
11. Cohen S, Blanco L, Berman L. Vertical root fractures: clinical and radiographic diagnosis. The Journal of the American Dental Association. 2003;134(4):434-41. doi: 10.14219/jada.archive.2003.0192.
12. Kamburoğlu K, Ilker Cebeci A, Gröndahl HG. Effectiveness of limited cone-beam computed tomography in the detection of horizontal root fracture. Dental Traumatology. 2009;25(3):256-261. doi: 10.1111/j.1600-9657.2009.00770.x.
13. Salineiro FCS, Kobayashi-Velasco S, Braga MM et al. Radiographic diagnosis of root fractures: a systematic review, meta-analyses and sources of heterogeneity. Dentomaxillofac Radiol. 2017;46(8):20170400. doi: 10.1259/dmfr.20170400.
14. Nayyar J, Clarke M, O'Sullivan M et al. Fractured root tips during dental extractions and retained root fragments. A clinical dilemma? Br Dent J. 2015;218(5):285-290. doi: 10.1038/sj.bdj.2015.147.
15. Samur S. Dişhekimliğinde cone beam bilgisayarlı tomografi. ADO klinik bilimler dergisi. 2009;3:346-351.
16. Benton PN, Chang P. Oral Surgery, Extraction of Roots. [Updated 2023 Feb 9]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK589696/
17. Baş A, Derelioğlu SŞ. Çocuk diş hekimliğinde kullanılan farklı radyografi tekniklerinde radyasyon dozunu azaltıcı önlemler. Current Research in Dental Sciences.2022;32:231-238. doi: 10.17567/ataunidfd.1038856.
18. Avsever H, Gunduz K, Orhan K, et al. Comparison of intraoral radiography and cone-beam computed tomography for the detection of horizontal root fractures: an in vitro study. Clin Oral Investig. 2014;18(1):285-292. doi: 10.1007/s00784-013-0940-4.
19. Kambungton J, Janhom A, Prapayasatok S et al. Assessment of vertical root fractures using three imaging modalities: cone beam CT, intraoral digital radiography and film. Dentomaxillofac Radiol. 2012;41(2):91-95.
20. Kaaber L, Matzen LH, Spin-Neto R, et al. Low-dose, standard, and high-resolution cone beam computed tomography for alveolar bone measurements related to implant planning: An ex vivo study in human specimens. Clin Oral Implants Res. 2024. doi: 10.1111/clr.14326. Online ahead of print.
21. Keyzer C, Tack D, de Maertelaer V et al. Acute appendicitis: comparison of low-dose and standard-dose unenhanced multi-detector row CT. Radiology. 2004;232(1):164-172. doi: 10.1148/radiol.2321031115.