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HABILIDADE DE ALUNOS DE GRADUAÇÃO EM ODONTOLOGIA NO DIAGNÓSTICO DE FRATURAS RADICULADES: ANÁLISE COMPARATIVA DE DIFERENTES MÉTODOS DE IMAGEM

DENTAL UNDERGRADUATE STUDENTS ABILITY IN THE DIAGNOSIS OF ROOT FRACTURES: COMPARATIVE ANALYSIS OF DIFFERENT IMAGING METHODS

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DENTAL UNDERGRADUATE STUDENTS ABILITY IN THE DIAGNOSIS OF ROOT FRACTURES: COMPARATIVE ANALYSIS OF DIFFERENT IMAGING METHODS

Trabalho de conclusão de curso apresentado a Faculdade de Odontologia da Universidade Federal de Uberlândia, como requisito parcial para obtenção do título de Cirurgião-dentista.

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ABSTRACT

Objective: The aim of this study was to evaluate the diagnostic ability of dental undergraduate students to detect horizontal and oblique root fractures using different imaging techniques.

Materials and methods: Nine teeth were selected and randomly divided in three groups in order to create a fracture line without fragments separation: Control (without fracture), Horizontal root fracture (HRF) and Oblique root fracture (ORF). The root fracture was created using perpendicular force, and were confirmed by transillumination. A model with two adjacent teeth was created and different imaging techniques were performed: conventional periapical radiograph; mesially and distally shifted periapical radiographs; CBCT, cone-beam computer tomography. Twenty students that had participation on Dental Trauma Clinic at the year of 2019, were invited to identify root fractures by a 5-point scale: (i) fracture definitely not present, (ii) fracture probably not present, (iii) uncertain whether fracture is present or not, (iv) fracture probably present and (v) fracture definitely present. Data were analyzed by Kappa test for agreement evaluation.

Results: Comparing each student to the gold standard, there was a variation in reproducibility and performance from poor to substantial (0.042-0.667). Reproducibility values ranged from poor to good for all periapical radiographs both in the diagnosis of ORF (-0.33-0.667) and in HRF (0-1).

Conclusions: In CBCT images, the students ability was lower in HRF detection in comparison with the oblique ones. The students showed limited capacity to diagnose root fractures, however when CBCT was used the performance was more satisfactory than when periapical radiographs were used.

Keywords: diagnosis; dental students; education; tooth fractures; radiology; cone-beam computed tomography

SUMÁRIO

1 INTRODUCTION

Traumatic dental injuries (TDI) affect more than one billion of people around the world, being an important public health challenge[1,2]. The anterior maxilla and anterior upper teeth are the region most affected by trauma[3], and initial management that is provided at the time of injury is a critical point in long-term prognosis [4]. In addition, the correct diagnosis is fundamental for an adequate treatment, which is based not only on clinical and radiographic exams, but also on the professional's experience.[5]

A common type of dental traumatic injury is root fracture, which can lead to the development of tooth mobility[6, 7] and eventually lead to early loss[8]. Rates of 1.2% to 7.0% of frequency of root fractures in permanent dentition have been reported[8,9]. Several aspects determine the treatment options and prognosis of the traumatized tooth such as the affected location of the root fracture: cervical, medium or apical third[4,10], the root fracture orientation, if oblique, vertical, or horizontal[8] the fracture location, buccal or palatine/lingual[11]. Oblique (ORF) and horizontal root (HRF) fractures are difficult to diagnose using radiographic exams, which leads to tooth extractions without indication and worse prognosis in the medium and long-term[7, 10].

Periapical radiographs are commonly requested to assist clinicians for definition of the root fracture diagnosis[12]. However, the superposition of anatomical structures makes it challenging[13]. For a root fracture to become visible on radiological examination, the X-ray beam needs to be parallel to the fracture plane[14]. Thus, changes in the angulation of the X-ray beam can contribute to the alignment of the beam thus facilitating the identification of fracture presence[15,16]. Other imaging techniques such as cone-beam computer tomography (CBCT) may help the correct fracture diagnosis, since it is a three-dimensional exam that allows a multi-plane visualization and parameters adjustments such as slice-thickness and slice interval [17, 18].

Defining the efficiency of the diagnostic technique as well as the training of professionals since graduation to improve its effectiveness is an important factor to be considered and consequently can improve patient care[19]. The ability of clinicians, specialists in oral radiology and various other areas in the diagnosis of root fractures

has been previously evaluated[18, 20, 21]. However, few studies aimed to assess the ability of undergraduate students.

The application of clinical studies to solve some question on dental traumatology is not always possible. Thus, in vitro studies are proper alternatives to study situations such as diagnosis of simulated root fractures[22]. Due the importance of radiographic exams for diagnosing the root fractures, associated with the lack of studies evaluating the capacity of dental students in this task, the aim of this study was to evaluate the diagnostic ability of undergraduate dental students to detect HRF and ORF using different imaging techniques: periapical radiographs in orthoradial, mesial and distal angulations and CBCT. The null hypothesis is that: Different radiographic techniques and the type of fracture will not influence the diagnostic ability of dental students to detect root fractures.

2 MATERIAL AND METHODS

2.1 Ethical Considerations and Participants

This study was approved by the Ethics Committee in Research of the Federal University of Uberlandia (protocol #1.516.162). A total of twenty undergraduate dental students of the 4th (2nd year) to the 10th period (5th year), participants of Dental Trauma Clinic of the School of Dentistry, at the year of 2019, were invited and agreed spontaneously to participate of this study. All the participants signed a consent form and all of them maintained their right to withdraw from the study at any time. The invited students have participated of a training to diagnostic dental root fractures, including manipulation of 2D and 3D images, in addition to the clinical aspects related to dental root fractures.

2.2 Preparation of Samples

For simulated root fractured model preparation, sound bovine incisors were obtained from a local slaughterhouse. The teeth were collected, cleaned and

adequately stored in distilled water to keep their humidity. Nine teeth were selected by similarity variability higher than 5% measured the root dimensions using digital caliper (Mytutoyo, Tokyo, Japan) and the straight root shape. They were randomly divided through draw in 3 groups (n = 3): Control (without fracture) Horizontal root fracture (HRF) and Oblique root fracture (ORF).

In order to create a fracture line, without fragment separation for HRF and ORF groups, the teeth were stabilized and force was applied in a perpendicular way using a hammer. To confirm the discontinuity of the root and classify its orientation, all specimens were inspected by transillumination (Photonita, model P1050, model P1050, Florianópolis, SC, Brazil)[23]. The images of the specimens were captured at 1.5x magnification (Nikon D60 with a Nikkor 105 mm macro lens, Chiyoda, Tokyo, Japan) and the and fracture lines were confirmed in the using the software ImageJ (National Institutes of Health, Bethesda, MD, EUA) by a blinded evaluator.

Each tooth of the three groups, was placed imbedded in an artificially created model to simulate the anterior mandible region. A red wax barrier (Wilson, Polidental Indústria e Comércio Ltda, Cotia, Brazil) was made around a human mandible involving three dental alveoli: one central socket for the tooth to be analyzed and two adjacent sockets for sound teeth. A vinyl polysiloxane impression material (Aerojet, São Paulo, Brazil) was prepared and inserted into the wax barrier. An impression was made and melted wax was inserted into this mould. All teeth were removed the wax model and an impression was made using vinyl polysiloxane material[24]. The artificial alveoli model were individualized using bur #1516 (Edenta, São Paulo, Brazil) for handpiece, until the bovine teeth could be easily inserted into the sockets. The pouring and curing procedures were repeated to produce nine standardized models[25].

To simulate the periodontal ligament, the roots were coated into melted wax (Epoxiglass, Diadema, SP, Brazil) up to 2.0 mm below the cementum-enamel junction (CEJ), resulting in a 0.3 mm thick wax layer to accommodate the space for a periodontal ligament[26]. The models with artificial alveoli were filled with melted wax and the teeth inserted in the alveoli. Subsequently, the teeth were removed from artificial alveoli and the wax was removed from the root surface. The periodontal ligament was simulated with polyether impression material (Impregum F, 3M ESPE,

St. Paul, MN) that was inserted in the artificial alveoli and later the tooth was then reinserted into the alveoli and the excesses removed with a scalpel blade[26, 27] (Figure 1).

2.3 Image Acquisition

All models were submitted to four different imaging techniques: CRx, conventional periapical radiograph, MRx, mesially shifted periapical radiographs, DRx, distally shifted periapical radiographs and CBCT exam.

The digital intraoral periapical radiographs were acquired using VistaScan Mini Plus® photostimulable phosphor (PSP) system (Dürr Dental, Bietigheim-Bissingen, Germany). An acrylic device was manufactured in order to promote the stabilization of the model and assure the proximity and the correct parallel relation of the PSP plate with the model, as well as guide the perpendicular incidence of the x-ray beam. Exposures at mesial and distal angulations were obtained by shifting the cylinder in twenty degrees. A Timex 70E x-ray unit (Gnatus, Ribeirão Preto, SP) was used, operating at 70 kV, 7 mA and 0.2 seconds exposure time and 35 cm focus / film distance. The CBCT images were acquired in a Gendex CB-500 unit (Gendex Dental Systems, Hatfield, PA, USA) using the following parameters: 120 kV, 5 mA, 8,5cm FOV and 0.2 mm voxel size.

2.4 Radiographic Assessment

All images were randomized on random.org (Randomness and Integrity Services Ltd, Dublin, Ireland) and were evaluated in blocks of 10 images by the students in a secluded, dimly lit room, at three different times to avoid eye fatigue. The radiographs in tiff format were assessed in Windows default photo viewer, and the dicom files from CBCT images were evaluated in CS 3D Imaging software (version 7; Carestream Health, Rochester, NY, USA) using multiplanar reconstructed images (axial, coronal and sagittal) simultaneously. The images were analyzed on a Notebook HP Intel® Core™ 14” (Hewlett-Packard Company, USA) workstation. The observers were allowed to use tools for zoom, brightness and contrast adjustment.

The students were oriented to evaluate the central tooth of the model in relation to presence or absence of root fracture using 5-point scale as follows: (1) fracture definitely not present, (2) fracture probably not present, (3) uncertain whether fracture is present or not, (4) fracture probably present and (5) fracture definitely present.

2.5 Statistical Analysis

In order to verify the agreement of students evaluations of the CRx, MRx, DRx and CBCT images in relation to the gold standard (transillumination), Kappa test was applied and interpreted according to Landis.[28] as follows: values 0.00-0.20, poor 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. The tests were performed in MedCalc Statistical Software (version 15.2, MedCalc Software, Ostend, Belgium).

3 RESULTS

The total of participants was 20 undergraduate of dentistry school ranging to the 2nd to 5th year. Of this amount, one of 2nd year, eight of 3rd year, nine of 4th year and two of the 5th (last) year.

The Kappa test results regarding the agreement of each student evaluations in relation to the gold standard for the different imaging methods (CRx; MRx; DRx and CBCT) for each type of fracture (horizontal and oblique) are presented in Table 1. Regarding the performance of each evaluator, great variation was observed showing heterogeneity in the evaluators' ability to diagnose root fractures. By averaging the Kappa values of each student in relation to the gold standard, there is a variation in reproducibility and performance from poor to substantial (0.042-0.667).

Concerning the diagnosis of Oblique root fracture, reproducibility values ranged from poor to good (-0.33-0.667) for all periapical radiographs and from reasonable to substantial (0.33-0.714) for CBCT images. Regarding horizontal root fracture, the values also varied from poor to good (0-1) for all periapical radiographs and from poor to substantial (-0.33-0.667) on tomographic images. The horizontal

and oblique fractures are represented in figure 2 by means of periapical radiographs (a-f) and CBCT images (g-l).

In general, the lowest reproducibility was associated with the oblique root fracture when analyzed by periapical radiographs. CBCT showed lower performance for horizontal root fracture than for the oblique ones.

4 DISCUSSION

Dental trauma is usually associated with undesirable effects such as root resorption and loss of the injured teeth[29]. The diagnosis of root fracture is a challenge even for the most experienced professionals[30]. Depending on the educational philosophy of the curriculum of different universities and the learning methodology employed, undergraduate students may have little contact with this type of trauma. This study evaluated dental undergraduate students ability in the diagnosis of root fracture, aiming to understand frequency of diagnostic errors, to contribute the improvement of educational programs and enhance health services[31]. The null hypothesis was rejected that different radiographic techniques and the type of fracture would not influence the diagnostic ability of dental students.

The null hypothesis was rejected. Kappa scores obtained in this study indicated only poor to substantial reproducibility when compared to gold standard, transillumination. Although these values are lower than expected, this suggests that among students there would exist more distinct criteria when evaluating radiographs. This may be related to several factors, such as the variability of the students' levels. In this study, the grade of students varied from the 2rd to the 5th year (last year), which can affect the Kappa values[32]. Lower experience on diagnosis may contributed to difficult the correct diagnostic of root fractures, which is a challenge even for more experienced specialists and professionals[30]. The fact that some students develop a particular interest in just one area of the profession can also impair learning and consequently the level of care provided to patients[33]. Thus, the results obtained may have been influenced by factors such as age, training, skills, preferences and students experiences [34].

Another factor to be considered is the inadequacy of educational programs. There is a consensus that should be an emphasis on education and training to radiographic diagnosis in undergraduate dental students[35, 36]. This can be neglected by educational institutions, where the content of diagnostic imaging is only given in initial periods, creating a long period between the theoretical / laboratory approach and clinical practice, in addition to the limitation of the hourly load given to the content by several institutions. The adequacy of the undergraduate curriculum, the increase in practical classes so that students can interact more with image exams, and increase their experience are important elements for improving student competency in diagnosis of root fractures[37]. Recognize the reasons that affect the success of dental treatment is extremely important to improve undergraduate programs[38]. Moreover, a good imaging diagnosis is extremely important to better prognosis and treatment outcome[18].

In this study, regardless of the type of root fracture diagnosed, reproducibility values ranged from poor to good for all periapical radiographs, demonstrating the difficulty in diagnosing root fractures using only conventional radiographs, just like a study by Salineiro *et al* (2017)[39]. Root anatomy and image overlapping can lead professionals to neglect the fracture[13]. The reproducibility values for ORF diagnosed by periapical radiography were very low, independent of the angle of the X-ray beam (CRx; MRx; DRx). This method had the worst performance and did not contribute to the diagnosis. Thus, CBCT images could contribute to the diagnosis of this type of fracture, where the performance was better.

In another in vitro study, Kobayashi-Velasco *et al* (2017) demonstrated that the observers were able to detect the root fracture on periapical radiographs[18]. However, the induction of the root fracture was carried out with separation of fragments, which improves observation on imaging studies. The fractures simulated in this study was more challenging because the fracture maintained the fragments perfectly connected with visible space between them.

Several *in vitro* studies[14, 40] induced root fracture sectioning the tooth by using diamond discs, that results in wide and regular lines of fracture, different from what is often found in clinical practice. In the present study, we seek to get as close to the

clinical reality through the induction of root fractures by applying force with the aid of a hammer[12, 16, 21, 41, 42] aiming to obtain more irregular and thin lines of fracture.

The parallelism of the X-ray beam to the root fracture plane is also very important to achieve a good radiographic image and, consequently a correct diagnosis[43]. The 3D exams allow a better visualization of the region of interest, once there is no superposition of anatomical structures[12]. CBCT is a three-dimensional exam that allows better visualization eliminating the superposition of maxillofacial structures[44]. A systematic review sought to evaluate several radiographic methods in diagnosis of root fractures[39]. The included studies found better results for CBCT, and only one study reported no improvements using this imaging technique[42]. CBCT was significantly more accurate in the diagnosis of root fractures in comparison with intraoral radiography[21,41,45], which corroborates with the findings of the present study. Even with the limitations of the students, CBCT was more accurate in the diagnosis of ORF and HRF.

In relation to the type of fracture, the performance of CBCT was inferior in diagnosis of horizontal root fracture in comparison with the oblique root fracture. In vitro studies demonstrated that CBCT imaging obtained higher scores in detecting oblique root fractures[46,47]. Limitations of the CBCT technique, including higher radiation dose and higher cost when compared to two-dimensional images, may limit its use as a method of initial choice. Thus, conventional radiographs should be the first imaging exam to assess the region of interest and look for the presence of root fractures. In cases of insufficient imaging data for the final diagnosis, advanced methods can be acquired[47].

Radiographic examinations should be evaluated together with the patient's history and clinical examination to achieve an appropriate diagnosis[48]. In in vitro studies, this can be a limitation since observers only have images to define the diagnosis. Furthermore, this study reports on the experience at our dental course, so the results cannot be generalized. Further investigations involving other dental schools are recommended to assess students diagnostic ability using different imaging techniques. Another limitation would be in the use of artificial models with the use of plastic teeth. So, in this study bovine teeth were used to simulate human teeth.

The development of learning methodologies is necessary and can contribute to the improvement and development critical thinking of students during the undergraduate course, as well as improve students interpretation ability and enhance learning retention[33].

5 CONCLUSION

The students showed limited capacity to diagnose the root fractures.

Using CBCT the performance was more satisfactory than when they used periapical radiographs for ORF and HRF.

For CBCT images, the student's ability was lower in HRF detection in comparison with the oblique ones.

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Table 1 - Kappa test values. Agreement of each students evaluations in relation to the gold standard for the different imaging methods (conventional periapical radiograph; mesially shifted; distally shifted and CBCT) for each type of fracture (horizontal and oblique), on diagnosis of root fractures.

Radiographic method	Fracture orientation	Observers																			
		Obs 1	Obs 2	Obs 3	Obs 4	Obs 5	Obs 6	Obs 7	Obs 8	Obs 9	Obs 10	Obs 11	Obs 12	Obs 13	Obs 14	Obs 15	Obs 16	Obs 17	Obs 18	Obs 19	Obs 20
Periapical conventional	Oblique	0,00	0,33	0,00	-0,33	-0,33	0,00	0,66	0,33	0,00	-0,33	0,00	0,00	-0,33	-0,33	-0,33	0,00	0,33	0,33	0,33	-1,00
	Horizontal	1,00	1,00	0,33	0,66	0,66	0,66	1,00	1,00	1,00	0,66	0,33	0,66	0,66	0,33	0,33	1,00	1,00	1,00	0,33	0,00
Periapical mesially	Oblique	-0,33	0,00	0,00	0,00	-0,33	0,33	-0,33	1,00	-0,33	0,00	-0,33	0,00	0,00	0,00	0,33	0,67	0,67	-0,33	0,00	0,00
	Horizontal	0,33	0,33	0,67	1,00	0,67	0,67	0,00	0,67	0,33	0,67	0,33	0,33	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67
Periapical distally	Oblique	-0,67	0,67	0,00	-0,67	-0,67	0,00	0,33	0,67	0,00	0,00	0,33	0,33	-0,67	0,33	0,67	0,00	0,33	0,00	0,33	-0,67
	Horizontal	0,00	1,00	0,67	0,00	0,33	0,33	0,67	1,00	0,67	0,67	0,67	1,00	0,00	0,67	0,67	0,33	0,67	0,33	0,00	0,00
CBCT	Oblique	0,33	1,00	1,00	0,71	0,33	1,00	0,67	0,33	0,67	1,00	0,33	0,67	0,67	0,67	1,00	1,00	1,00	0,67	1,00	1,00
	Horizontal	-0,33	0,67	0,67	0,43	-0,33	0,67	0,67	0,00	0,00	0,00	0,33	0,67	0,00	0,33	0,00	0,33	0,67	0,67	0,33	0,67

Kappa test values. Intraobserver concordances on diagnosis horizontal and oblique root fractures, in relation to the gold standard.

FIGURES

Fig. 1. Artificially created model to simulate the anterior mandible region, with three dental alveoli: one central socket for the tooth to be analyzed (root fracture) and two adjacent sockets for sound teeth.

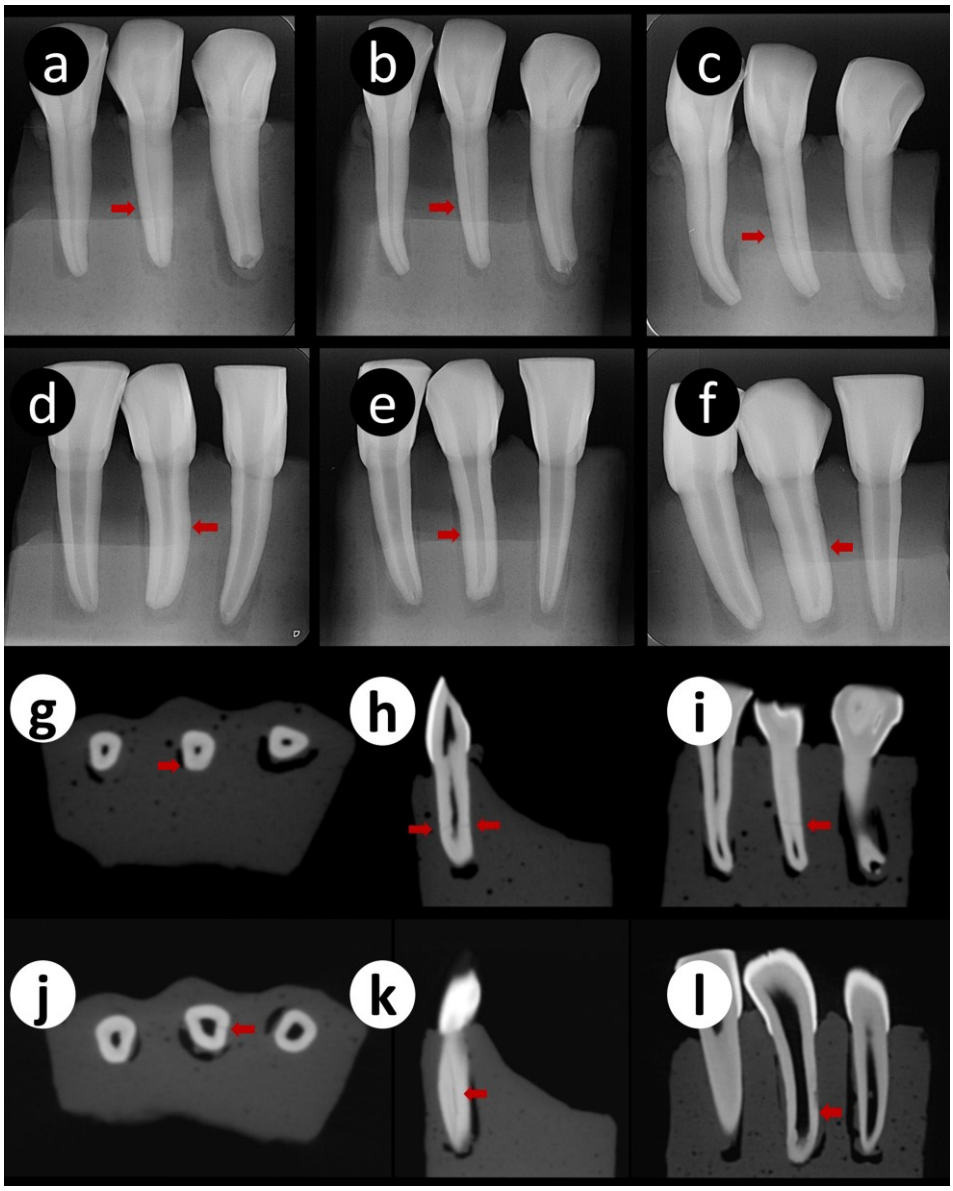

Fig. 2. Imagens of horizontal and oblique fracture on periapical radiography (a-f) and CBCT (g-l). Periapical radiography: a- mesially; b- conventional; c- distally, indicating a horizontal fracture. Periapical radiography: d- mesially; e- conventional; f- distally, indicating an oblique fracture. CBCT images: g- axial, h- sagittal, i- coronal, indicating a horizontal fracture. CBCT images: j- axial, k- sagittal, l- coronal, indicating an oblique fracture. The red arrows indicate the fracture lines.

Decision Letter (0042-May-21-JDE.R1)

From: Michael.Reddy@ucsf.edu

To: pbfsoares@yahoo.com.br

CC: Michael.Reddy@ucsf.edu

Subject: Journal of Dental Education - Decision on Manuscript ID 0042-May-21-JDE.R1

Body: 03-Sep-2021

Dear Dr. Barbosa Ferreira Soares:

It is a pleasure to accept your manuscript entitled "Dental undergraduate students ability in the diagnosis of root fractures: Comparative analysis of different imaging methods" in its current form for publication in the Journal of Dental Education. The comments of the reviewers who reviewed your manuscript are included at the foot of this letter.

First Look: Please note that your manuscript files will now be checked to ensure that everything is ready for publication. You will be contacted with instructions if final versions of your files are required.

JDE is published by Wiley, Inc. The corresponding author will receive an email from Wiley asking them to register with Wiley's Author Services. Once registered, the corresponding author can sign a license agreement and monitor the article's progress through the production process.

Thank you for your fine contribution. On behalf of the Editors of the Journal of Dental Education, we look forward to your continued contributions to the Journal.

Sincerely,

Michael Reddy

Reviewer(s)' Comments to Author:

Reviewer: 1

Comments to the Author
It can be accepted after corrections.

Reviewer: 2

Comments to the Author
The authors revisions to the manuscript in red font are acceptable in content but almost every entry has grammatical errors that need to be corrected before publication. No other concerns.

Reviewer: 3

Comments to the Author
no corrections

Date Sent: 03-Sep-2021