http://dx.doi.org/10.1590/1981-86372022001820200067

| ORIGINAL

Imaginologic resources used in diagnosis of root resorptions: comparative study

Recursos imaginológicos utilizados no diagnóstico de reabsorções radiculares: estudo comparativo

Paloma Gonçalves **CERQUEIRA**[1] 0000-0003-4205-4309

Hannah Barros **SIMÕES**[1] 0000-0001-9820-0251

Maria Cristina Teixeira **CANGUSSU**[2] 0000-0001-9295-9486

Luis Cardoso **RASQUIN**[1] 0000-0002-5797-9999

Fabiola Bastos de **CARVALHO**[3] 0000-0001-5326-9562

ABSTRACT

Objective: Compare the accuracy of early diagnosis of simulated internal root resorptions and external root resorption, using digital periapical radiography and cone beam computed tomography. **Methods**: Root resorption were simulated in extracted human teeth by demineralization with 5% nitric acid solution and 8% Sodium Hypochlorite in different periods (1 and 5 days). For the group external root resorption (n=12) composite resin cylinders were positioned on middle third of buccal surface of roots, to delimit application of demineralization substances. In group internal root resorptions (n=12) the teeth were sectioned longitudinally, and the composite resin cylinders were positioned in the middle third of root canals. The teeth were mounted in a dry mandible and evaluated by digital radiography and tomography. The images were evaluated by two examiners. **Results**: Analyzing the tomographic images in period of 1 day, the examiner 2 identified internal root resorptions that were not identified in radiographic images ($p<0.05$). No examiner was capable of diagnosing external root resorption irrespective of exam, in the group of 1 day ($p>0.05$). In 5 day period of induction, both exams identified internal root resorptions ($p>0.05$), however, the tomographic images were more effective in identifying external root resorption ($p <0.05$) for both examiners. **Conclusion**: Cone beam computed tomography was shown to be more effective than digital periapical radiography for detecting internal root resorptions with 1 day of induction. The imaginological resources used in this study were not able to early detect external root resorption.

Indexing terms: Cone-beam computed tomography. Radiography dental digital. Root resorption.

RESUMO

***Objetivo**: Comparar a acurácia do diagnóstico precoce de reabsorções radiculares interna (RRI) e reabsorções radiculares externa (RRE) simuladas, por meio de radiografia periapical digital e tomografia computadorizada de feixe cônico. **Métodos**: Reabsorções radiculares*

[1] Universidade Federal da Bahia, Faculdade de Odontologia, Departamento de Propedêutica e Clínica Integrada. Salvador, BA, Brasil.
[2] Universidade Federal da Bahia, Faculdade de Odontologia, Departamento de Odontologia Social e Pediátrica. Salvador, BA, Brasil.
[3] Universidade Federal da Bahia, Faculdade de Odontologia, Departamento de Clínica Odontológica. Av. Araújo Pinho, 62, Canela, 40110-150, Salvador, BA, Brasil. Correspondence to: FB Carvalho. E-mail: <fabiolabastoscarvalho@gmail.com>.

How to cite this article

Cerqueira PG, Simões HB, Cangussu MCT, Rasquin LC, Carvalho FB. Imaginologic resources used in diagnosis of root resorptions: comparative study. RGO, Rev Gaúch Odontol. 2022;70:e20220018. http://dx.doi.org/10.1590/1981-86372022001820200067

foram simuladas em dentes humanos extraídos utilizando a desmineralização com ácido nítrico 5% e hipoclorito de sódio 8% em diferentes períodos (1 e 5 dias). Para o grupo reabsorções radiculares externa (n=12) cilindros de resina composta foram posicionados no terço médio das faces vestibulares das raízes, delimitando a aplicação das substâncias de desmineralização. No grupo reabsorções radiculares interna (n=12) os dentes foram seccionados longitudinalmente, e os cilindros de resina posicionados no terço médio dos canais radiculares. Os dentes foram montados em mandíbula seca e avaliados por meio de radiografia digital e tomografia por dois examinadores. ***Resultados****: Nas imagens tomográficas no período de 1 dia, o examinador 2 identificou reabsorções radiculares interna as quais não foram identificadas nas radiografias (p<0,05). Nenhum examinador foi capaz de diagnosticar as reabsorções radiculares externa independente do exame no grupo de 1 dia (p>0.05). No período de indução de 5 dias ambos os exames identificaram as reabsorções radiculares interna (p>0,05), entretanto, as tomografias foram mais eficazes na identificação das reabsorções radiculares externa (p<0,05) para ambos os examinadores.* ***Conclusão****: A tomografia computadorizada de feixe cônico mostrou-se mais eficaz do que a radiografia periapical digital na detecção de reabsorções radiculares interna com 1 dia de indução. Os recursos imaginológicos utilizados neste estudo não foram capazes de detectar precocemente a reabsorção radicular externa.*

Termos de indexação: *Tomografia computadorizada de feixe cônico. Radiografia dentária digital. Reabsorção da raiz.*

INTRODUCTION

Root resorption is caused by a complex interaction of inflammatory cells that promote tissue demineralization and progressive loss of dental hard tissue. This may occur in two ways, external (external root resorption – ERR) or internal (internal root resorption – IRR), depending on its localization, and may vary relative to the cause, complexity and pathogenesis [1-6].

Damage and stimulation are required for reabsorption to occur. Damage is related to the non-mineralized layer covering internal walls of root canal, pre-dentin or external walls of the roots, and perishment. Without continuous stimulation, resorption stops spontaneously [1-4,7,8] Should this stimulation not cease, or be duly identified, resorption progresses and if not treated may lead to communication the root canal with periodontium [1,3].

Imaginologic exams, especially periapical radiographs are the resources most used for diagnosing root resorptions. Radiography provides information essential to diagnosis, planning, treatment and follow-up of cases [2]. However, the conclusive diagnosis based only on periapical radiography, because it represents a two-dimensional image of a three-dimensional lesion, ends up being limited. May be image distortions due to superimposition of anatomic structures, and cortical bone density, leading to an incorrect diagnosis [1-3].

Even if the periapical radiographs reveal mesio-distal details of teeth and peri-radicular region, structures of bucco-lingual axis are normally hardly visualized, making it difficult to identify lesions and juxtaposed structures [1,2].

Cone Beam Computed Tomography (CBCT) obtains a three-dimensional image it is a great help in obtaining diagnosis in endodontics [1-6]. This exam allows the creation of images in three dimensions (axial, coronal and sagittal axes), oblique, curved images and those in 3D. CBCT has helped in determining extension and localization of root resorptions [9].

An early diagnosis is the most critical and favourable factor in root resorption management, because the earlier the treatment is initiated, the less severe the resorption consequences will be, thus determining a favorable prognosis.

Therefore, the present study had as objective compare the accuracy of early diagnosis using digital periapical radiography (DPR) and cone beam computed tomography (CBCT), of internal (IRR) and external (ERR) root resorptions artificially created in extracted human teeth.

METHODS

The regional Committee of Ethics (Protocol number 63907417.0.0000.5024) approved the present study. For the study a sample of 24 single-rooted extracted human teeth were used (upper canines and incisors with completely formed apex). The teeth underwent a cleaning and sterilization process, and were stored in physiological solution up to the time of study. This sample was obtained after exclusion of teeth with calcifications and root resorptions (internal or

external) detected by means of conventional periapical radiographs taken in the mesio-distal and vestibular-lingual directions.

Teeth were divided into two groups of 12 specimens each, according to type of resorption to be induced, and subsequently sub-divided at random into two groups of 6 specimens each, according to time of induction of the resorptions (table 1).

Table 1. Type of resorption and induction time interval in the different groups.

Resorption	Induction time interval		Total (n)
	1 day – T1 (n)	5 days – T2 (n)	
Internal (IRR)	06	06	12
External (ERR)	06	06	12

For induction of internal root resorption, teeth were sectioned longitudinally (buccal-lingual direction) using a 76 x 0.2mm diamond cutting disc – Series 15HC (Buehler, Lake Bluff, Illinois, USA) mounted in an Isomet machine (Buehler, Lake Bluff, Illinois, USA) under constant cooling, producing two halves.

Length of all teeth was measured with aid of a digital pachymeter (Mitutoyo Sul Americana Ltda, Santo Amaro, SP, Brazil) with the purpose of marking middle third of root in both segments of tooth to simulate resorption.

A composite resin (Filtek Z250, 3M ESPE, St Paul, MN, USA) cylinder was fabricated, measuring 2mm in diameter and 2mm high [5] to delimit application of substances for induction of resorption in the two halves. Light polymerizing gingival barrier (Top dam, FGM, Joinvile, SC, Brazil) was used to seal the sides of the resin composite cylinder, along root canal, and thus avoid eventual leaks.

Internal root resorption was produced by demineralization with 5% nitric acid solution (Essencia Vitae Farmácia de Manipulação LTDA, Feira de Santana, BA, Brazil) used for 12 hours; 8% Sodium Hypochlorite (A Formula – Farmacia de Manipulação, Salvador, BA, Brazil) for 10 minutes; and 5% nitric acid solution for another 12 hours [5]. The solutions were placed inside the cylindrical chamber by means of micropipettes. Distilled water was used for washing, before the placement of each substance. The samples were kept in a refrigerator (-1ºC ± 3ºC) throughout the entire induction time interval.

After 24 hours of resorption induction a sample of 6 teeth were removed, characterizing Group IRR 1 day. The other 6 teeth were removed on the fifth day determining Group IRR 5 days.

For induction of external root resorption, the length of all teeth was also measured with aid of a digital pachymeter (Mitutoyo Sul Americana Ltda., Santo Amaro, SP, Brazil), to marking the middle third of root to simulate the resorption.

Similarly to procedure performed for induction of IRR, a composite resin (Filtek Z250, 3M ESPE, St Paul, MN, USA) cylinder was fabricated, measuring 2mm in diameter and 2mm high [5] to delimit the application of substances for induction of resorption on buccal surface of root. Same substances and same root resorption protocol were used. After 24 h of induction, 6 teeth were also removed, and another 6 teeth after 5 days of induction, characterizing the Groups ERR 1 day and ERR 5 days, respectively.

Before taking the radiographic and tomographic images, the composite resin was highlighted with aid of a Lecron spatula, and residues of substances were removed by means of washing with distilled water for 24h. The confirmation of the presence of simulated IRR and ERR in all specimens was performed using an operating microscope (16x, Alliance Model ALL 03, São Paulo, SP, Brazil), thus generating a gold standard.

In teeth with internal root resorptions halves were united with aid of wax, to enable the imaging exams to be obtained afterwards.

To take digital periapical radiographs, all the teeth, both those of IRR and ERR were mounted in a dry mandible (one at a time). A digital radiographic positioner "A" 107588100017 (Indusbelo, Londrina, PR, Brazil) was used, into which a digital sensor Fona CDR Elit (Sirona Dental, Long Island City, Nova York, USA) Size 2 (30x43mm^2), CMOS-APS technology with 27 ppl/mm^2 was fitted. Radiographic appliance used was SPECTRO 70X SELETRONIC (Dabi Atlante, Ribeirão Preto, SP, Brazil) power 1.20kVA, power/head of 70kVP, amperage 8mA, and exposure time of 0.15s. Digital images obtained were analyzed in a computer screen (figure 1).

Figure 1. Digital radiographic images showing examples of simulated IRR and ERR lesions. Arrow points at resorption. A) IRR of Group 1 day of induction; B) IRR of Group 5 days of induction; C) ERR of Group 1 day of induction; D) ERR of Group 5 days of induction.

For tomographic images, a digital Cone Beam Tomograph Kodak 9000 3D (Kodak Dental Systems, Carestream Health, Rochester, Nova York, EUA) appliance was used. Teeth were mounted in a dry mandible (four at a time, which was submerged in a receptacle containing water to simulate soft tissues). Following parameters were used: 74kV, 10mA, voxel 0.076 mm and FOV 53x74 mm for taking all the CBCTs. All images were stored in DICOM format – Digital Image and Communications in Medicine (figure 2).

The two methods of obtaining images for detection of simulated root resorptions were evaluated by two professional dentistry, one with 1 year of experience (EXA 1) and the other with 10 years of experience (EXA 2) in image analyses. Examiners made evaluation knowing of "suspected" presence of internal and/or external root resorptions, and that they had to report whether or not resorption was present.

Results obtained were tabulated and statistically analyzed using SPSS program (Version 21.0; IBM Corp, Armonk, NY, USA). Differences between data were evaluated by Pearson Chi-Square test at a 5% level of significance ($p<0.05$).

RESULTS

Results of the analyses of digital periapical radiography and cone beam computed tomography are described in table 2.

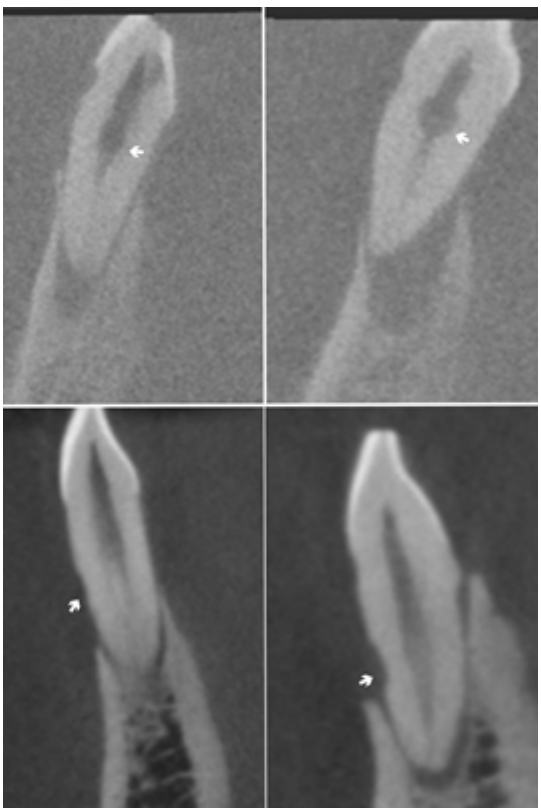

Figure 2. Tomographic images showing examples of simulated IRR and ERR lesions. Arrow points at resorption. A) IRR of Group 1 day of induction; B) IRR of Group 5 days of induction; C) ERR of Group 1 day of induction; D) ERR of Group 5 days of induction.

Table 2. Results of the evaluation of teeth with IRR and ERR.

Exam	Internal root resorption						External root resorption					
	Tooth	EX 1 T1	EX 2 T1	Tooth	EX 1 T2	EX 2 T2	Tooth	EX 1 T1	EX 2 T1	Tooth	EX 1 T2	EX 2 T2
Radiography												
	1	No	No	7	Yes	Yes	13	No	No	13	No	No
	2	Yes	No	8	Yes	Yes	14	No	No	14	No	No
	3	No	No	9	Yes	Yes	15	No	No	15	No	No
	4	Yes	No	10	No	No	16	No	No	16	No	No
	5	No	No	11	Yes	Yes	17	No	No	17	No	No
	6	Yes	No	12	Yes	Yes	18	No	No	18	No	No
Tomography												
	1	No	Yes	7	Yes	Yes	19	No	No	19	Yes	Yes
	2	No	Yes	8	Yes	Yes	20	No	No	20	Yes	Yes
	3	Yes	Yes	9	No	Yes	21	Yes	Yes	21	Yes	Yes
	4	No	No	10	Yes	Yes	22	No	No	22	Yes	Yes
	5	Yes	Yes	11	Yes	Yes	23	No	No	23	Yes	Yes
	6	Yes	Yes	12	Yes	Yes	24	No	No	24	Yes	Yes

Note: EX 1 – Examiner with 1 year of experience in analyzing images. EX 2 – Examiner with 10 years of experience in analyzing images. T1 – Resorption induced for 1 day. T2 – Resorption induced for 5 days.

In comparison between exams made by the same examiner, results demonstrated that for examiner 1 in Time 1, there was no statistical difference between them in the identification of internal root resorption ($p>0.05$). Whereas for examiner 2, in Time 1, there was statistical difference between digital periapical radiograph and CBCT ($p<0.05$) in identification of IRR. In evaluation of CBCT images, internal root resorptions were identified, which were not identified in digital periapical radiograph. In Time 2, for both examiner 1 and examiner 2, no statistical difference ($p>0.05$) was observed between exams in the identification of more advanced internal root resorption. On being evaluated, both imaginologic exams were capable of demonstrating the presence of IRR.

For examiner 1, in the evaluation of the digital periapical radiograph there was no statistical difference ($p>0.05$) between times (IRR 1 day and IRR 5 days), although examiner 1 had identified more internal root resorptions in Time 2. The same occurred with the evaluation of the CBCT images; there was no difference between the identification of IRR in Time 1 and Time 2 ($p>0.05$).

For examiner 2, when comparing the IRR in Times 1 and 2 in the evaluation of the digital periapical radiograph, statistical difference was observed between times ($p<0.05$). Examiner 2 identified more internal root resorptions in Time 2 (5 days) than in Time 1 (1 day). Whereas for tomographic images, there was no difference ($p>0.05$) in identification of IRR between Times 1 and 2. Examiner 2 was able to identify IRR in practically all CBCT images (Table 2) irrespective of time of resorption.

In comparison between exams made by the same examiner, results demonstrated that for examiner 1 in Time 1, and for examiner 2 in Time 1, there was no statistical difference between exams in identification of ERR ($p>0.05$). Both digital periapical radiography and CBCT were not capable of diagnosing ERR in its initial period.

In Time 2, for examiner 1 and examiner 2, there was statistical difference ($p<0.05$) when comparing exams. In evaluation of CBCT images, both examiners were capable of diagnosing the presence of ERR, in comparison with digital periapical radiography.

When comparing ERR of Time 1 and ERR of Time 2, in evaluation of digital periapical radiographs by examiner 1, no statistically significant differences ($p>0.05$) between times were observed. Irrespective of time of external root resorption, it was not possible to identify it in radiograph. The same was observed for examiner 2.

In evaluation of CBCT images by both examiner 1 and examiner 2, there was statistically significant difference ($p<0.05$) between times (ERR 1 day and ERR 5 days). Examiners were able to identify advanced ERR (ERR 05 days) in CBCT images. However, external root resorptions in their initial period (ERR 1 day) were not identified in CBCT irrespective of examiner.

DISCUSSION

Root resorptions are considered challenging situations in endodontic practice. Early detection and precise differential diagnosis are important factors that determine clinical and radiographic success of proposed treatment.

In this study, for simulating root resorptions, the method suggested by da Silveira et al. [5] with a combination of 5% nitric acid and 8% sodium hypochlorite was used. Due to dentin decalcification, these substances produce non-standardized erosions simulating clinical resorptions. In other studies, simulations of both internal and external root resorptions were conducted by using multi-bladed burs of different calibers [6,8,10,11] however, resorptions made by using these methods are uniform and circular, and hardly resemble real format of the lesion [1].

Our results demonstrated for internal root resorption in induction period of 1 day, that digital periapical radiograph was not effective as an auxiliary resource for diagnosis. Small sized root resorptions are difficult to identify in radiographic exams, corroborating with the findings of Vasconcelos et al. [4].

When comparing analyses of the digital radiographic images with those of CBCT images, it could be observed that tomography was shown to be superior for diagnosis of IRR of 1 day of induction, only for examiner 2. Possibly

the examiner experience with evaluation of tomographic images was fundamental for a precise diagnosis. Examiner experience and knowledge are essential in interpretation of imaginologic exams, and training is also indispensable for obtaining a precise evaluation with use of new technologies.

In internal root resorptions in the induction period of 5 days, since they were larger lesions, there was no difference between the exams in identifying the lesions; digital periapical radiographs and CBCT were equally capable of identifying resorption, thus showing that the capacity for detection increased with the size of the defect, in which there is significant difference when comparing small, medium and large defects [12].

For external root resorption in induction of 1 day, both digital periapical radiography and CBCT were not capable of diagnosing lesions in their initial period. Studies [9,13] have reported that periapical radiography does not have a good performance in detecting small resorptions (smaller than 0.6mm in diameter and 0.3mm deep), particularly on account of superimposition of anatomic structures. Whereas, CBCT has advantage of absence of this superimposition which facilitates diagnosis, in disagreement with the present study, in which ERR of 1 day of induction were incapable of being diagnosed in tomographic images.

For digital periapical radiography even in ERRs of 5 days of induction, they did not obtain 100% of identification. This result indicates that among root resorptions, external type appears to present greater difficulty with diagnosis by radiographic exams than internal type. In internal root resorption, lesions are in continuity with canal walls, the contour of root canal cannot be followed through lesion because canal walls in the area are dished, whereas in external root resorption, canal wall can be traced through resorption, because of the latter being superimposed on root canal [1].

Previous studies [7,9] have demonstrated that periapical radiography has low performance in detection of smaller lesions localized on vestibular or lingual surface of teeth, a fact confirmed in present study, in which root resorptions were simulated on vestibular surface. Although radiographic diagnosis of ERR is more difficult, knowledge and previous experience with variation in horizontal angulation on obtaining periapical radiographs generally elucidate these doubts [9], however, in this study only orthoradial periapical radiographs were taken.

Increase in size of resorption cavities led to greater diagnostic capacity by CBCT, as observed in this study, in which examiners were able to identify advanced ERR (ERR 5 days) in tomographic images. In general, root resorptions are more difficult to diagnose in CBCT only in the apical third [14,15] due to characteristics of narrowing of root and reduced area in the region.

It may be suggested that CBCT image quality is more closely associated with the voxel size than the FOV size. In the study of Da Silveira et al. [16], using either restrict or large FOV did not influence the IRR volume measured. The tomographic images of the present study were obtained using the Kodak 9000 3D tomography device with voxel 0.076 mm and the smallest FOV of the device 53x74 mm.

In spite of not being the aim of this study, it was observed that sagittal plane offered a better image for diagnosing internal and external root resorptions. Similar situation observed in the study of Sonmez and Kamburoglu [7], when they concluded that on requesting tomographic cuts for diagnosis of vestibular or lingual external root resorption, sagittal cuts provided better characterization of image of resorption process. Sagittal plane revealed various important points and characteristics of dental structures, such as cement-enamel junction and morphology of roots, which helped to localize cavities through root thirds especially small types facilitating diagnosis.

CONCLUSION

Cone beam computed tomography was shown to be more effective than digital periapical radiography for detecting IRR with 1 day of induction. The imaginological resources used in this study were not able to early detect external root resorption.

Acknowledgements

The authors wish to thank the Computed Tomography Laboratory of the School of Dentistry, Federal University of Bahia for allowing tomographic images to be made.

Collaborators

PG Cerqueira, researcher responsible for conceptualization, study design, writing of the manuscript and review of the manuscript. HB Simões researcher responsible for conceptualization, study design, writing of the manuscript and review of the manuscript. MCT Cangussu researcher responsible for statistic, supervision, visualization and writing of the manuscript. LC Rasquin, researcher responsible for conceptualization, study design, writing of the manuscript and review of the manuscript. FB Carvalho researcher responsible for conceptualization, study design, project administration, writing of the manuscript and review of the manuscript.

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Received on: 11/5/2020
Final version resubmitted on: 29/10/2020
Approved on: 10/12/2020

Assistant editor: Marcelo Sperandio