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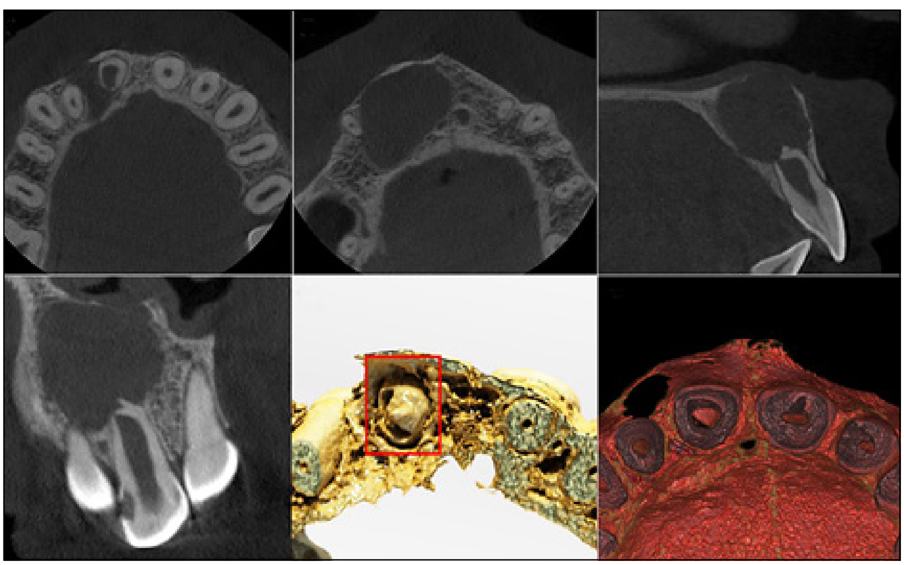

Case series

Nonsurgical management of maxillary first molars with 5 root canals: a multicenter case series

Original Articles

Effect of horizontal position of fiber post placement on fracture resistance and location in endodontically treated premolars with a MOD preparation

Accuracy of a minimally invasive surgical guide in microsurgical endodontics: a human cadaver study

Case Report

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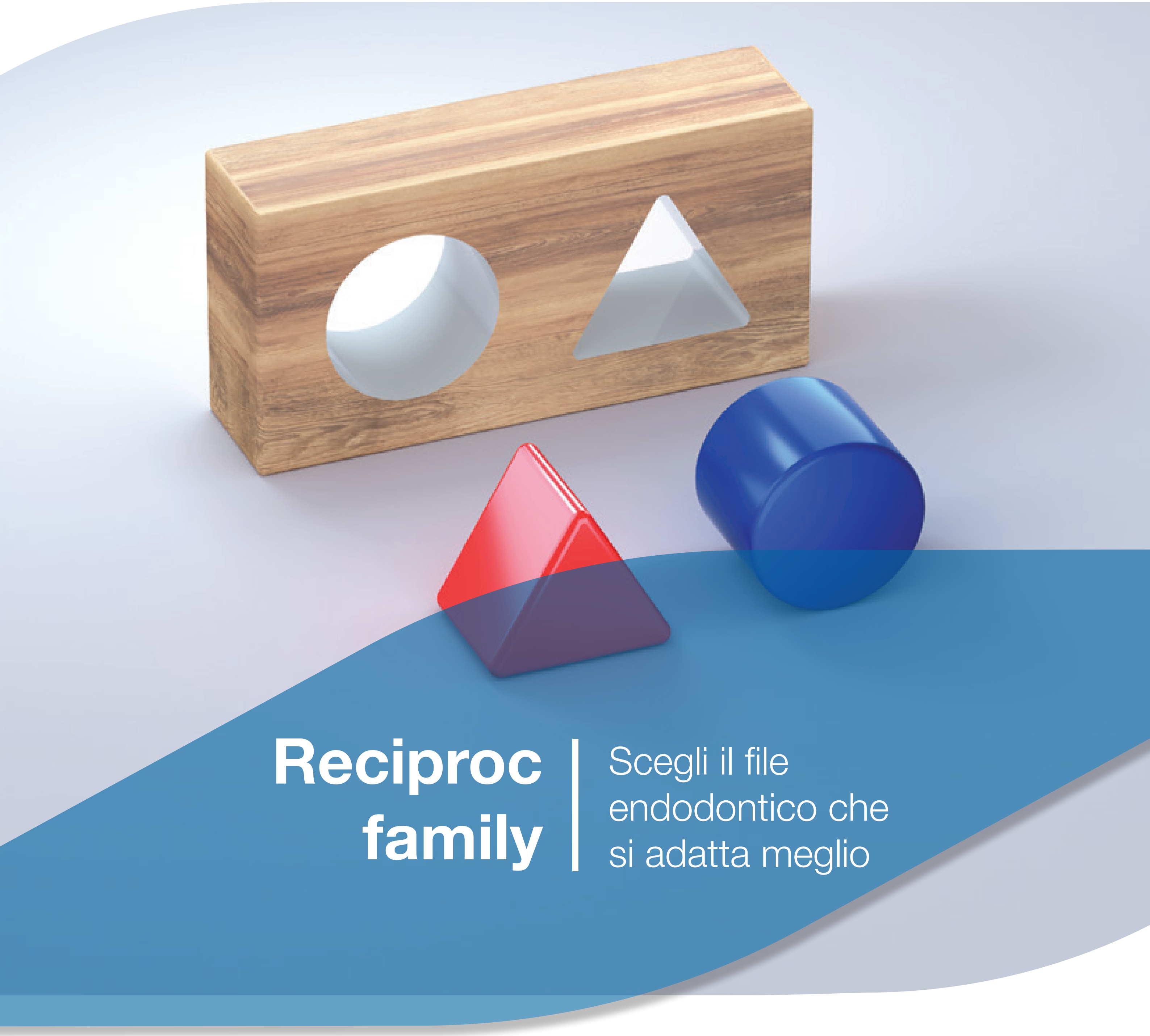

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Giornale Italiano di Endodonzia *was founded in 1987 and is the official journal of the Italian Society of Endodontics (SIE). It is a peer-reviewed journal publishing original articles on clinical research and/or clinical methodology, case reports related to Endodontics. The Journal evaluates also contributes in restorative dentistry, dental traumatology, experimental pathophysiology, pharmacology and microbiology dealing with Endodontics. Giornale Italiano di Endodonzia is indexed in Scopus and Embase and published online on ScienceDirect and www.giornaleitalianoendodonzia.it. Giornale Italiano di Endodonzia is an Open Access Journal.*

REGISTRATION Court of Milan n° 89, 3 March 2009

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ENDODONZIA
PROTOCOLLI CLINICI SU BASI SCIENTIFICHE

BOLOGNA, 12-13 NOVEMBRE 2021
Palazzo della Cultura e dei Congressi
Piazza della Costituzione, 4/A - 40128 Bologna

PROGRAMMA

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9.00-9.15	Apertura Lavori a cura del Presidente SIE - Roberto Fornara
Corso Pre-Congresso	PRESIDENTI DI SESSIONE Roberto Fornara - Andrea Polesel
9.15-10.45	Incontro conclusivo SIE ENDODONTIC COURSES 2021 “Endodonzia & Protesi: come ottenere la simbiosi ideale” Cristian Coraini e Gaetano Noè
10.45-11.30	Coffee Break
11.30-13.00	Incontro conclusivo SIE ENDODONTIC COURSES 2021 “Endodonzia & Protesi: come ottenere la simbiosi ideale” Cristian Coraini e Gaetano Noè

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15.10-15.50	Gianluca Plotino I fattori prognostici del trattamento endodontico
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SABATO 13 NOVEMBRE

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13.50-14.00	Chiusura Lavori e Saluto del Presidente

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Editorial

Endodontics: clinical protocols on scientific basis

The 37th National Congress of the Italian Society of Endodontics (SIE), that will take place in Bologna the next 12th and 13th of November, finally marks a new beginning of in-person activities, as symbolically represented by the motto "SIE restart".

Last year the absence of our National Congress was admirably replaced by the Virtual Endodontic Week Convention of SIE from 3rd to 7th of November 2020. However, the urgent need of social as well as scientific restart, in line with the improvement of the pandemic condition and in compliance with laws, has allowed the creation of a full cultural program that will deal with ***Endodontics: clinical protocols on scientific basis****. Specifically, during the two-days Congress personalities of note belonging to our Society and scientific community will present several lectures to provide an* excursus *on different fields of endodontics, from traditional endodontic approach to endodontic surgery and minimally-invasive procedures, taking into account new digital technologies and supporting the clinical results with the most recent scientific evidences. Indeed, Evidenced-Based Medicine (EBM) plays a central role in daily clinical practice, allowing more expert clinicians to make more aware clinical decisions based on high quality scientific research with the aim to maintain the global health of patients. Even in the endodontic field, this approach not only provides more complete endodontists but also establishes the topics of future studies.*
Looking forward to see You in-person at the 37th National Congress of SIE!

Peer review under responsibility of Società Italiana di Endodonzia.

10.32067/GIE.2021.35.02.39

CASE REPORT

Endodontic guides and ultrasonic tips for management of calcifications

ABSTRACT

Aim: *To describe the role of guided endodontics with ultrasonic tips in management of calcified canals.*

Summary

Case 1: A 23-year old female presented with esthetic complaint related to the maxillary left central incisor with a history of trauma. Radiographic examination revealed internal resorption and apical calcification. A silicone impression of the maxillary jaw was obtained and scanned to plan for access of the calcified canal by means of implant planning software. Guides were fabricated through rapid prototyping and allowed for the correct orientation of an ultrasonic tip to provide access through the calcifications. An access cavity was done, the calcified canal was accessed by the help of the fabricated guide, and the root canal was prepared and obturated using warm vertical technique apical to the resorptive defect. The rest of the canal was filled with mineral trioxide aggregate (MTA). One-year follow-up revealed no symptoms and evidence of radiographic healing.

Case 2: A 43-year old male was referred for endodontic treatment of the maxillary right first molar. The mesiobuccal and palatal canals were prepared by the referring dentist who failed to locate the distobuccal canal. Radiographic examination revealed a previously initiated root canal therapy, widening of the periodontal membrane space and coronal calcification of the distobuccal canal. A silicone impression of the maxillary jaw was obtained and scanned similar to the first case. The distobuccal canal was located using the ultrasonic tip through the guide, prepared, and obturated using warm vertical technique. One-year follow-up revealed no symptoms and evidence of radiographic healing.

Key-learning points

- *Endodontics guides with ultrasonic tips are reliable in management of root canal calcifications.*
- *Three-dimensional imaging using CBCT and CAD/CAM provides accurate 3D guides.*

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KEYWORDS *cone beam computed tomography, calcification, intraoral scanning, resorption, ultrasonic*

Key-learning points

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Introduction

Partial or complete canal calcification is a common finding in permanent teeth which may be a sequela of caries, aging, traumatic injuries and systemic conditions (1). In such cases, root canal treatment is recommended in symptomatic cases of pulpal and/or periapical pathosis (2). Localization and negotiation of calcified root canals is a challenging procedure, where iatrogenic errors may occur.
According to the classification of the American Association of Endodontists of the level of difficulty, treatment of calcified root canals is considered to have a high level of difficulty (3). Long-shank drills and ultrasonic tips coupled with dental operating microscope are used for such cases. Yet, the possibility of procedural errors and risk of failure are still high when dealing with calcified canals. Surgical approach is another treatment option, but it possesses many challenges (4).
Cone beam computed tomography (CBCT) is a very beneficial tool for diagnosis and treatment planning of complex endodontic cases and management of procedural errors (5, 6). Guided endodontics and virtual planning help to preserve the remaining tooth structure and avoid procedural errors.
According to the European Society of Endodontology statement in 2019 about the applications of CBCT in endodontics, it is recommended for the identification of the spatial location of extensively obliterated canals taking into account the possibilities of guided endodontics (7). Guided endodontics in the management of root canal calcification has been previously reported and considered safe and predictable (8). Guided endodontics in addition to dynamic navigation has shown excellent results as a training tool for dental students and might be of great value in management of calcified root canals (9).
In this report we describe the management of calcified canals in maxillary central incisor and maxillary first molar to reach the remaining apical tissues using the guided endodontic technique and ultrasonic tips.

Report

#*Case 1*
On October 15th, 2019, a 23-year old female patient presented with esthetic complaint related to the maxillary left central incisor. The patient gave history of a traumatic injury about 10 years ago with intrusion of the tooth. The patient was asymptomatic and two-dimensional periapical radiographic examination revealed internal resorption and apical calcification plus widening of the periodontal membrane space. No previous dental intervention was noted. Clinical examination revealed an intruded maxillary left central incisor which was sensitive to percussion and negative on palpation. Normal periodontal support was noted. Negative response was shown to thermal and electrical pulp testing. CBCT scans confirmed the periapical radiographic findings. Different treatment options were discussed with the patient taking into consideration the case difficulty. The use of 3D guide was decided, and a written consent was obtained.
An impression was done to the maxillary jaw using an addition silicone (Elite, Zhermack, Germany) then poured with dental stone material (Elite, Zhermack, Germany). The dental cast was scanned using CBCT so that it can be used along with the patient's scan for planning and guide fabrication.
Clinical procedures were done under local anesthesia. The coronal access cavity preparation was done in the usual position in the middle middle third of the palatal surface of the tooth using diamond round bur size 2 operated in high speed. The fabricated guide was adjusted in place. An ultrasonic tip ET25 (Satelec, France) attached to P5 ultrasonic scaler (Satelec, France) was used to locate the canal and access through the calcification. The ultrasonic tip operated till reaching the predetermined planned length. After reaching the length, the 3D guide was removed, and rubber dam isolation was done. K file #10 and #15 (Mani, Japan) were used to negotiate the canals and working length was determined using electronic apex locator (Dentaport, Morita, Japan). Root canal preparation was performed using rotary file system M3-Pro Gold (Udg, China)

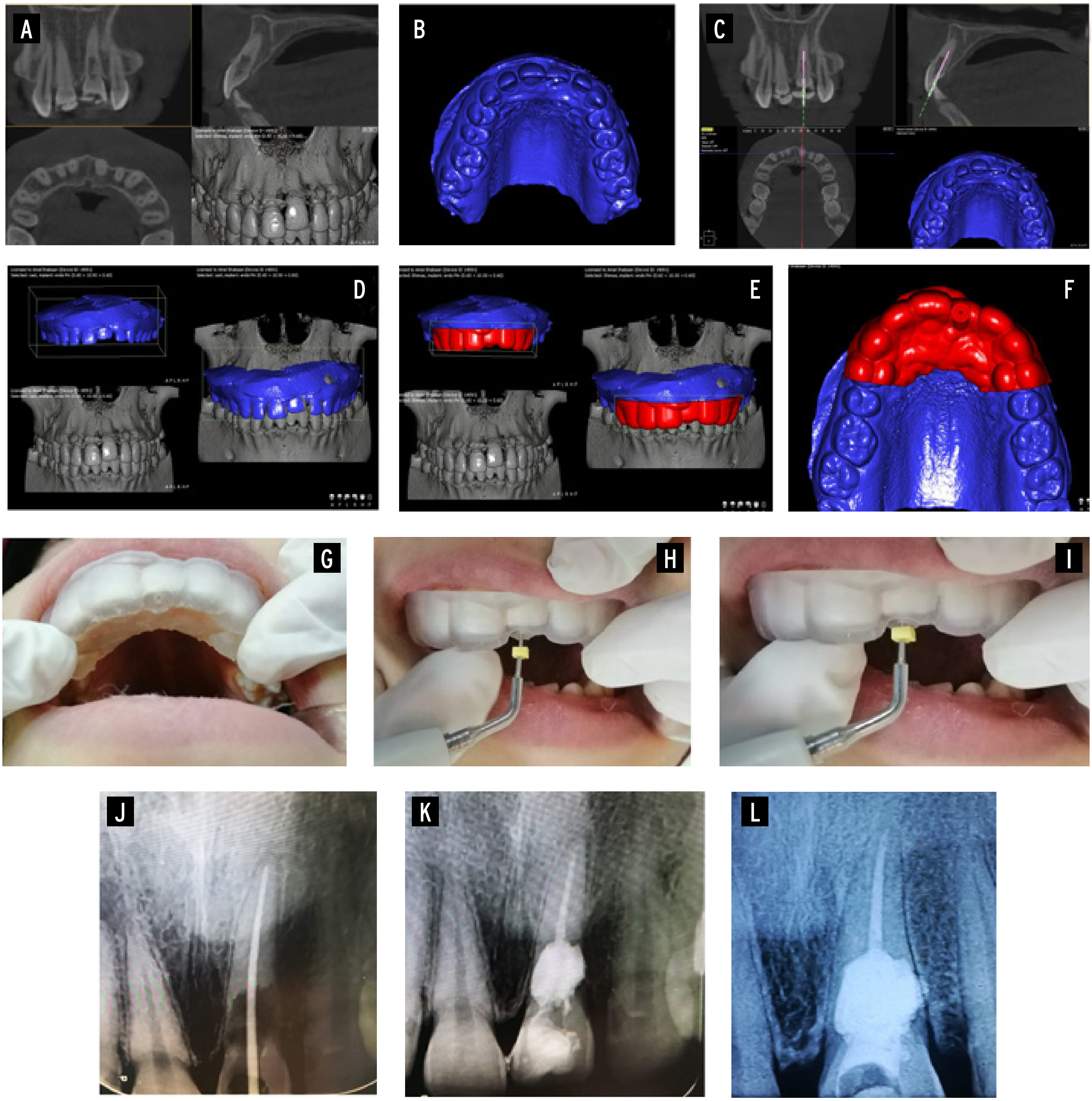

Figure 1
A) Preoperative CBCT scan showing maxillary left central incisor with internal resorption and calcified root canal apical to the resorption. **B**) CBCT scan for a stone cast for the maxillary jaw converted to STL file. **C)** CBCT scan showing the virtual planning for the ultrasonic tip in a guided path to the calcified canal. **D)** Superimposition of the cast scan and the CBCT scan **E)** and **F)** design of the guide. **G)** The 3D printed guide fitting inside the patient's mouth. **H)** Ultrasonic tip guided through the 3D acrylic guide. **I)** Ultrasonic tip after reaching the planned working length. **J)** Periapical radiograph showing the master gutta percha cone reaching the working length. **K)** Postoperative periapical radiograph showing MTA in the resorptive area and gutta percha apically. **L)** One-year follow up periapical radiograph with normal periapical bone and periodontium.

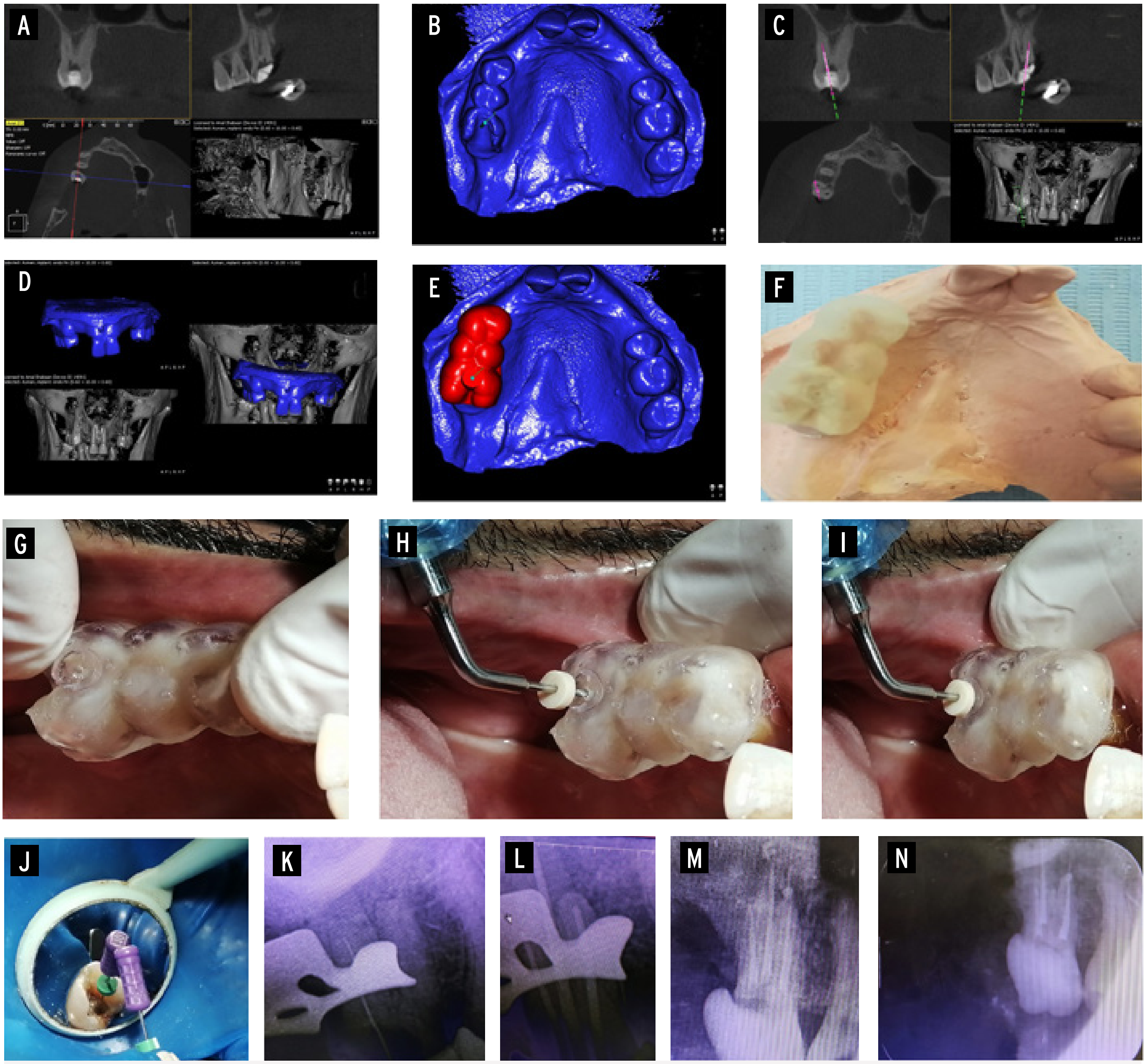

Figure 2
A) Preoperative CBCT scan showing maxillary right first molar with calcified coronal part of the DB canal. **B)** CBCT scan for a stone cast for the maxillary jaw converted to STL file. **C)** CBCT scan showing the virtual planning for the ultrasonic tip in the guided path to the calcified canal. **D)** Superimposition of the cast scan and the CBCT scan. **E)** Design of the 3D guide. **F)** Acrylic guide fitting on the cast. **G)** 3D printed guided fitting inside the patient's mouth. H) Ultrasonic tip in the planned path through the acrylic guide. I) Ultrasonic tip after reaching the planned working length. **J)** Negotiation of the DB canal using k file #10. **K)** Periapical radiograph showing k file reaching the working length in the DB canal. **L)** Periapical radiograph showing the master gutta percha cones. **M)** Postoperative periapical radiograph showing the obturated maxillary first molar. **N)** One-year follow up periapical radiograph with normal periapical bone and periodontium.

with the following sequence 20 .04, 25 .06, 30 .04, 35 .04, 40 .04 at 300 rpm rotational speed and 1.5 N/cm^2 torque. Copious irrigation using 2.5% sodium hypochlorite (NaOCl) was performed along the procedure. Finally, active irrigation using 2.5% NaOCl was performed using ultrasonic tip ET25 for one minute to ensure proper cleaning of the resorptive defect.

Following canal dryness, warm vertical compaction technique was used to seal the apical third of the canal using master gutta percha cone 40 .04 (Meta Biomed, Chungcheongbuk-do, Republic of Korea) and AH Plus resin sealer (Dentsply Tulsa Dental, Tulsa, OK, USA). The coronal portion of the canal was filled with MTA (Angelus, Londrina, Parana, Brazil).

#Case 2

On November 2, 2019, 43-year old male patient was referred to our clinic for endodontic treatment of the maxillary right first molar. The mesiobuccal (MB) and palatal (P) canals were prepared by the referring dentist who failed to locate the distobuccal (DB) canal after troughing.

Clinical examination revealed a previously initiated root canal therapy. The tooth was sensitive to percussion, negative on palpation and no swelling was noted. Two-dimensional periapical radiographic examination revealed widening of the periodontal membrane space. CBCT confirmed calcification of the coronal 2.4 mm of the DB canal. Ultrasonic troughing was done in a wrong direction endangering the furcation.

Different treatment options were discussed with the patient taking into consideration the case difficulty. The use of 3D guide was decided, and a written consent was obtained. Maxillary impression and cast fabrication were performed as detailed in the first case. Clinical procedures were done under local anesthesia. The 3D guide was properly seated on the occlusal surfaces as designed. An ultrasonic tip ET25 (Satelec, France) attached to P5 ultrasonic scaler (Satelec, France) used to locate the canal and access through the calcification. The ultrasonic tip operated till the predetermined planned length. After reaching the length the guide was removed and rubber dam isolation was done. K file #10 and #15 (Mani, Japan) were used to negotiate the canals and working length was determined using electronic apex locator (Root ZX II, Morita, Japan). The DB canal was prepared using rotary file system M3-Pro Gold (Udg, China) with the following sequence 17 .04, 20 .04, 25 .06, 30 .04, 35 .04. Refinement of the preparation of the MB and P canals was done.

The root canals were irrigated using 2.5% sodium hypochlorite (NaOCl) along the procedure followed by manual dynamic agitation for 5 minutes (100 stroke per 30 seconds) using master gutta percha cone 35 .04 in MB and DB canals and 50 .02 in the palatal canal.

Following canal dryness, warm vertical compaction technique was applied using master gutta percha cones (Meta Biomed, Chungcheongbuk-do, Republic of Korea) and AH Plus resin sealer (Dentsply Tulsa Dental, Tulsa, OK, USA).

At two-week follow-up examination, both cases were totally asymptomatic, negative on palpation and percussion.Both cases were referred for prosthetic treatment. One-year follow-up showed good evidence of healing and normal periapical radiographic appearance.

Fabrication of the endodontic guide

Limited field of view, high resolution CBCT scan for the patient was stored in Digital Imaging and Communication (DICOM) format. Record of tooth surface and soft tissue surfaces was obtained indirectly by scanning the model obtained from the impression. One quadrant was obtained to secure a stable support for the guide. CBCT scan for the stone cast was exported from DICOM file to Surface tessellation language (STL) file using special software (Romexis). Data from DICOM format of the patient and STL file of the study cast was imported and superimposed over each other on software that was originally designed for guided implantology (DDS PRO, Poland). During superimposition, three to six points or reference landmarks are marked, then the software automatically merges both scans. Tracing of the calcified canal was performed, and if the canal is not visible, law of canal centrality was followed. The target point was placed at the first visible part of the pulp canal space. Virtual drill path, 1 mm in diameter, was planned by placing a thin drill

along the path of the canal and maintain centrality within the root. The angle of the drill was a bit tilted to avoid the incisal edge.
Virtual images of the ultrasonic tip were designed and implemented in the software to the proper position and direction at the beginning of the root canal beyond the calcification. The data was transferred to a three-dimensional printer (Formlab 3, USA), and the three-dimensional template was fabricated.

Discussion

Pulp space calcification is considered a normal aging process. Nowadays, there are lots of elderly patients retaining their normal dentition, showing pulp space calcifications, in need of root canal treatment (10).
Dental trauma is a major cause of pulp space calcifications in younger patients (11). Calcified dental pulp does not require any intervention; yet, about 1-27% of these pulps will become necrotic at a certain point (12).
Localization and negotiation of the root canal orifice past the calcification is a challenging procedure which might be associated with procedural errors such as loss of tooth structure, ledge formation, risk of fracture, and perforation (13, 8).
Three-dimensional CBCT imaging is valuable tool in endodontic diagnosis, assessing treatment outcomes, studying root canal morphology, pre-surgical planning, and guided endodontic treatment (6, 7).
Three-dimensional endodontic guides have been previously reported in management of root canals with calcifications (2, 8, 13-16). This technique is reported to be fast, safe and predictable.
The 3D guides direct the drill to the proper position, without the need for dental operating microscope, without any reported procedural errors to date reported.This technique replaced the valuable chairside time by spending time in the digital lab designing and manufacturing the guide. Yet, further research is deemed mandatory in this field in order to reach a standardize clinical protocol. In both cases reported, silicon impression was obtained that yielded great precision. Silicon impression is readily available, easy to use and less costly than optical impression which was used in all previously reported cases (2, 15, 17).
The use of drills or round burs with resin-based guide will result in damage of the guide. Metallic sleeves are used with drills in order to keep it within the planned path. In both cases reported, ultrasonic tip ET25 was used which allowed the use of resin-based guide without metallic sleeves and kept the amount of tooth structure lost to minimum.
No radiographs were needed during drilling which was terminated upon reaching the predetermined working length.
The first limitation of these 3D guides is the relatively large amount of tooth structure lost due to the drill size used. Yet, the loss of tooth structure is less than that occurring without using 3D guides, even when dental operating microscope is used (13). Connert et al (16) used this technique in mandibular incisors with very small drills that were quite precise in such narrow canals. In both cases reported, ET25 ultrasonic tip was used which is 20 mm in length, 0.3 mm in diameter at the tip with 3% taper; much smaller than any other drill or bur previously used.
The second limitation is related to the interocclusal distance available as previously reported by Connert et al (16) who suggested that it might be inapplicable in posterior teeth. In the present case report, similar to Lara Mendes et al (17), it was possible to apply the 3D guides in maxillary molars. Patients with limited mouth opening might not be good candidates for the 3D guides. Buchgreitz et al (2) reported successful use of intracoronal 3D guides in order to overcome the constrain of interocclusal distance available, especially in posterior teeth.
The third limitation is the inability to apply these guides beyond curvatures, limited to the straight portion of the canal (16)
As long as pulp space calcifications are located mostly in the straight portion of the canal, cervical and middle thirds (18), the 3D guides appear to be applicable in most of the cases.

Conclusions

Endodontics guides and ultrasonic tips were shown to be a valuable, predictable, safe, reliable and accurate technique for management of calcified root canals. Three-dimensional imaging using CBCT and CAD/CAM are needed to create accurate 3D guides. Further research is deemed mandatory in this field in order to reach a standardized clinical protocol.

Clinical Relevance

Endodontics guides and ultrasonic tips were shown to be an excellent technique in management of root canal calcifications.

Conflict of Interest

The authors deny any conflicts of interest related to this study.

Acknowledgments

None.

References

1 Andreasen FM, Kahler B. Pulpal response after acute dental injury in the permanent dentition: Clinical implications - A review. Vol. 41, Journal of Endodontics. Elsevier Inc.; 2015. p. 299-308.
2 Buchgreitz J, Buchgreitz M, Bjørndal L. Guided Endodontics Modified for Treating Molars by Using an Intracoronal Guide Technique. J Endod [Internet]. 2019;45(6):818-23. doi.org/10.1016/j.joen.2019.03.010
3 Colleagues for Excellence ENDODONTICS Colleagues for Excellence Contemporary Endodontic Microsurgery: Procedural Advancements and Treatment Planning Considerations. 2010.
4 McCabe PS, Dummer PMH. Pulp canal obliteration: An endodontic diagnosis and treatment challenge. Vol. 45, International Endodontic Journal. 2012. p. 177-97.
5 Alemam S, Abuelsadat S, Saber S, Elsewify T. Accuracy, sensitivity and specificity of three imaging modalities in detection of separated intracanal instruments. G Ital Endod [Internet]. 2020 Jun 6 [cited 2021 Apr 5];34(1):97-103. doi.org/10.32067/GIE.2020.34.01.03
6 Patel S, Brown J, Pimentel T, Kelly RD, Abella F, Durack C. Cone beam computed tomography in Endodontics – a review of the literature [Internet]. Vol. 52, International Endodontic Journal. Blackwell Publishing Ltd; 2019 [cited 2020 Nov 20]. p. 1138-52. doi: 10.1111/iej.13115.
7 Patel S, Brown J, Semper M, Abella F, Mannocci F. European Society of Endodontology position statement: Use of cone beam computed tomography in Endodontics: European Society of Endodontology (ESE) developed by: Int Endod J [Internet]. 2019 Dec 1 [cited 2020 Nov 20];52(12):1675-8. Available from: https://pubmed.ncbi.nlm.nih.gov/31301231/
8 van der Meer WJ, Vissink A, Ng YL, Gulabivala K. 3D Computer aided treatment planning in endodontics. J Dent. 2016 Feb 1;45:67-72.
9 Pirani C, Spinelli A, Marchetti C, Gandolfi MG, Zamparini F, Prati C, et al. Use of dynamic navigation with an educational interest for finding of root canals. G Ital Endod. 2020;34(1):82-9. doi.org/10.32067/GIE.2020.34.01.02.
10 Wu B, Hybels C, Liang J, Landerman L, Plassman B. Social stratification and tooth loss among middle-aged and older Americans from 1988 to 2004. Community Dent Oral Epidemiol [Internet]. 2014 Dec 1 [cited 2020 Nov 3];42(6):495-502. doi.wiley.com/10.1111/cdoe.12116.
11 Ranjitkar S, Taylor JA, Townsend GC. A radiographic assessment of the prevalence of pulp stones in Australians. Aust Dent J. 2002;47(1):36-40.
12 Oginni AO, Adekoya-Sofowora CA, Kolawole KA. Evaluation of radiographs, clinical signs and symptoms associated with pulp canal obliteration: An aid to treatment decision. Dent Traumatol [Internet]. 2009 Dec [cited 2020 Nov 3];25(6):620-5. Available from: https://pubmed.ncbi.nlm.nih.gov/19917027/.
13 Krastl G, Zehnder MS, Connert T, Weiger R, Kühl S. Guided Endodontics: A novel treatment approach for teeth with pulp canal calcification and apical pathology. Dent Traumatol. 2016 Jun 1;32(3):240-6.
14 Buchgreitz J, Buchgreitz M, Bjørndal L. Guided root canal preparation using cone beam computed tomography and optical surface scans – an observational study of pulp space obliteration and drill path depth in 50 patients. Int Endod J. 2019 May 1;52(5):559-68.
15 Zehnder MS, Connert T, Weiger R, Krastl G, Kühl S. Guided endodontics: accuracy of a novel method for guided access cavity preparation and root canal location. Int Endod J. 2016 Oct 1;49(10):966-72.
16 Connert T, Zehnder MS, Weiger R, Kühl S, Krastl G. Microguided Endodontics: Accuracy of a Miniaturized Technique for Apically Extended Access Cavity Preparation in Anterior Teeth. J Endod [Internet]. 2017 May 1 [cited 2020 Nov 3];43(5):787–90. Available from: https://pubmed.ncbi.nlm.nih.gov/28292595/
17 Lara-Mendes ST d. O, Barbosa C de FM, Santa-Rosa CC, Machado VC. Guided Endodontic Access in Maxillary Molars Using Cone-beam Computed Tomography and Computer-aided Design/Computer-aided Manufacturing System: A Case Report. J Endod. 2018 May 1;44(5):875-9.
18 Smith JW. Calcific metamorphosis: A treatment dilemma. Vol. 54, Oral Surgery, Oral Medicine, Oral Pathology. 1982. p. 441-4.

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CASE REPORT

A contemporary approach to treat necrotic immature teeth using different bioceramic materials

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ABSTRACT

Aim: *The present report describes the endodontic treatment of an immature maxillary central incisor with an open apex and extensive periapical lesion.*
Summary: *Cone-beam computed tomographic images demonstrated the unusual root canal anatomy and a contemporary approach using bioceramic intracanal dressing, root repair materials and root canal sealers were used. One year after the end of treatment, the patient was asymptomatic and a new cone-beam computed tomographic exam showed complete apical repair, with deposition of mineralized tissue and closure of the root apex. The combination of modern imaging and the use of contemporary materials contributed to adequate diagnosis, planning and treatment of this case.*
Key-learning points
- *Immature permanent teeth with apical periodontitis represent a clinical challenge.*
- *Calcium silicate-based materials are widely used in endodontics, mainly due to their excellent biological and physical properties.*
- *The association of different type of calcium silicate-based materials could be a good option of the treatment of immature permanent teeth with apical periodontitis.*

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KEYWORDS *Apexificication, immature teeth, periapical lesion, tricalcium silicate-based material*

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Introduction

Immature permanent teeth with apical periodontitis represent a clinical challenge. The presence of a wide root canal, which hinders effective decontamination; the fragility of the dentinal walls; and the presence of a wide foramen are the greatest difficulties for an adequate prognosis of these teeth. Apexification with calcium hydroxide has been widely proposed for these cases. However, there are major disadvantages within this therapy, mainly related to long treatment time, unpredictability in the formation of the apical barrier (1, 2), risk of root fracture due to prolonged exposure to calcium hydroxide (2) and persistence of a short root with thin walls (3).

New therapies such as performing apical barriers with biomaterials, which allow safe root canal filling in a reduced number of sessions, have been recommended. For these techniques, calcium silicate-based materials are suggested due to their excellent biological and physico-chemical properties (4-6). Based on these favorable properties, calcium silicate-based materials also started to be marketed as root canal sealer and intracanal dressing, bringing a new therapeutic aspect in endodontics. When used as root canal sealer, these materials have shown tissue compatibility (7), bioactivity with calcium release (8, 9), strong alkalinization activity (8, 10), good bond strength and excellent adhesion pattern to the root canal walls (11), radiopacity (8, 10, 12) and adequate flow (10).

Recently, a new ready-to-use bioceramic intracanal dressing, composed of tricalcium and dicalcium silicates, tricalcium aluminate and calcium oxide, was launched on the endodontic market (Bio-C Temp; Angelus, Londrina, Brazil). According to the manufacturer this is a biocompatible material, with high alkalinity (pH 12±1) and high radiopacity. It also has in its composition a long chain polymer, which prevents the interlacing of the crystals formed, preventing the product from hardening, and facilitating its removal (http://www.angelusdental.com/products/details/id/214).

Figure 1
Initial periapical radiography of tooth #8.

The present case report describes the treatment of an immature permanent tooth with an open apex and extensive periapical lesion, in which bioceramic intracanal dressing, root repair materials and root canal sealers were used.

Case Report

The PRICE guidelines were followed in this manuscript (Supplementary figure 5) (13). A 14-year-old girl was referred for evaluation of tooth #8, with a previous history of dental trauma, two years earlier. On clinical examination, the patient was symptomatic, with tooth discoloration, edema without floating point, negative response to cold pulp vitality test (Endofrost; Roeko, Langenau, Germany) and positive responses to vertical and horizontal percussion and apical palpation tests. The cold pulp vitality test was also performed on teeth #7 and #9, with positive responses in both.

On periapical radiographic exam, a short root with a wide canal and open apex was observed, associated with extensive periapical lesion (Figure 1). Cone-beam computed tomography (PreXion 3D Inc., San Mateo, CA, USA) revealed an extensive unilocular lesion with defined limits, expansion of bone cortical, with rupture of the vestibular and lingual bone crest, associated with the roots of teeth #8 and #7. Also, it was possible to observe the presence of external apical root resorption and open apex only in the palatal face, in the teeth #8 (Figure 2 and Supplementary video 1).

Based on clinical and imaging findings, an acute dentoalveolar abscess was diagnosed and endodontic treatment was proposed. The proposed treatment was discussed and authorized by the patient's legal responsible, through the informed consent form.

In the first appointment, after local anesthesia and rubber dam isolation, access cavity was performed, and the canal was copiously irrigated with 2.5% sodium hypochlorite (NaOCl). Then, the working length (WL) was established using a size 80 K-file (Dentsply-Maillefer, Ballaigues,

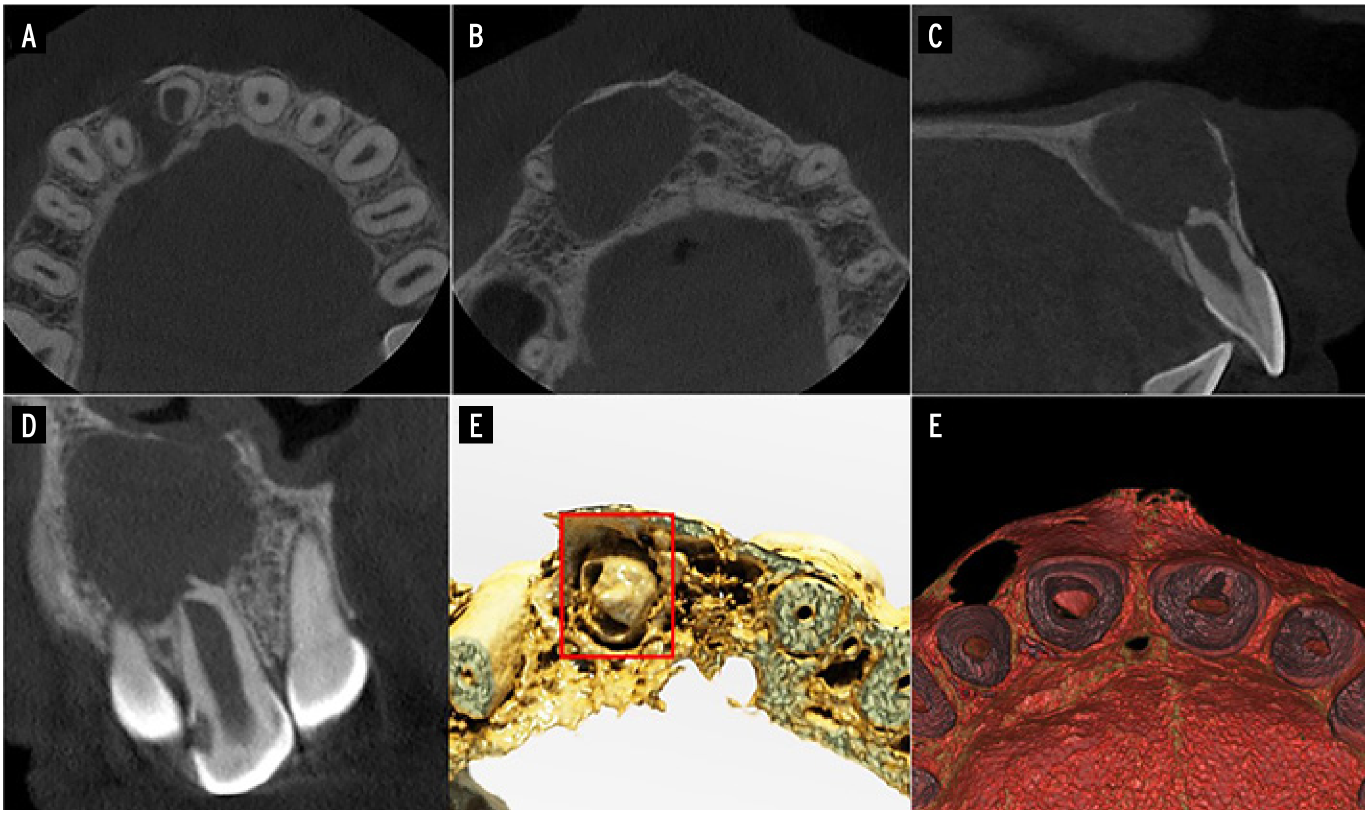

Figure 2
Initial cone-beam computed tomography of tooth #8 (E-Vol DX software). **A)** Axial section of the root apical portion. **B)** Axial section of the apical region. **C)** Sagittal section. **D)** Coronal section. **E)** 3D reconstruction of the foraminal opening. **F)** Front 3D reconstruction.

Switzerland). At this point the tooth presented copious drainage of purulent secretion. A vigorous irrigation protocol was performed using 20 ml of 2.5% NaOCl with 4 cycles of activation using Irrisonic ultrasonic insert (Helse Ultrasonic, Florida, USA) 1 mm bellow the root apex. Afterwards, the intracanal bioceramic dressing Bio-C Temp (Angelus) was inserted and temporary coronal restoration with glass ionomer was performed.

For six months, three changes of intracanal dressing were performed, always under rubber dam isolation. In all sessions, an irrigation protocol was performed with activation of the irrigant, alternating the ultrasonic insert Irrisonic and the Easy Clean instrument (Bassi Endo, Florida, USA) coupled in a low rotation contra-angle. After the six months, the complete remission of signs and symptoms was achieved, with radiographic visualization of partial apical closure and deposition of mineralized tissue in the apex (Figure 3A). Therefore, root canal filling procedures were performed. Initially, an apical plug was made with Biodentine® bioceramic repair cement (Septodont, Saint-Maur-des-Fossés, France). After the initial setting time of 20 minutes, the root canal was filled with gutta-percha cone #140 and accessory cones (Denstply-Maillefer) and BioRoot RCS® bioceramic root canal sealer (Septodont). Down-pack procedures were performed using a medium-size thermoplasticizer tip (Bassi Endo, Belo Horizonte, MG, Brazil) and a heat source (Bassi Endo) 5 mm short of the WL. (Figure 3B). Backfill were then performed by injecting gutta-perch in 4-mm increments into the canal. A gutta percha obturation gun (Bassi Endo) with #23-gauge needle was set on 180 °C and gutta percha pellets (Bassi Endo) and NiTi pluggers (Bassi Endo) were used during backfilling procedures (Figure 3C).

For coronal restoration, the enamel surface was etched for 15s with 35% phosphoric acid Ultra Etch (Ultradent, Utah, EUA), washed for 20s and dried, avoiding desiccation. Then, two consecutive layers of Single Bond Universal Adhesive (3M, Minneapolis, MN, USA) were applied on enamel and dentin, dried with oil free

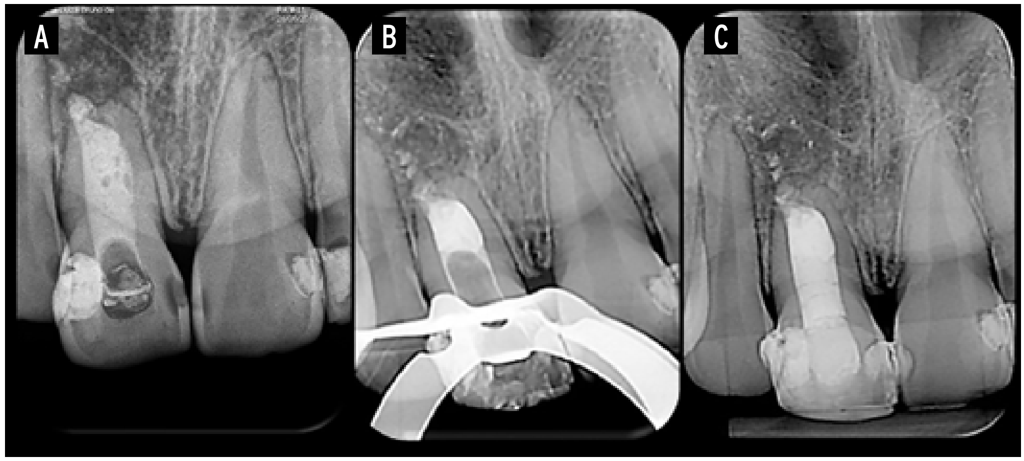

Figure 3
A) Radiographic aspect of the intracanal dressing Bio-C Temp on tooth #8. **B)** Apical plug with Biodentine and down-pack procedures in the apical third with BioRoot RCS. **C)** Final radiography after filling with backfill.

compressed air during 10s and cured for 20s with a led device Valo Cordless (Ultradent). Then, the cavity preparation was restored using a nanofilled composite resin A3 Filtek Z-350 (3M) in layers up to 2mm that were cured individually for 20s. All the procedures had been undertaken under rubber dam isolation.
In the 12-month follow-up, the patient was asymptomatic and without infection. Cone-beam computed tomography (PreXion 3D Inc., San Mateo, CA, USA) showed complete periapical repair, with deposition of mineralized tissue and root apex closure (Figure 4 and supplementary video 2).

Discussion

Regenerative endodontics is a viable therapeutic option with a high success rate for immature teeth, even in cases with periapical disease, as it allows for continued root formation in length, thickness and apical closure (14). However, in the present report, this treatment was not performed, since the apical root portion of tooth had already started its formation, with an opening only on the palatal surface, as observed in the cone-beam computed tomographic exam, which made the induction of bleeding into the root canal, indispensable for root maturation, unpredictable (14).
In the present case report, 2.5% NaOCl was constantly activated with ultrasonic insert and Easy Clean instrument. Literature demonstrates an improvement in the cleaning and disinfections of the root canal using final agitation protocols (15-19). Although highly effective, there are some concerns regarding the risk of apical extrusion in immature teeth. However, a recent study demonstrated that conventional irrigation without agitation caused the same extrusion pattern, in immature teeth, as the techniques activated with ultrasonic insert and mechanical agitation instruments such as Easy Clean (14). Such techniques have an important role in the treatment of immature teeth with thin walls, as instrumentation procedures must be minimal or even contraindicated.
Another important step for root canal disinfection is the use of intracanal dressing. In the present case, bioceramic dressing Bio-C Temp was chosen. According to the manufacturer, its advantage over calcium hydroxide pastes lies in its low solubility, allowing the use of this material for a long period of time, increasing the pH gradually and continuously, with no need of frequent substitutions. Furthermore, its particle is micronized (<2 μm), with an improvement in its physical properties such as greater flow and penetrability in the accessory canal and dentinal tubules; and with greater product reactivity and release of calcium and hydroxyl ions (http://www.angelusdental.com/products/details/id/214).
The new bioceramic dressing Bio-C Temp had acceptable cell viability, similar to that of MTA Flow (Ultradent) e UltraCal XS (Ultradent) at the highest dilutions, and resulted in less tooth colour change (20). When compared to calcium hydrox-

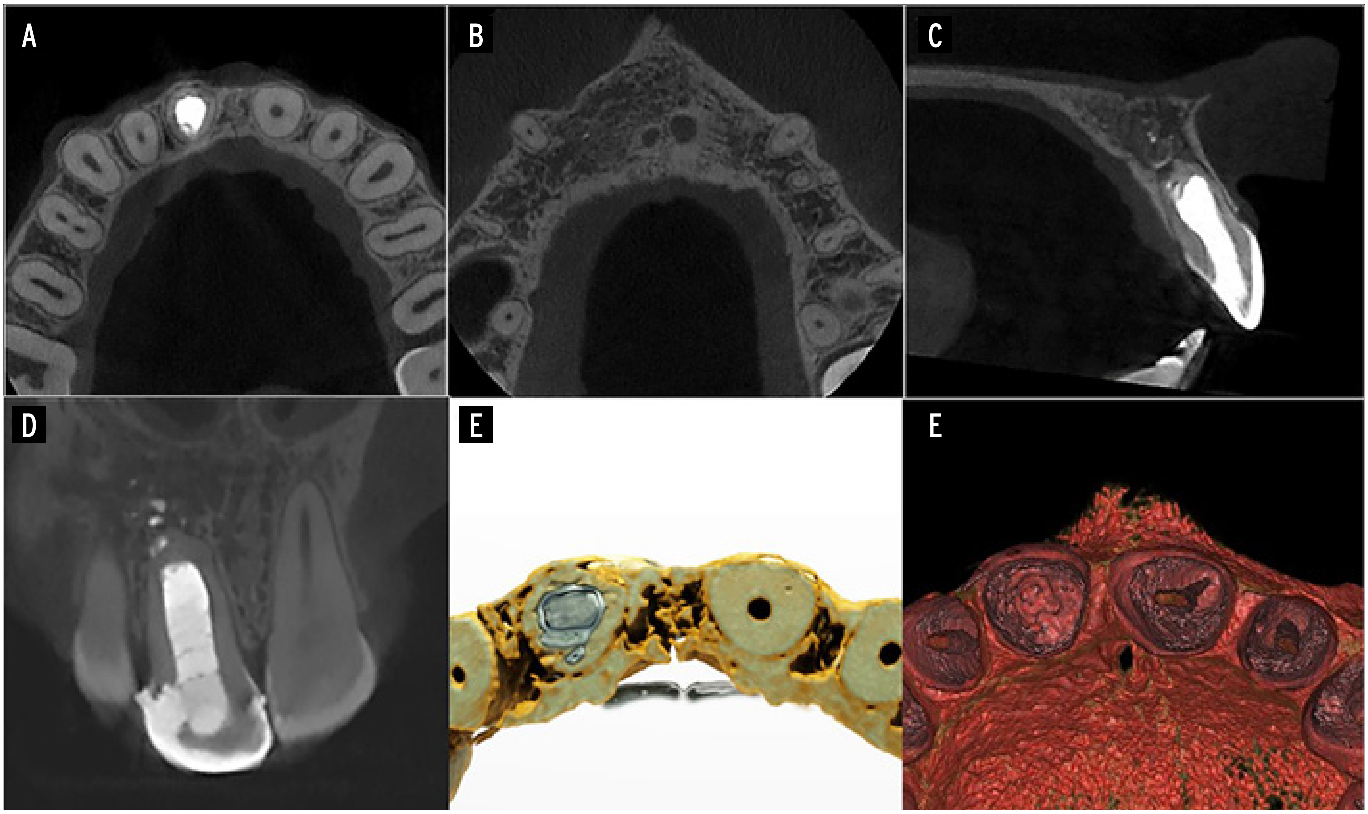

Figure 4
Cone-beam computed tomography 12 months after tooth #8 preservation (Software E-Vol DX). **A)** Axial section of the root apical portion. **B)** Axial section of the apical region. **C)** Sagittal section. **D)** Coronal section. **E)** 3D reconstruction of the root canal filling. **F)** Front 3D reconstruction.

ide-based intracanal medicaments, Bio-C Temp had similar cytocompatibility at higher dilutions, and higher or similar induction of alkaline phosphatase activity and deposition of mineralized nodules in comparison with Calen (SS White, PR, Brazil) and Ultracal XS (Ultradent). However, this new material showed significantly less antibacterial and antibiofilm activity than these other intracanal medicaments (21). Previous studies of calcium silicate-based materials also revealed excellent cytocompatibility and bioactive properties in direct contact with stem cells from human exfoliated deciduous teeth (22) and human dental pulp cells (23).
Biodentine cement was used during apical plug procedures, allowing root canal filling without risks of root canal sealer high extrusion. This is a bioactive dental substitute with excellent biological and mechanical properties, with emphasis on bioactivity (24), biocompatibility (25) and high resistance to compression (26). Also, its pre-dosed form, minimizes the operator's interference in the consistency and homogenization of the material (27).
BioRoot RCS root canal sealer was used during filling procedures. In a comparative study with the Pulp Canal Sealer, BioRoot RCS exhibited less toxic effect on cells of the periodontal ligament and induced greater release of angiogenic and osteogenic growth factors (28). Siboni et al. (8) also found that this sealer showed a greater release of calcium ions, with a higher capacity for forming carbonated apatite when compared to MTA Fillapex, AH Plus and Pulp Canal Sealer. This characteristic of bioactivity can contribute significantly to apical repair, inducing greater deposition of mineralized tissue, which is essential in extensive lesions.

Conclusions

The used protocol culminated in clinical success and complete periapical repair. After 12 months of root canal filling procedures, deposition of mineralized tissue and apical closure with hard tissue deposition were observed. Through the aforementioned criteria, the combination of modern imaging and the use of contemporary materials contributed to adequate diagnosis, planning and treatment of this case.

Clinical Relevance

The combination of modern imaging and the use of contemporary materials contributed to adequate diagnosis, planning and treatment of this immature maxillary central incisor with an open apex and extensive periapical lesion.

Conflict of Interest

The authors have no conflict of interest to declare.

Acknowledgements

None.

References

1 Shabahang S. Treatment options: apexogenesis and apexification. J Endod. 2013;39:26-9.
2 Andreasen JO, Farik B, Munksgaard EC. Long-term calcium hydroxide as a root canal dressing may increase risk of root fracture. Dent Traumatol. 2002;18:134-7.
3 Rafter M. Apexification: a review. Dent Traumatol. 2005;21:1-8.
4 Duarte MAH, Marciano MA, Vivan RR, Filho MT, Tanomaru JMG, Camilleri J. Tricalcium silicate-based cements: properties and modifications. Braz Oral Res. 2018;32:111-18.
5 Shabahang S, Torabinejad M. Treatment of teeth with open apices using mineral trioxide aggregate. Pract Periodontics Aesthet Dent. 2000;12:315-20.
6 Holden DT, Schwartz SA, Kirkpatrick TC, Schindler WG. Clinical outcomes of artificial root-end barriers with mineral trioxide aggregate in teeth with immature apices. J Endod. 2008;34:812-7.
7 López-García S, Pecci-Lloret MR, Guerrero-Gironés J, Pecci-Lloret MP, Lozano A, Llena C, et al. Comparative cytocompatibility and mineralization potential of Bio-C Sealer and TotalFill BC Sealer. Materials (Basel). 2019;12:1-12.
8 Siboni F, Taddei P, Zamparini F, Prati C, Gandolfi MG. Properties of BioRoot RCS, a tricalcium silicate endodontic sealer modified with povidone and polycarboxylate. Int Endod J. 2017;50: 120-36.
9 López-García S, Lozano A, García-Bernal D, Forner L, Llena C, Guerrero-Gironés J, et al. Biological Effects of New Hydraulic Materials on Human Periodontal Ligament Stem Cells. J Clin Med. 2019;14:1-13.
10 Zordan-Bronzel CL, Torres FFE, Tanomaru-Filho M, Chávez-Andrade GM, Bosso-Martelo R, Guerreiro-Tanomaru JM. Evaluation of Physicochemical Properties of a New Calcium Silicate-based Sealer, Bio-C Sealer. J Endod. 2019;45:1248-52.
11 Lim M, Jung C, Shin DH, Cho YB, Song M. Calcium silicate-based root canal sealers: a literature review. Restor Dent Endod. 2020;45:e35.
12 Prüllage R-K, Urban K, Schäfer E, Dammaschke T. Material properties of a tricalcium silicate-containing, a mineral trioxide aggregate-containing, and an epoxy resin-based root canal sealer. J Endod. 2016;42:1784-88.
13 Nagendrababu V, Chong BS, McCabe P, Shah PK, Priya E, Jayaraman J, et al. PRICE 2020 Guidelines for reporting case reports in Endodontics: A consensus-based development. Int Endod J. 2020;53:619-26.
14 Diogenes A, Ruparel NB. Regenerative Endodontic Procedures: Clinical Outcomes. Dent Clin North Am. 2017;61:111-25.
15 Kato AS, Cunha RS, da Silveira Bueno CE, Pelegrine RA, Fontana CE, de Martin AS. Investigation of the efficacy of passive ultrasonic irrigation versus irrigation with reciprocating activation: an environmental scanning electron microscopic study. J Endod. 2016;42:659-63.
16 Andrade-Junior CV, Batista RM, Marceliano-Alves M, Alves FRF, Silva EJNL. Efficacy of a new Activation Device in Irrigant Penetration Into Simulated Lateral Canals. Eur Endod J. 2016;1:1-4.
17 Duque JA, Duarte MA, Canali LC, Zancan RF, Vivan RR, Bernardes RA, et al. Comparative effectiveness of new mechanical irrigant agitating devices for debris removal from the canal and isthmus of mesial roots of mandibular molars. J Endod. 2017;43:326-31.
18 Aveiro E, Chiarelli-Neto VM, de-Jesus-Soares A, Zaia AA, Ferraz CCR, Almeida JFA, et al. Efficacy of reciprocating and ultrasonic activation of 6% sodium hypochlorite in the reduction of microbial content and virulence factors in teeth with primary endodontic infection. Int Endod J. 2020;53:604-8.
19 Reis S, Cruz VM, Duarte MAH, Bueno CES, Vivan RR, Pelegrine RA, Bruno KF, Kato AS. Volumetric Analysis of Irrigant Extrusion in Immature Teeth After Different Final Agitation Techniques. J Endod. 2020;46(5):682-87.
20 Oliveira LV, Silva GR, Souza GL, Magalhães TEA, Barbosa GLR, Turrioni AP, Moura CCG. A laboratory evaluation of cell viability, radiopacity and tooth discoloration induced by regenerative endodontic materials. Int Endod J. 2020; 53(8):1140-52.
21 Guerreiro JMC, Ochoa-Rodrigéz VM, Rodrigues EM, Chaves-Andrade GM, Tanomaru-Filho M, Guerreiro-Tanomaru JM, Faria G. Antibacterial activity, cytocompatibility and effect of Bio-C Temp bioceramic intracanal medicamento n osteoblast biology. Int Endod J. 2021;27:1-11.
22 Sanz JL, Forner L, Llena C, Guerrero-Gironéz J, Melo M, Rengo S, Spagnuolo G, Rodríguez-Lozano FJ. Cytocompatibility and bioactive properties of hidraulic calcium silicate-based cements (HCSCs) on stem cells from human exfoliated deciduous teeth (SHEDs): a systematic review of in vitro studies. J Clin Med. 2020;9(12):3-15.
23 Ghilotti J, Sanz JL, Lopéz-García S, Guerrero-Gironéz J, Pecci-Lloret MP, Lozano A, Llena C,

Rodríguez-Lozano FJ, Forner L, Spagnuolo G. Comparative surface morphology, chemical composition, and cytocompatibility of Bio-C Repair, Biodentine, and ProRoot MTA on hDPCs. Materials (Basel). 2020;13(9):1-13.
24 Daltoé MO, Paula-Silva FW, Faccioli LH, Gatón-Hernández PM, De Rossi A, Bezerra Silva LA. Expression of Mineralization Markers during Pulp Response to Biodentine and Mineral Trioxide Aggregate. J Endod. 2016;42(4):596-603.
25 Kenchappa M, Gupta S, Gupta P, Sharma P. Dentine in a capsule: clinical case reports. J Indian Soc Pedod Prev Dent. 2015;33(3):250-4.
26 Grech L, Mallia B, Camilleri J. Investigation of the physical properties of tricalcium silicate cement-based root-end filling materials. Dent Mater. 2013;29(2):e20-8.
27 Aguiar BA, Frota LMA, Taguatinga DT, Vivan RR, Camilleri J, Duarte MAH, de Vasconcelos BC. Influence of Ultrasonic Agitation on Bond Strength, Marginal Adaptation, and Tooth Discoloration Provided by Three Coronary Barrier Endodontic Materials. Clin Oral Investig. 2019; 23(11):4113-22.
28 Camps J, Jeanneau C, El Ayachi I, Laurent P, About I. Bioactivity of a Calcium Silicate-based Endodontic Cement (BioRoot RCS): Interactions with Human Periodontal Ligament Cells In Vitro. J Endod. 2015;41(9):1469-73.

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CASE SERIES

Nonsurgical management of maxillary first molars with 5 root canals

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ABSTRACT

Aim: *This case series reports the nonsurgical management of five maxillary first molars with five root canals in different ethnic groups and geographic locations.*
Summary: *Diagnosis and management of complex root canal anatomy, especially of the maxillary first molar, can be frustrating and challenging and also may increase the risk of failure if not managed with appropriate tools. In this case series the primary endodontic treatment of four, and a nonsurgical retreatment of one maxillary first molar with five root canals treated by three different endodontists from India, Spain, and Portugal has been described. None of the cases presented in the paper were performed without magnification and troughing of the pulp chamber floor using ultrasonic tips. Although CBCT wasn't used in all cases, its prudent use respecting the ALARA principle is highlighted in the paper. This paper also highlights the importance of anatomical variations in different ethnic groups with the maxillary first molar.*
Key-learning points
- *Operator should consider the ethnicity of the patient and thoroughly study pre-operative radiographs to carry out successful endodontic treatment.*
- *Use of magnification and ultrasonic tips are fundamental especially in treating unusual canal anatomies.*
- *The prudent use of CBCT should be performed respecting the ALARA principle in all given situations.*

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Introduction

The failure of endodontic treatment has often been accused of the anatomical complexities and variations that exist in the root canal system (1). Maxillary first molars have been shown to have an extra canal in the mesial root, ranging from 48% up to 97.6% of the time, which is one of the most common variations of this tooth (2-4). Variations of palatal root having 2 canals and/or 2 roots have also been reported in some case reports (5, 6). Nonetheless, distal root has also variations reported with the presence of 2 (7) and even up to a 3 canals configuration (6, 8).

Technological advancements in dentistry, especially in endodontics regarding detection, improved cleaning & shaping, and obturation of the root canal space, have noticeably improved in the last decade. CBCT has proved to be an invaluable tool in endodontics for the detection of extra canals and also has been demonstrated to have higher sensitivity and specificity compared to traditional radiographs (9-12). Periapical radiographs have also been demonstrated to detect extra canals specifically when a different beam angulation is used (13). It helps to spot superimposed roots, better visualize buccal roots for the maxillary molars, and makes it easier to visualize the apices of the roots usually covered by the zygomatic process (14). Considering the ALARA (As low as reasonably achievable) principle (15), and according to the latest guidelines, it is wise to use a CBCT only in cases where clinical examination and conventional radiography don't provide sufficient information to perform the correct treatment (16).

The dental operating microscope has demonstrated to detect more missed canals when compared to naked eyes and is found to detect MB2 canals ranging from 71-83% in the maxillary first molars when compared to other magnification aids (4, 17, 18). A study even demonstrated that with the increase in operator experience with the operating microscope, the detection of additional canals can reach up to 93% (4). The use of magnification with the addition of ultrasonic troughing also has been proven to help find missed canals (19, 20).

The presence of root canal variations of teeth is dependent on the population being studied. In a worldwide analysis, it was found that the highest prevalence of an extra mesiobuccal (MB2) canal in the first maxillary molars was in the Belgian population. Also, other countries like India (64.8%), China (76.4%), Spain (68%), and Portugal (72.8%) had a high prevalence regarding its presence (3). Publications of maxillary first molars with five, six, seven, and even up to an eight canal configuration have also been reported in different populations including the Indian, American, and Brazilian population (7, 21-25).

This case series reports the endodontic management of five maxillary first molars with the presence of 5 canals from different dental centers of India, Spain and Portugal.

Case report

This paper presents the endodontic treatment of five maxillary first molars, out of which three were treated in 3 different private dental offices in Pune, India, one tooth treated in a private dental office in Lisbon, Portugal, and one tooth in Barcelona, Spain. A detailed clinical and radiographic examination was performed for all the cases. None of the patients had any relevant medical history. All patients signed informed consent before starting any treatment. Vitality tests were carried out using a cold test and heated gutta-percha. Local anaesthesia was administered in all the cases and treatments were carried out under absolute rubber dam isolation with either loupes or dental operating microscope used for magnification.

#Case 1

A 40-year-old male of Indian origin was referred to a private office in Pune, India due to pain in the upper right region of the jaw. The referring dentist had made an access opening on the tooth 16 as an emergency treatment. Probing depth of 5mm was noted in the distobuccal and distopalatal areas of the tooth and mobility were within physiologic limits. The tooth was

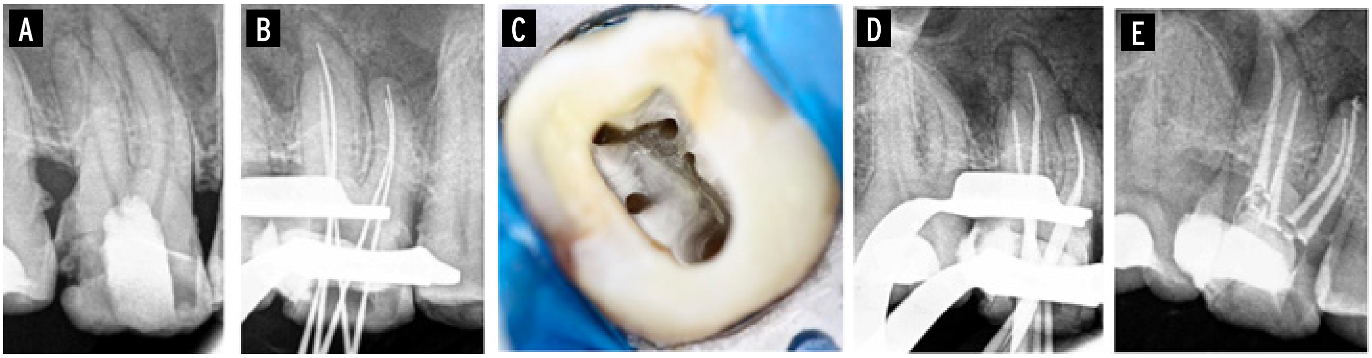


Figure 1
A) Pre-operative radiograph. **B)** Working length radiograph. **C)** Dried pulp chamber**. D)** Cone-fit radiograph. **E)** Post-operative radiograph
CBCT images exemplifying the different anatomic relationship between maxillary sinuses and molars.

tender on vertical percussion and negative to palpation. Radiographic examination revealed deep distal caries and previous access cavity filled with a temporary restoration and periapical lesions associated with palatal and mesial roots (Figure 1A). The tooth 16 was therefore diagnosed as "Previously initiated therapy with symptomatic apical periodontitis".
After removal of temporary restoration and caries, a pre-endo build-up was performed with composite resin (Filtex Z250, 3M ESPE, St. Paul, MN, USA) using Automatrix (Dentsply Maillefer, Ballaigues, Switzerland). After pulp chamber debridement and irrigation, pinpoint bleeding was noted beside the distal canal. The access cavity was then modified using No. 3, Start-X (Dentsply Maillefer, Ballaigues, Switzerland) ultrasonic tips, and the pulpal floor was explored using a DG-16 explorer (Hu-Friedy, Chicago, IL) under a dental microscope (Extaro 300, Carl Zeiss, Oberkochen, Germany). The tooth presented with 2 mesiobuccal canals (MB1, MB2), 2 distal canals (DB1, DB2), and 1 palatal canal. A 10 ISO K-file (Mani, Inc., Tochigi, Japan) was introduced into the canals which revealed that the mesial root canals (MB1, MB2) were completely independent, demonstrating a Vertucci's type IV canal configuration, and the distal canals (DB1, DB2) joining at the apical third, demonstrating a Vertucci's Type II canal configuration. The WL was determined using 15 ISO K-Files and an apex locator (VDW Gold, VDW, Munich, Germany) and then confirmed with a periapical radiograph (Figure 1B). A proglider (Dentsply Maillefer, Ballaigues, Switzerland) glide path file was used and Edge File X3 files (EdgeEndo, Albuquerque, NM, USA) were used to finish the cleaning and shaping of the root canals using 5.25% sodium hypochlorite and citric acid 10% alternatively. Sonic activation of the irrigants was performed intermittently using an EndoActivator system (Dentsply Maillefer, Ballaigues, Switzerland) for 1min in each canal. After confirming cone fit and drying the canals with paper points (Figure 1C, 1D), the canals were obturated using a warm vertical compaction technique with AH Plus sealer (Dentsply Maillefer, Ballaigues, Switzerland) (Figure 1E) and referred back to the referring dentist to complete the restorative procedure.

#Case 2

A 54-year-old male of Indian origin reported to our private practice with the chief complaint of pain on biting in the upper left back tooth. The clinical and radiographic examination revealed deep distal caries with tooth 26 with an exaggerated response to cold test and positive vertical percussion (Figure 2A). Probing and mobility were within physiologic limits. A diagnosis of "Irreversible pulpitis with symptomatic apical tissues" was made. After profound anaesthesia, removal of caries and raising of the mesial wall with a composite resin was performed. A conventional access opening was then made and modified using Start-X ultrasonic tips (Dentsply Maillefer, Ballaigues, Switzerland). After scouting the canals the tooth revealed 2 palatal canals (P1, P2), 2 mesial canals (MB1, MB2), and a single distal canal (MDB1). An attempt was made to search for the second distobuccal canal but it was concluded not to be present

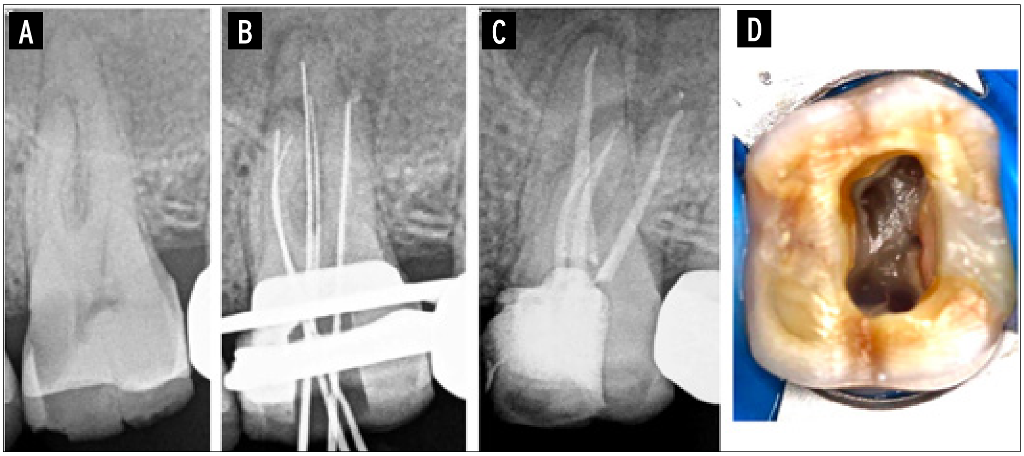


Figure 2
A) Pre-operative radiograph. **B)** Working length radiograph. **C)** Final periapical radiograph. **D)** Dried pulp chamber.

(Figure 2D). The mesial root canals (MB1, MB2) were completely separate demonstrating Vertucci's Type IV canal configuration and the palatal root (P1, P2) revealed a Vertucci's Type II canal configuration (Figure 2B). The canals were then instrumented, irrigated, and obturated similarly to case 1 and then sealed with a temporary filling (Cavit, 3M ESPE, St Paul, MN) (Figure 2C).

#Case 3

A 36-year-old Indian female came to our dental office as an emergency with a chief complaint of immense pain and sensitivity to cold in her upper right back region of the jaw. Radiographic examination revealed deep mesial caries close to the pulp chamber. Clinical examination only revealed an exaggerated response to the cold test. Percussion, Palpation were negative and mobility and probing were within physiologic limits. A diagnosis of "Irreversible pulpitis with normal apical tissues" with tooth 16 was made. After caries excavation and an adequate rubber dam isolation, an access cavity was prepared taking advantage of the excavated caries. Removal of the pulp from the chamber and provisional instrumentation of the palatal canal was performed before the placement of calcium hydroxide (VOCO, Germany) and a provisional dressing (Cavit, 3M ESPE, St Paul, MN). A limited field of view CBCT was performed to confirm the anatomy of the tooth (Figure 3A). In the second visit, a 10 ISO k-file (Mani, Inc., Tochigi, Japan) was used to scout the canals and a 15 ISO

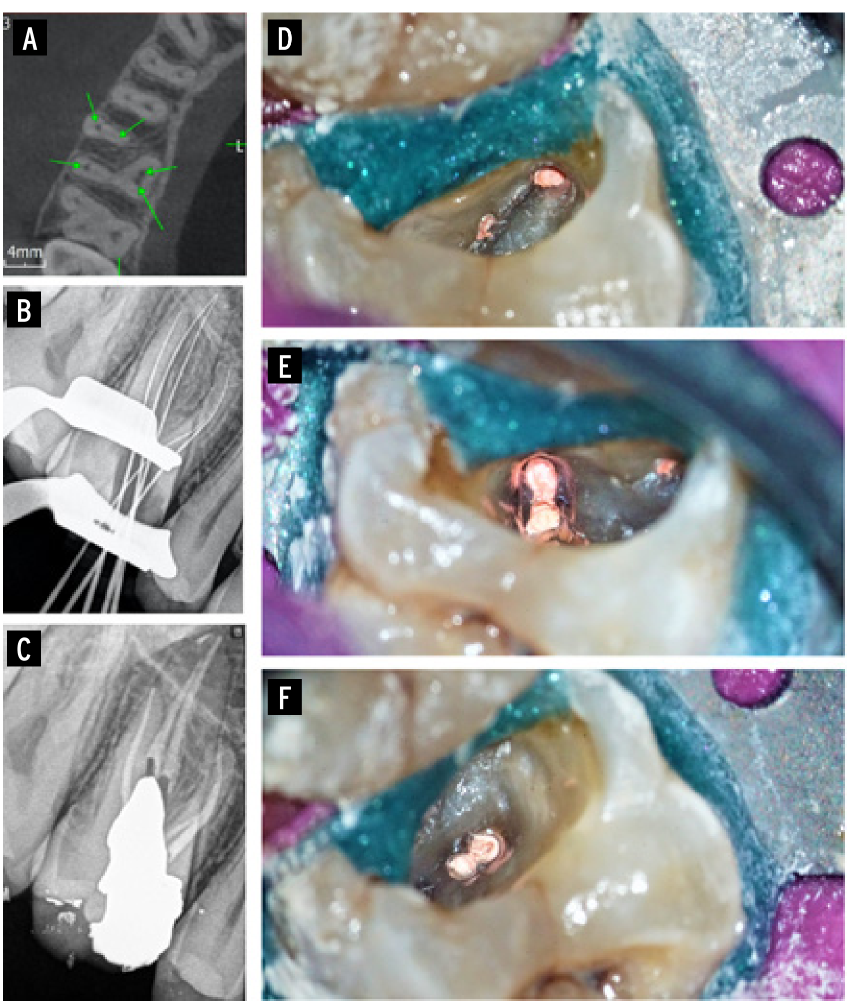
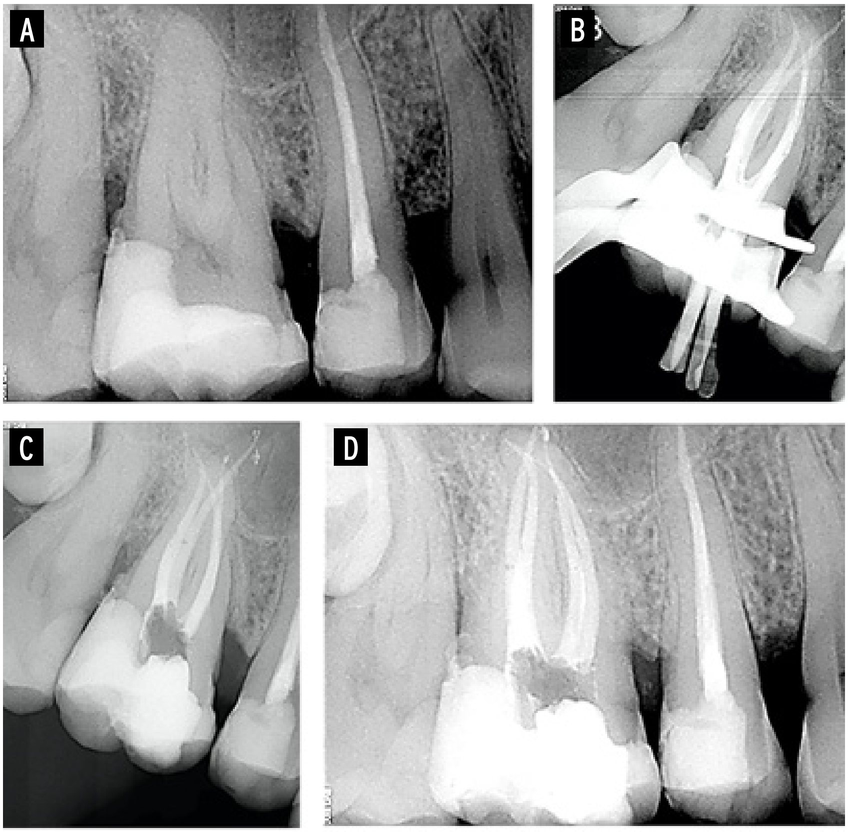


Figure 3
A) CBCT slice showing 5 root canals. **B)** Working length radiograph. **C)** Post-operative radiograph. **D, E, F**) Pulp chamber showing canal orifice obturated with gutta-percha.



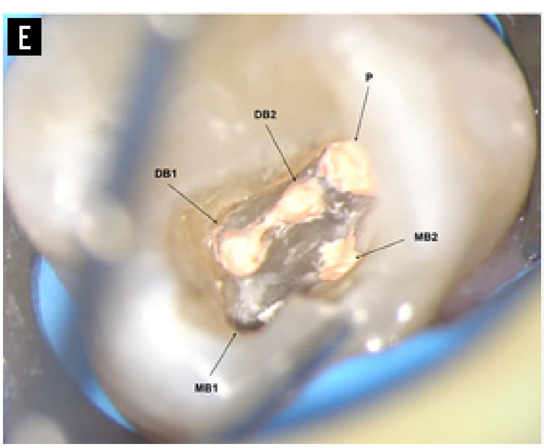


Figure 4
A) Pre-operative radiograph. **B)** Cone-fit radiograph. **C, D)** Post-operative radiograph. **E)** Pulp chamber showing canal orifices obturated with gutta-percha.

k-file was used to determine the working length similar to the previous cases (Figure 3B). The CBCT and working length radiograph revealed a Vertucci's Type II canal configuration of the palatal root (P1, P2), and mesial root (MB1, MB2), and a single canal in the distal root (D1). Instrumentation was performed using a combination of Edge File X3 and X5 file systems (EdgeEndo, Albuquerque, NM, USA) with continuous intermittent irrigation. Final irrigation was then performed, canals were dried, and obturated using a warm vertical condensation technique similarly to case 1 (Figure 3C, D, E, F).

#Case 4
A 42-year-old Portuguese male came to our private practice in Lisbon, Portugal with a chief complaint of "I feel some discomfort in my upper back teeth". Clinical and radiographic examination revealed a huge disto-occlusal composite restoration on tooth 16 (Figure 4A). There was no response to the cold test, but a low response when heated gutta-percha was applied. Probing and mobility were within physiologic limits. A diagnosis of "Asymptomatic irreversible pulpitis with normal apical tissues" was made for tooth 16. After profound anesthesia and isolation, the tooth was accessed with a round bur (Mani, Inc., Tochigi, Japan) under an operating microscope (OMS2380, Zumax Medical Co, Ltd, Suzhou, China). Using a DG-16 explorer (Hu-Friedy, Chicago, IL) a huge pulp stone from the pulp chamber was dislodged and removed. The access cavity was then refined using Start-X (Dentsply Maillefer, Ballaigues, Switzerland) ultrasonic tips, and pre-flaring of canals up to the middle third was performed using Reciproc Blue 25 (VDW Gold, VDW, Munich, Germany) without any predetermined WL or glide path (Supplementary Video 1). Multiple 15 ISO K-Files were used to check the type of anatomy of the canals, which revealed mesial root with 2 individual canals (MB1, MB2), distal with 2 canals (DB1, DB2) with Vertucci's Type II configuration, and a single palatal canal. An R-Pilot (VDW Gold, VDW, Munich, Germany) in reciprocating motion was then used to create a glide path, and Reciproc Blue was used until the WL to complete the instrumentation (Supplementary Video 1). Continuous irrigation with 4.25% sodium hypochlorite was carried out between each instrument change. Sonic activation was performed using the Eddy activation tip (VDW, Munich, Germany). Calibration and cone fit radiograph were made, (Figure 4B) and a warm vertical condensation was used with AH plus sealer to obturate the canals (Figure 4C, D, E).

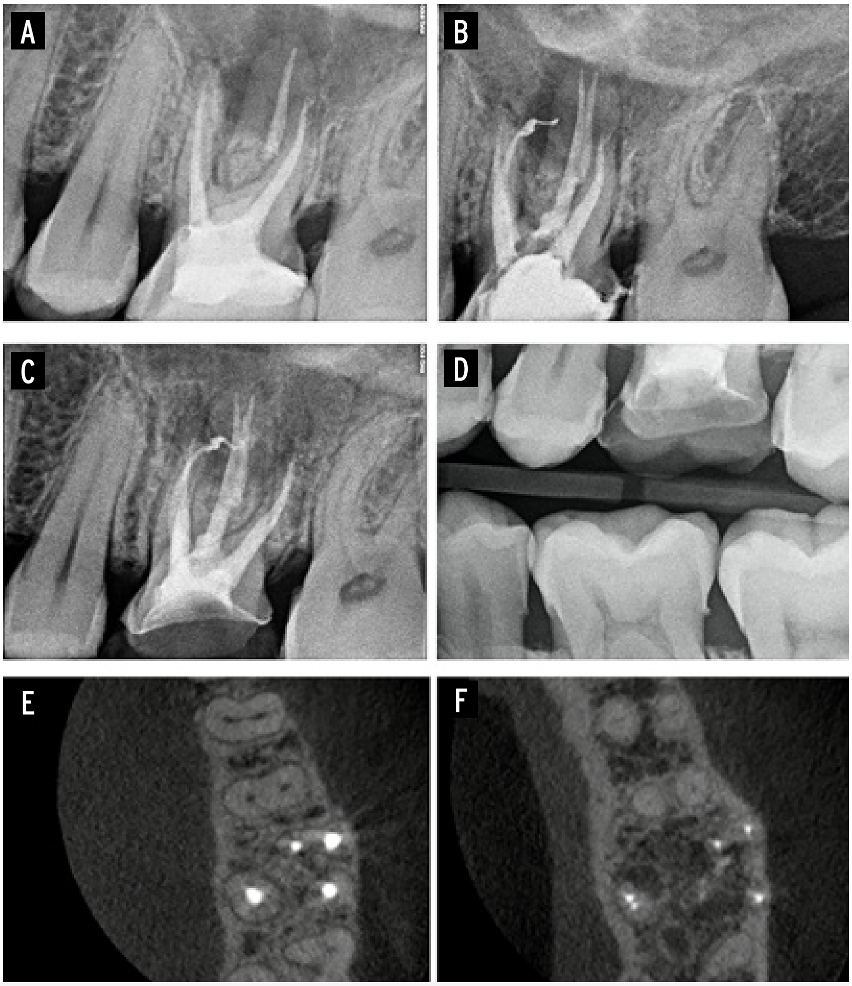


Figure 5
A) Pre-operative radiograph. **B)** Post-operative radiograph showing all 5 canals. **C)** Post-operative periapical radiograph and **D)** bite-wing radiograph demonstrating adaptation of indirect restoration. **E, F)** CBCT slices showing all 5 canals and reduction in the furcal and periapical radiolucencies.

#Case 5
A 42-year-old Spanish male was referred due to a vestibular abscess with tooth 16 which was endodontically treated a year ago. Clinical examination showed that the tooth was positive to vertical percussion with grade II furcation involvement and grade I mobility. Slight buccal and palatal swelling was evident. Radiographic examination revealed a previously treated tooth with periapical radiolucency and a fiber post placed in the palatal root canal (Figure 5A). A periapical radiograph suggested an uncentered palatal and mesial root obturation and a probable Vertucci's Type V canal anatomy, missed in the palatal root (Figure 5A). A diagnosis of "Previously treated tooth with chronic apical abscess" with tooth 16 was determined. An orthograde retreatment was chosen as the treatment of choice. After profound anesthesia and removal of all old restoration, access was made with a careful approach towards the palatal root. The fiber post was distinguished due to its more translucent shade and was removed using ultrasonics (Start-X, Dentsply Maillefer, Ballaigues, Switzerland). The gutta-percha was removed using a Reciproc R25 (VDW Gold, VDW, Munich, Germany), and both the missed MB2 and the second palatal canal were negotiated using ISO 10 K-Files and then instrumented. Continuous irrigation with 4.25% sodium hypochlorite and 10% citric acid, and a final rinse with alcohol 96% was performed. The canals were then calibrated and obturated using a warm vertical condensation technique (Figure 5B). Following the retreatment, an overlay was then placed over the tooth (Figure 5C, D). A 6-month radiograph and CBCT, taken for implant placement purposes, revealed the true anatomy of the tooth and reduction in the furcal and periapical radiolucency (Figure 5E, 5F).

Discussion

Different case report papers of upper first molars with five root canals have been published in the literature (22, 24, 26). One of the first, maxillary first molar with five root canals was reported by Cecic et al. in 1982 (26). In this case report, the molar had two mesiobuccal, two palatals, and an individual distal root canal. Later a case report by Beatty in 1984 (24), showed the presence of three mesiobuccal root canal configuration. Reports of the maxillary first molar with four roots and different canal configurations have also been published (27, 28).
In the cases presented, all the five teeth had 2 mesiobuccal canals out of which three of the teeth had 2 canals in the palatal root, and two of the teeth had 2 distal canals. Apart from demonstrating the prevalence of MB2 canal in geographically different population, this case series

also emphasizes on the uncommon variations found with this tooth. Most case reports of maxillary first molars with more than five, even up to an eight canal configuration have been reported from the Indian subcontinent (6, 7, 23). Cases reported in this case series are specifically from regions where the incidence of anatomical variations in their population is reported to be high, affirming the published findings.

Complete knowledge of the morphologic variations and anatomy with appropriate tools is essential especially for endodontically treating rare variations in tooth anatomy (29). None of the cases reported were performed without magnification. Magnification has been proven to be an essential tool in endodontics. A study by Buhrley et al. (4) showed detection of MB2 canals was almost three times higher when microscopes were used in comparison to the naked eye, while dental loupes also performed equally well. All of the cases in this series needed some kind of modification of the access cavity with ultrasonic troughing to address these extra canals.

Following the ALARA principle, CBCT was not used in each case in this series, although it has been demonstrated to detect more missed mesiobuccal (MB2) canals in the maxillary first molar especially in cases of retreatments, where one might suspect it to be present more often (30). Vasundhara et al. (31) also showed that CBCT performed significantly better in the detection of missed canals when compared with magnification. With its higher sensitivity and specificity and the advantages over the shortcomings of conventional radiographs, CBCT has proven to be a vital tool in endodontics.

Conclusions

This case series demonstrates the incidence of maxillary first molars with 5 canals and its different variations. It also validates the fundamental role of magnification, ultrasonic, and CBCT in the endodontic management of such complex root canal anatomy.

Clinical Relevance

The cases presented in this paper highlight the inevitable use of technology like magnification, ultrasonic, and especially the prudent use of CBCT in the management of complex anatomies of the maxillary first molar in different ethnic groups.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgement

The authors deny any financial affiliations related to this study or its sponsors.

References

1 *Favieri A, De Barros FGB, Campos LC. Root canal therapy of a maxillary first molar with five root canals: Case report. Braz Dent J. 2006;17:75-8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16721471.*

2 *Pécora JD, Woelfel JB, Sousa Neto MD, et al. Morphologic study of the maxillary molars. Part II: Internal anatomy. Braz Dent J. 1992;3:53-7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/1303118.*

3 *Kottoor J, Hemamalathi S, Sudha R, et al. Maxillary second molar with 5 roots and 5 canals evaluated using cone beam computerized tomography: a case report. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010;109:e162-5. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20123395.*

4 *Buhrley LJ, Barrows MJ, BeGole EA, et al. Effect of magnification on locating the MB2 canal in maxillary molars. J Endod. 2002;28:324-7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/12043874.*

5 *Holderrieth S, Gernhardt CR. Maxillary molars with morphologic variations of the palatal root canals: a report of four cases. J Endod. 2009;35:1060-5. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19567335.*

6 *Kottoor J, Velmurugan N, Surendran S. Endodontic management of a maxillary first molar with eight root canal systems evaluated using cone-beam computed tomography scanning: a case report. J Endod. 2011;37:715-9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21496678.*

7 *Albuquerque DV, Kottoor J, Dham S, et al. Endodontic management of maxillary permanent first molar with 6 root canals: 3 case reports. Oral Surgery, Oral Med Oral Pathol Oral Radiol Endodontology. 2010;110:e79-83. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20656533.*

8 *Baratto Filho F, Zaitter S, Haragushiku GA, et al. Analysis of the internal anatomy of maxillary first*

molars by using different methods. J Endod. 2009;35:337-42. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19249591.
9 Cotton TP, Geisler TM, Holden DT, et al. Endodontic applications of cone-beam volumetric tomography. J Endod. 2007;33:1121-32. Available from: http://www.ncbi.nlm.nih.gov/pubmed/17931947.
10 Patel S. New dimensions in endodontic imaging: Part 2. Cone beam computed tomography. Int Endod J. 2009;42:463-75. Available from: http://doi.wiley.com/10.1111/j.1365-2591.2008.01531.
11 Vizzotto MB, Silveira PF, Arús NA, et al. CBCT for the assessment of second mesiobuccal (MB2) canals in maxillary molar teeth: effect of voxel size and presence of root filling. Int Endod J. 2013;46:870-6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23442087.
12 Blattner TC, George N, Lee CC, et al. Efficacy of cone-beam computed tomography as a modality to accurately identify the presence of second mesiobuccal canals in maxillary first and second molars: a pilot study. J Endod. 2010;36:867-70. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20416435.
13 Klein RM, Blake SA, Nattress BR, et al. Evaluation of X-ray beam angulation for successful twin canal identification in mandibular incisors. Int Endod J. 1997;30:58-63. Available from: http://www.ncbi.nlm.nih.gov/pubmed/9477795.
14 Castellucci A. Endodontics (Vol 1). In: Endodontics. 2005. p. 66.
15 Miller D, Schauer D. The ALARA Principle in Medical Imaging. AAPM Newsl. 2015;40:38-40. Available from: https://www.researchgate.net/publication/272504868_The_ALARA_principle_in_medical_imaging.
16 Patel S, Brown J, Semper M, et al. European Society of Endodontology position statement: Use of cone beam computed tomography in Endodontics: European Society of Endodontology (ESE) developed by. Int Endod J. 2019;52:1675-8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/31301231
17 Yoshioka T, Kobayashi C, Suda H. Detection rate of root canal orifices with a microscope. J Endod. 2002;28:452–3. Available from: http://www.ncbi.nlm.nih.gov/pubmed/12067127
18 Baldassari-Cruz LA, Lilly JP, Rivera EM. The influence of dental operating microscope in locating the mesiolingual canal orifice. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2002;93:190-4. Available from: http://www.ncbi.nlm.nih.gov/pubmed/11862210.
19 Mendes EB, Soares AJ, Martins JNR, et al. Influence of access cavity design and use of operating microscope and ultrasonic troughing to detect middle mesial canals in extracted mandibular first molars. Int Endod J. 2020;53:1430-7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/32602578.
20 Yoshioka T, Kikuchi I, Fukumoto Y, et al. Detection of the second mesiobuccal canal in mesiobuccal roots of maxillary molar teeth ex vivo. Int Endod J. 2005;38:124-8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15667634.
21 Kottoor J, Velmurugan N, Sudha R, et al. Maxillary first molar with seven root canals diagnosed with cone-beam computed tomography scanning: a case report. J Endod. 2010;36:915-21. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20416446.
22 Kottoor J, Hemamalathi S, Sudha R, et al. Maxillary second molar with 5 roots and 5 canals evaluated using cone beam computerized tomography: a case report. Oral Surgery, Oral Med Oral Pathol Oral Radiol Endodontology. 2010;109:e162-5.
23 Kishan K V, Das D, Chhabra N, et al. Management of maxillary first molar with six canals using operating microscope. Indian J Dent Res. 2018;29:683-6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/30409954.
24 Beatty RG. A five-canal maxillary first molar. J Endod. 1984;10:156-7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/6586970.
25 de Almeida-Gomes F, Maniglia-Ferreira C, Carvalho de Sousa B, et al. Six root canals in maxillary first molar. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;108:e157-9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19716486.
26 Cecic P, Hartwell G, Bellizzi R. The multiple root canal system in the maxillary first molar: a case report. J Endod. 1982;8:113-5. Available from: http://www.ncbi.nlm.nih.gov/pubmed/6951912.
27 Di Fiore PM. A four-rooted quadrangular maxillary molar. J Endod. 1999;25:695-7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/10687532.
28 Adanir N. An unusual maxillary first molar with four roots and six canals: a case report. Aust Dent J. 2007;52:333-5. Available from: http://www.ncbi.nlm.nih.gov/pubmed/18265691.
29 Slowey RR. Root canal anatomy. Road map to successful endodontics. Dent Clin North Am. 1979;23:555-73. Available from: http://www.ncbi.nlm.nih.gov/pubmed/294389.
30 Studebaker B, Hollender L, Mancl L, et al. The Incidence of Second Mesiobuccal Canals Located in Maxillary Molars with the Aid of Cone-beam Computed Tomography. J Endod. 2018;44:565-70. Available from: http://www.ncbi.nlm.nih.gov/pubmed/29153734.
31 Vasundhara V, Lashkari K. An in vitro study to find the incidence of mesiobuccal 2 canal in permanent maxillary first molars using three different methods. J Conserv Dent. 2017;20:190. Available from: http://www.jcd.org.in/text.asp?2017/20/3/190/218308.

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ORIGINAL ARTICLE

Effect of horizontal position of fiber post placement on fracture resistance and location in endodontically treated premolars with a MOD preparation

ABSTRACT

Aim: *To evaluate the effect of the position of fiber post placement on fracture resistance and location in endodontically treated teeth.*
Methods: *Forty healthy double-rooted human first premolars were divided into five groups. S: healthy teeth without intervention; C: endodontic treatment with MOD cavity preparation; CR: restoration with composite resin; CMP: fiber post placed horizontally in the center of the middle third of the crown; CAP: fiber post placed horizontally 2 mm below the center of the middle third of the crown. After thermocycling and fracture strength tests using a universal test machine, pulp floor involvement was evaluated. The Tukey test was used for statistical analysis.*
Results: *Means and standard deviations of fracture strength (N) were as follow. S: 2451^{A}±552.9; C: 32.63^{B}±4.89; CR: 398.7^{C}±73.8; CRMFP: 1253^{D}±82.15; and CRAFP: 1156^{D}±88.23 (different letters indicate statistical differences, P>0.05). Posts placed 2 mm below the center of the middle third of the crown were associated with catastrophic fractures of the pulp chamber floor.*
Conclusions: *The position of a fiber post seems to affect fracture location. The use of fiber posts, regardless of position, increases fracture resistance of endodontically treated teeth.*

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KEYWORDS *Endodontically treated teeth, fracture resistance, horizontal fiber post, position of the post*

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Introduction

Endodontically treated teeth have a higher risk of biomechanical failure than vital teeth, despite advances in restorative materials and procedures (1). The loss of structural integrity of cusps and ridges and the complete removal of the pulp chamber roof during endodontic access affect tooth function because of cusp deflection, which may lead to a higher occurrence of fractures (2).

Restorative treatments using posts placed horizontally across the dental crown seem to be an excellent method to increase the resistance to fracture of the crown in weakened teeth, although catastrophic fractures may still occur (3-6). According to Mangold et al (7), unfortunately, most tooth fractures occur 2 to 3 mm below the coronal margin, which may complicate restoration and make prognosis unclear. Dentists should be aware of the interaction between loads applied to the tooth, the distribution of areas of greatest stress and the types of potential fractures, so that they may plan a restorative treatment that eliminates or reduces the effect of these factors to preserve any remaining tooth structure as much as possible. This study evaluated the effect of horizontally placed fiber posts on fracture strength and location in endodontically treated premolars restored with a MOD preparation.

The initial null hypothesis was that there would be no influence of the horizontally placed fiber posts on fracture strength and location in the restored teeth.

Methods

This study was approved by the local Research Ethics Committee (CAAE 68708217.2.0000.5347).

Sample selection and preparation

Forty double-rooted human maxillary first premolars, free of carious lesions, restorations, or cracks were selected.

Buccolingual (9 mm ± 0.5 mm) and mesiodistal (7 mm ± 0.5 mm) dimensions of the crowns were measured at the most prominent part of their surfaces using a digital caliper (Mitutoyo, Suzano, SP, Brazil). After cleaning, the teeth were placed in 0.5% chloramine (Seachem Laboratories, Madison, GA) for 48 hours for disinfection. After that, they were randomly divided into five experimental groups (Table 1).

Preparation of specimens

Each tooth was individually included in PVC cylinder measuring 2 cm in height and 3 cm in diameter using a self-curing acrylic resin. The specimens were centered inside the PVC cylinder and the anatomic neck of the tooth was kept 2 mm above the edge of the acrylic material. After that, the specimens were stored in distilled water at 37 °C.

MOD cavity preparation

The inclination and movements of a #2143 diamond bur (KG Sorensen, São Paulo,

Table 1

Experimental groups

Groups	n	Group Description
S	8	Healthy tooth
C	8	MOD preparation (MOD) + endodontic treatment (RCT)
CR	8	MOD + RCT + composite resin restoration (R)
CMP	8	MOD + RCT + horizontal fiberglass post transfixed in the middle third of dental crown center + R
CAP	8	MOD + RCT + horizontal fiberglass post transfixed 2 mm below the center of middle third dental crown + R

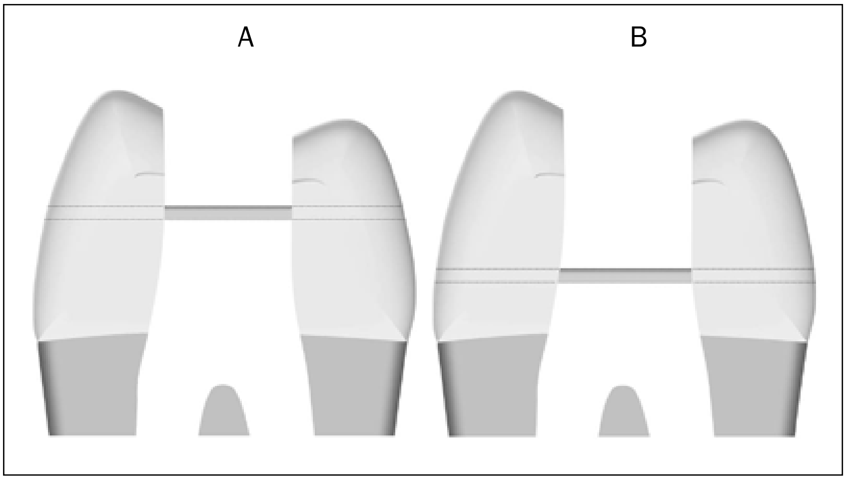

Figure 1
Schematic drawing of the transfix position of the fiberglass post in the dental crown **A)** middle third of dental crown; **B)** 2 mm below the middle third of dental crown.

Brazil) were standardized for the preparation of MOD cavities.
Cavity preparations followed the method described by Cötert et al (8) and Beltrão et al (9). A line from the central groove was drawn to ensure that the buccal and palatal walls of the prepared area were at a distance that corresponded to two-thirds of the intercuspal distance. This line ran over the central groove, to the mesial surface, over the marginal ridge and towards the tooth neck to define a height of 4 mm for the preparation. The same buccolingual width previously determined on the occlusal surface was defined for the mesial surface, and the same width was defined for the proximal boxes. A #2143 diamond bur initially positioned on the mesial surface over the central line was used along a predetermined length. Next, a mesiodistal box as wide as the tip was prepared. The buccal and palatal walls followed the predetermined limits, so that the gingival floor was connected to the pulp floor of the occlusal box, forming a single mesiodistal corridor. Therefore, the MOD preparation had only buccal and palatal walls and a common mesiodistal floor; the buccal and palatal angles of the pulp chamber floor were rounded using a #2143 bur, replaced after each five cavity preparations. The superficial cavity angle was finished manually using #28 and #29 margin cutters (SSWhite Art. Dentários Ltda., Rio de Janeiro, Brazil). In group S, no MOD cavity was prepared.
After MOD preparation, the specimens were again stored in distilled water at 37 °C.

Endodontic treatment
The pulp chamber was accessed using #02 and #04 Carbide burs (KG Sorensen Ind. E Com Ltda., Barueri, SP, Brazil) at high speed, under water cooling. Convenience form was established using the Endo Z tip (Dentsply Ind. E Com Ltda, Petrópolis, Brazil).
The working length was set at 1 mm short of the foramen, and canals were prepared following a serial technique using #15, #20, #25, #30, and #35 K-files (Dentsply/Maillefer, Ballaigues, Switzerland). Canals were irrigated with 2.5% sodium hypochlorite applied with a 10-mL plastic syringe and a 30-ga Navitip® (Ultradent Products, Inc. South Jordan, UT). The cervical area was prepared before canal preparation using a #35 La Axxess® bur (SybronEndo, Glendora, CA), 0.6 mm taper, to a depth of 5 mm of canal access, under irrigation with hypochlorite.
After cleaning and before filling, the canals were rinsed with 17% EDTA under agitation with a #35 file for 3 minutes. The canals were filled with gutta-percha cones and AH Plus® epoxi resin-based sealer (Dentsply/Maillefer Instruments SA, Ballaigues, Switzerland) using the Tagger hybrid technique and a #60 McSpadden® compactor (Dentsply/Maillefer Instruments SA, Ballaigues, Switzerland).

Perforation for post placement
The fiber posts used were Reforpost® (Angelus, Londrina, Brazil) measuring 1.1 mm in diameter. They were perforated on the buccal and palatal walls using a #3145 diamond tip (KG Sorensen, São Paulo, Brazil) at high rotation and under refrigeration. As the #3145 tip has a diameter of 1.2 mm, slightly larger than that of the post, the posts fit the perforated holes. The perforation of both buccal and palatal walls was simultaneous and along the axis of tip insertion. The tip was changed after perforation of each five teeth.
The teeth of the CMP group were perforated in the central area of the middle third of the crown on the two tooth surfaces. In the CAP group, the perforations were made 2 mm below the most prominent point of the middle third of the crown (Figure 1).

Bonding of fiber posts place horizontally and restorative procedures
Bonding of the posts placed horizontally followed the protocol below:
-cleaning of the posts with 70% alcohol and drying with air spray;
-application of a silane layer (FGM Produtos Odontológicas, Joinville, Brazil); drying at room temperature, followed by application of air spray from a distance of 15 cm for one minute;
-application of a thin layer of Singlebond Universal adhesive (3M ESPE, St. Paul, MN), and photoactivation using a LED light unit (Bluephase, Ivoclar) for 20 seconds;
-enamel and dentin etching with 35% phosphoric acid (Dentsply Ind. e Com. Ltda, Petrópolis, Brazil) applied to the holes for 15 seconds, then rinsing for 20 seconds and air drying for 5 seconds;
-etching of enamel on the cavity surface with 35% phosphoric acid for 30 seconds, rinsing for 30 seconds and air drying for 5 seconds;
-application of the Singlebond Universal adhesive to the holes, cavity and pulp chamber preparation, drying for 5 seconds, and photoactivation for 20 seconds on each surface;
-insertion of Bulkfill flow resin (3M ESPE, St. Paul, MN) into the pulp chamber up to the middle of the cavity below the site of the holes, and photoactivation for 40 seconds; all teeth, with or without posts were filled from the pulp chamber to the middle of the area prepared using the Bulkfill flow resin, applied to a thickness of about 4 mm;
-insertion of Bulkfill flow resin into the holes, placement of the fiber posts horizontally in the holes, removal of excess resin with a microbrush, and photoactivation for 40 seconds;
-application of Z250 resin (3M ESPE, St. Paul, MN) to the MOD cavity in four increments of 2 mm each, and photoactivation for 40 seconds for each incremental application.
After restorations, the specimens were placed back in distilled water and stored for 48 h at 37° C.

Mechanical compression test
Specimens were thermocycled between 5° C and 55° C for 500 cycles. Fracture strength was determined using an EMIC DL 2000 universal testing machine (São José dos Pinhais, Brazil) with a 10 kN load cell at a crosshead speed of 0.5 mm/min. A 6.0-mm metal sphere was used for contact only with the inclined planes of the intercuspal surface of the occlusal surface of the specimen, without any contact with the restorative material. Compressive stress was applied parallel to the long axis of the tooth until fracture. The maximum fracture strength (rupture) was recorded in Newton for each specimen

Analysis of type of tooth fracture
A magnifying glass (4X magnification) was used to examine specimens visually for fractures, which were classified either as a pulp chamber floor fracture associated or not with the cusp, or as a cusp fracture only. Floor fractures separated the tooth into two parts at the pulp chamber floor, in a buccolingual or mesiodistal direction. Cusp fractures involved one or more cusps totally or partially, with or without displacement.

Statistical analysis
The Shapiro-Wilk test was used to evaluate normality of the results, and data were analyzed using one-way ANOVA and the Tukey test (α=5%). The GraphPad Prism 7 software (GraphPad Software Inc., San Diego, CA) was used for all statistical analyses.

Results

Table 2 shows that teeth restored with fiberglass post and composite resin (CMP and CAP) presented statistically higher fracture load than teeth filled with composite resin only (CR). However, there is no difference in fracture load between groups CMP and CAP regardless of fiberglass post localization. The presence of fiberglass post in the middle of the crown (CMP) promoted lower pulp floor fracture percentage than CAP and CR groups.

Discussion

Fractures of endodontically treated teeth are common in clinical practice, and numerous studies have reported a high incidence of fractures of maxillary premolars

Table 2

Fracture strength, Newtons (N), coefficient of variation (CV), strength recovery in relation to group S, and pulp and cusp floor fracture in different experimental groups

Groups	Mean ± SD (N)	CV	Strength recovery	Pulp floor fracture	Cusp fracture
S	2451^{A} ± 552.9	23%	——	12.5% (1)	87.5%(7)
C	32.63^{B} ± 4.89	15%	-98.6%	100% (8)	—
CR	398.7^{C} ± 73.8	18%	-83.7%	87.5% (7)	12.5% (1)
CMP	1253^{D} ± 82.15	7%	-48.8%	62.5% (5)	37.5% (3)
CAP	1156^{D} ± 88.23	8%	-52.8%	87.5% (7)	12.5% (1)

Means followed by different uppercase letters differ significantly in one-way ANOVA and Tukey's test (p<0.05).

(10-12). Ibrahim et al (13), Taha et al (14), and Aslan et al (4) also used premolars in their experimental studies.
The use of intraradicular posts in these types of cases has not shown additional benefits (15), since the retainers vertically cemented inside the root canal have as main purpose to promote the retention of the restorative material and not to increase the resistance to dental structure (16). This can be seen in the study by Aslan et al (4) in which the use of the fiberglass post transfixed to the dental crown of a premolar with MOD preparation showed better results of resistance to dental fracture than cases in which the post was placed inside the root canal. According to Saatian et al (17), all types of intraradicular posts produce some degree of tension within the root dentin, causing some stress force to be transmitted vertically along the root (18), which can cause deeper levels of fractures and complex (4). In addition, when preparing the canal to receive the retainer, more root dentin is usually removed; thus, resistance to occlusal forces is decreased and the possibility of fracture increases (19).
This study simulated an unfavorable clinical scenario, in which the cusps lose tissue support and tend to undergo greater deflection, and used class II MOD preparations for restorations, as in the studies by Salameh et al (20), Soares et al (21), and Taha et al (14). Lopes et al (22) showed that MOD preparations in premolars reduce cusp stiffness to a third of that of a healthy tooth, which makes them more susceptible to fracture.
Horizontally placed posts associated with the material used for restorations in endodontically treated teeth, regardless of placement position, had greater fracture resistance than teeth restored without posts. These findings are in agreement with the studies by Karzoun et al (3), Aslan et al (4), and Dhingra et al (5), who also worked with horizontal post placement in premolars with MOD cavities.
The horizontal placement of posts in the center of the middle third of the crown is associated with a greater chance of fractures at the cusp level, without involvement of the pulp floor. These fractures have a better prognosis and result in better tooth survival and restoration. In specimens that received other treatments in this study, including horizontal post placement 2 mm below the center of the middle third of the crown, most fractures occurred catastrophically at or below the floor of the pulp chamber. All fractures were above the horizontal post, which is in agreement with the study conducted by Kao (23), who found that less catastrophic tooth fractures are largely associated with post placement position, that is, posts placed closer to the occlusal surface have better outcomes.
The cervical constriction of premolars may play an important role in the extension of tooth fractures to the most cervical region, at or below the floor of the pulp chamber. Restorations should be carefully planned to predict the site of a possible future fracture. Dentists may, thus, induce and direct the fracture to a position that, should it happen, ensures good conditions for a better restoration.
Almost all fractures in this study were in the palatal area of the teeth, in agreement

with findings by Mangold and Kern (7). According to Panahandeh et al (24), the stress area on the palatal cusp is greater than on the buccal cusp.

Conclusions

The use of fiber posts for restorations, regardless of their position, increases fracture resistance of endodontically treated teeth. However, their placement position seems to affect fracture location.

Clinical Relevance

Restorative treatments using posts placed horizontally across the dental crown seem to be an excellent method to increase the resistance to fracture. However, their placement position seems to affect fracture location.

Conflict of Interest

The authors declares that there is no conflict of interest.

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References

1 *Fennis WM, Kuijs RH, Kreulen CM, et al. A survey of cusp fractures in a population of general dental practices. Int J Prosthodont. 2002;15:559-63.*
2 *Mannocci F, Qualtrough AJ, Worthington HV, et al. Randomized clinical comparison of endodontically treated teeth restored with amalgam or with fiber posts and resin composite: five-year results. Oper Dent. 2005;30:9-15.*
3 *Karzoun W, Abdulkarim A, Samran A, Kern M. Fracture strength of endodontically treated maxillary premolars supported by a horizontal glassfiber post: na in vitro study. J Endod. 2015;41:907-12.*
4 *Aslan T, Sagsen B, Er Ö, et al. Evaluation of fracture resistance in root canal treated teeth restored using diferente techniques. Niger J Clin Pract. 2018;21:795-800.*
5 *Dhingra A, Singh A, Bisht G, et al. Fracture strength of endodontically treated maxillary premolars supported by diferente horizontal post systems: an in vitro study. Int J Sci Res. 2018;7:69-71.*
6 *Mergulhão VA, de Mendonça LS, de Albuquerque MS, Braz R. Fracture resistance of endodontically treated maxillary premolars restored with diferente methods. Oper Dent. 2019;44:E1-E11.*
7 *Mangold JT, Kern M. Influence of glass-fiber posts on the fracture resistance and failure pattern of endodontically treated premolars with varying substance loss: na in vitro study. J Prosthet Dent. 2011;105:387-93.*
8 *Cötert HS, Sem BH, Balkan M. In vitro comparison of cuspal fracture resistances of posterior teeth restored with various adhesive restorations. Int J Prosthodont. 2001;14:374-8.*
9 *Beltrão MC, Spohr AM, Oshima HM, et al. Fracture strength of endodontically treated molars transfixed horizontally by a fiber glass post. Am J Dent. 2009;22:9-13.*
10 *Testori T, Badino M, Castagnola M. Vertical root fractures in endodontically treated teeth: a clinical survey of 36 cases. J Endod. 1993;19:87-91.*
11 *Tamse A, Fuss Z, Lustig J, Kaplavi J. An evaliuation of endodontically treated vertically fractured teeth. J Endod. 1999;25:506-8.*
12 *Yamada Y, Tsubota Y, Fukushima S. Effect of restoration method on fracture resistance of endodontically treated maxillary premolars. Int J Prosthodont. 2004;17:94-8.*
13 *Ibrahim AM, Richards LC, Berekally TL. Effect of remaining tooth structure on the fracture resistance of endodontically treated maxillary premolars: an in vitro study. J Prosthet Dent. 2016;115:290-5.*
14 *Taha NA, Maghaireh GA, Ghannam AS, Palamara JE. Effect of bulk-fill base material on fracture strength of root filled teeth restored with laminate resin composite restorations. J Dent. 2017;63:60-64.*
15 *Mohammadi N, Kahnamoii MA, Yeganeh PK, et al. Effect of fiber post and cusp coverage on fracture resistance of endodontically treated maxillary premolars directly restored with composite resin. J Endod. 2009;35:142832.*
16 *Glazer B. Restoration of endodontically treated teeth with carbon fibre posts–a prospective study. J Can Dent Assoc. 2000;66:613-8.*
17 *Saatian S. Fracture strength of endodontically treated teeth restored with casting post and core and glass-fiber with composite core. Iran Endod J. 2006;1:65-8.*
18 *Dua N, Kumar B, Arunagiri D, et al. Comparative evaluation of the effect of different crown ferrule designs on the fracture resistance of endodontically treated mandibular premolars restored with fiber posts, composite cores, and crowns: Na ex-vivo study. J Conserv Dent. 2016;19:264-9.*
19 *Sorensen JA, Martinoff JT. Clinically significant factors in dowel design. J Prosthet Dent. 1984;52:2835.*
20 *Salameh Z, Sorrentino R, Ounsi HF, et al. Effect of diferente all ceramic crown system on fracture resistance and failure pattern of endodontically treated maxilary premolars restored with and without glass fiber posts. J Endod. 2007;33:848-51.*
21 *Soares PV, Santos-Filho PCF, Queiroz EC, et al. Fracture resistance and stress distribution in endodontically treated maxillary premolars restored with composite resin. J Prosthodont. 2008;17:114-119*
22 *Lopes LM, Leitao JG, Douglas WH. Effect of a new resin inlay-onlay restorative material on cuspal reinforcement. Quintessence Int. 1991;22:641-5.*
23 *Kao EC. Fracture resistance of pin-retained amalgam, composite resin, and alloy-reinforced glass ionomer core materials. J Prosthet Dent. 1991;66:463-71.*
24 *Panahandeh N, Torabzadeh H, Ziaee N, et al. The effect of composite thickness on the stress distribution pattern of restored premolar teeth with cusp reduction. J Prosthodont. 2017;26:440-445.*

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ORIGINAL ARTICLE

Apically extruded debris and irrigants during root canal instrumentation with TruNatomy and ProTaper Gold rotary file systems

ABSTRACT

Aim: *The objective of this study was to evaluate the amount of apically extruded debris and irrigants produced by TruNatomy and ProTaper Gold in mandibular incisor root canals.*
Methodology: *Forty mandibular incisors were instrumented using TruNatomy (Dentsply Sirona, Maillefer, Ballaigues, Switzerland) and ProTaper Gold (Dentsply Sirona, Maillefer, Ballaigues, Switzerland) rotary systems. Apically extruded debris and irrigants during instrumentation were collected into preweighed Eppendorf tubes and were assessed with an electronic scale. All the procedures were performed in a 35 °C hot water bath. The data were analyzed using the Shapiro-Wilk test and Mann-Whitney U test at a 5% significance level.*
Results: *Both NiTi file systems investigated extruded debris from the apical foramen. According to the data, the TruNatomy group extruded significantly less debris and irrigant from the apical foramen than the ProTaper Gold group ($p<0.05$).*
Conclusions: *All the instruments caused apical extrusion. The TruNatomy instruments extruded less debris and irrigants apically than the ProTaper Gold instruments.*

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KEYWORDS *Agar gel model, apical extrusion, debris, TruNatomy, ProTaper Gold*

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Introduction

For long-term success in root canal treatment, canal cleaning and shaping are critical. During these procedures, it is essential to pay great attention; otherwise, complications - such as extrusion of dentin chips, pulpal residue, microorganisms, and irrigants into the periradicular tissue - may occur (1). Apical extrusion of debris and irrigants (AEDI) may cause postoperative pain, exacerbation and delayed periapical healing, creating an undesirable situation (2, 3). Studies show that all instrumentation techniques and instruments cause apical extrusion (4, 5).
The amount of extruded debris through the apex is related to the design (size and type) of the endodontic instruments used (6). Technological advances in rotary nickel-titanium (NiTi) instruments have led companies to develop new instruments with new design concepts. Recently, a novel heat-treated NiTi rotary system, TruNatomy (Dentsply Sirona, Maillefer, Ballaigues, Switzerland), has been developed with higher flexibility, allowing the file to be pre-curved when needed. According to the manufacturer, this system has an off-centered parallelogram cross-section design that is 0.8 mm of NiTi wire instead of the up to 1.2 mm found in most other variable tapered instruments (Dentsply Sirona, TruNatomy Brochure. Available at: https://www.dentsplysirona.com/en/explore/endodontics/trunatomy.html. Accessed February 5, 2021). Van der Vyver et al. reported that TruNatomy instruments maintain their structural integrity via instrument geometry, regressive tapers, slim design and a heat-treated NiTi alloy (7). ProTaper Gold (Dentsply Sirona, Maillefer, Ballaigues, Switzerland) is made of "Gold-Wire" and has some characteristics similar to those of controlled memory wire (CM-wire) (8). This rotary system has a unique instrument design with a triangular cross-section and a variable progressive taper (9). To our knowledge, only one study has compared the apical extrusion effects of TruNatomy with ProTaper Gold and ProTaper Next rotary file systems (10).
The purpose of this investigation was to compare the AEDI associated with the use of TruNatomy and ProTaper Gold rotary file systems in mandibular incisor teeth with different methodology. The null hypothesis tested was that there would be no difference between TruNatomy and ProTaper Gold systems in terms of the amount of extruded debris and irrigants through the apex.

Materials and Methods

The Ethics Board approved the study protocol of Afyonkarahisar Health Sciences University (No: 2011-KAEK-2/2020/10). Based on the results of Tanalp et al. (11), a power calculation was performed using G*Power 3.1 software (Heinrich Heine University, Dusseldorf, Germany) with an alpha-type error of 0.05 and beta power of 0.80. The software indicated that the total sample size for the two groups must be a minimum of 40 teeth.
A total of 40 mandibular incisor teeth that had been extracted for periodontal reasons were included in the study. The inclusion criteria were as follows: mature apices with a single apical foramen without resorption/calcification or previous root canal treatment and roots with less than a 5° curvature (12). To increase the standardization, teeth that were abraded under water cooling to standardize their lengths to 20 mm, confirmed with a millimeter ruler, were included in the study. Soft and hard tissue debris on the external surfaces of all the teeth were mechanically removed.
The coronal access cavity was prepared using diamond burs. A #15 K-file (VDW GmbH, Munich, Germany) was advanced within the canal until the tip was seen through the major apical foramen, and the working length was determined by subtracting 1 mm from this length. The size of the apical foramen of the teeth was not greater than 0.15 mm.
The selected teeth were randomly divided into two groups (n=20) and numbered. The root surfaces of all teeth, except 1 mm of the apical part, were covered with a Teflon band. The weight of the samples was measured three times with an electronic scale of 10^{-4} g (Denver Instrument, New York, ABD), and

the mean value was calculated. Agar gel (3 mL, 1.5%) was injected into Eppendorf tubes, and the samples were then fixed in the tubes at the cementoenamel junction using cyanoacrylate adhesive (UHU Patafix; UHU GmbH & Co. KG, Baden, Germany) to prevent leakage of irrigating solution through the hole. After gelation of the agar, the weights of the tubes, including the agar solution, were measured three times again. The weight of each apparatus (tooth-free apparatus) was calculated by subtracting the first weight measurement of the samples from the second weight measurement value (14, 15). The Eppendorf tubes were positioned in a glass bottle filled with water. The equipment was placed in a 35 °C hot water bath (JSR Research Inc., Republic of Korea) (16).

Each instrument was used on four specimens, simulating a molar with four canals. All instruments were operated using an endodontic motor (VDW Gold, VDW, Munich, Germany). The root canal preparation was completed when the final instrument of each system had reached the working length. The canals were irrigated with 5 mL 2.5% NaOCl solution with a 30-G IrriFlex needle (Produits Dentaires SA, Switzerland). To standardize the irrigation protocol, the needle was attached to a device (Mindray BeneFusion SP1, Shenzhen, China) and inserted into the canal within 2 mm of the working length without binding and moved in an up-and-down motion. In all the groups, the flow rate of the irrigating solution was constant and equal to 2.5 ml/min. After completing the preparation, final irrigation was applied using 5 mL of 17% EDTA followed by 5 mL of 2.5% NaOCl.

All endodontic procedures were completed by a single operator.

Group 1 (n=20): the root canals were prepared using TruNatomy Glider (17.02), Small (20.04), Prime (26.04) and Medium (36.03) files at 500 rpm and 1.5 Ncm torque values.

Group 2 (n=20): the root canals were prepared using ProTaper Gold S1 (17.02), S2 (20.04), F1 (20.07), F2 (25.08) and F3 (30.09) files at 300 rpm and 2.0 Ncm torque values.

When the root canal preparation was completed, the Eppendorf tubes were removed from the glass bottles, and the teeth were removed from the tubes. After removal of the Teflon bands and the teeth from the Eppendorf tubes, each apparatus was weighed three times consecutively. The amount of extruded debris was calculated by subtracting the weight value of the tooth-free apparatus from the post-preparation weight value. The mean weight of each tube containing debris and irrigant was recorded. A second independent operator performed all the measurements of the AEDI.

Statistical Analysis

The median, minimum and maximum values were calculated for the two groups. To test for normality, the amount of extruded debris and irrigants were subjected Shapiro-Wilk test and were found to have a non-normal distribution. The data were analyzed via Mann-Whitney U test using SPSS 21.0 Software (IBM Corp, Armonk, NY). The alpha-type error was set at 0.05.

Results

The descriptive statistics in each group are listed in Table 1. All the groups extruded debris from the apical foramen. According to the data, the TruNatomy group extruded significantly less debris and irrigants from the apical foramen than the ProTaper Gold group ($p<0.05$).

Discussion

During cleaning and shaping of the root canals, microorganisms may pass to the periradicular tissues through the apical foramen, causing postoperative flare-up (16). This complication increases the need for the development of new root canal file designs that minimize debris extrusion. The instrument design, differences in instrument tapers and root canal anatomy are closely related to apical debris extrusion (1). This study assessed the weight of AEDI produced by TruNatomy and ProTaper Gold systems during root canal preparation.

In previous studies, distilled water was used during instrumentation to avoid crystallization of sodium hypochlorite, which could otherwise interfere with the weighing of the debris (5). However, sodium hypochlorite is

Table 1

The median, minimum and maximum values of AEDI according to groups in grams

Group (n=20)	Median (Min-Max)	U	p
TruNatomy	0.0104 (0.0019-0.0416)	108.5	0.013*
ProTaper Gold	0.0218 (0.0061-0.1774)		

Mann-Whitney U test

commonly used as an irrigation solution in root canal preparation. We used the same test apparatus to evaluate the amount of AEDI as that used by Uslu et al. (15). In this system, a 1.5% agar gel was used to simulate periapical tissue, and the weights of the tubes, including the agar solution, were measured; it was not necessary to vaporize the irrigant. Therefore, all samples were irrigated with 2.5% NaOCl and 17% EDTA solutions.

In all shaping procedures, many factors - such as the shape of the apical area, the instrumentation technique, the length of the irrigation needle, the penetration of the tip of the needle into the apical and the speed of the irrigant administration - can cause debris and irrigants extrusion (17, 18). To lower the irrigant extrusion achieved with regular needles (6), side-vented needles were used, and to standardize the irrigation protocol, the irrigant flow rate was provided with a device. Moreover, similar to other studies, in this study, a 30-G IrriFlex irrigation needle integrated into the syringe pump was set at a speed of 2.5 ml/min (19, 20).

Our study presents one variable data: the design (size and type) of the NiTi rotary endodontic instruments. The newly developed TruNatomy instruments are manufactured from a heat-treated NiTi alloy that exhibits higher fatigue resistance (21, 22). It has been reported that the TRN instruments preserve the structural dentine and tooth integrity due to instrument geometry, regressive tapers and the slim design, along with the heat treatment of the NiTi alloy (7). To the best of our knowledge, there has been only one study that compared TruNatomy and ProTaper Gold systems in terms of AEDI (10). Çırakoğlu et al. (10) compared the amount of extruded debris through the apex using ProTaper Next, ProTaper Gold, and TruNatomy systems. The ProTaper Gold system extruded more debris than the TruNatomy system with no significant difference. This result differs from those of the current study. The experimental set-up, design and type of teeth used might have led to different results.

The results of the present study show that the TruNatomy group extruded significantly less debris and irrigants from the apical foramen than the ProTaper Gold group. The null hypothesis was rejected because of AEDI with different amounts between the tested two instrumentation systems. Several studies reported that the larger tapers at the tips of instruments, resulting in more aggressive preparation of the root canals, might explain the increased amount of extruded debris through the apex (20, 23, 24). The design features of the ProTaper Gold system include progressive and regressive percentage tapers on a single file, but the TruNatomy System has variable regressive tapers on a single file. However, the TruNatomy Medium instrument has a 0.03 taper at the apical D0 point, whereas the ProTaper Gold F3 instrument has a 0.09 taper at the apical D0 point. The larger taper at the tip of the ProTaper Gold instrument might explain the increased amount of AEDI with this system. Moreover, the cross-sectional geometric design of the TruNatomy system is different from that of the ProTaper Gold system. TruNatomy instruments have an off-centered parallelogram cross- section design that incorporates a 0.8-mm NiTi wire instead of the up to 1.2 mm found in most other variable tapered instruments. All three shaping files offer a slim shape combined with a unique cross-section for better performance while providing more space for superior debris debridement (Dentsply Sirona, TruNatomy Brochure. Available at: https://www.dentsplysirona.com/en/explore/endodontics/trunatomy.html. Accessed February 5, 2021).

The elements of the file design, such as flute depth and cross-section, flexibility, alloy, are related to the amount of extruded debris through the apex (25). Koçak et al. (26) reported that the off-centered cross-sectional design might provide more space for debris extrusion through the coronal direction. According to the authors of this article, TruNatomy's slim design with an off-centered parallelogram cross-section might be led to the debris removal coronally, which reduces apical compaction of debris within the root canal. This result is according to a previous study that also displayed lower debris extrusion associated with the TruNatomy system compared Reciproc Blue, HyFlex, HyFlex EDM, and ProTaper Next systems. In the present study, agar gel was used to simulate the periapical tissues because it has a similar density to periapical tissues (14). The presence of periapical tissues and changes in this tissue (e.g., lesions, periapical granulomas, or cysts) could affect the amount of AEDI under clinical conditions (28). In the use of real teeth, dentin microhardness also affects the amount of apically extruded debris (5). Moreover, because the mean temperature in the root canal is 35 °C (29), the experiment system was placed into a 35 °C hot water bath to mimic clinical conditions.

Conclusions

The design features and sizes of rotary systems have influenced the amount of AEDI during root canal preparation. Within the limitations of this study, the results show that although both tested systems extruded debris, TruNatomy instruments produced less AEDI than ProTaper Gold instruments.

Compliance with ethical standards

Ethical approval for the manipulation of human samples was obtained from the ethical committee of the University of Afyonkarahisar Health Sciences (No: 2011-KAEK-2/2020/10).

Clinical Relevance

Both NiTi file systems that TruNatomy and ProTaper Gold caused apical extrusion of debris and irrigants during canal shaping. The design of the NiTi rotary endodontic instruments are considered to be effective in the amount of apically extruded debris and irrigants.

Conflict of Interest

The authors declare that they have any conflict of interest.

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References

1 *Bürklein S, Benten S, Schäfer E. Quantitative evaluation of apically extruded debris with different single-file systems: Reciproc, F360 and OneShape versus Mtwo. Int Endod J. 2014;47:405-9.*

2. *Reddy SA, Hicks ML. Apical extrusion of debris using two hand and two rotary instrumentation techniques. J Endod. 1998;24:180-3.*

3 *Siqueira JF. Microbial causes of endodontic flare-ups. Int Endod J. 2003;36:453-63.*

4 *Arslan H, Doğanay E, Alsancak M et al. Comparison of apically extruded debris after root canal instrumentation using Reciproc® instruments with various kinematics. Int Endod J. 2016;49:307-10.*

5 *Tanalp J, Güngör T. Apical extrusion of debris: A literature review of an inherent occurrence during root canal treatment. Int Endod J. 2014;47:211-21.*

6 *Koçak S, Koçak MM, Sağlam BC et al. Apical extrusion of debris using Self-Adjusting File, reciprocating single-file, and 2 rotary instrumentation systems. J Endod. 2013;39:1278-80.*

7 *Van der Vyver PJ, Vorster M PO. Minimally invasive endodontics using a new single-file rotary system. Int Dent African ed. 2019;9(4):6-20.*

8 *Kwak SW, Lee CJ, Kim SK et al. Comparison of screw-in forces during movement of endodontic files with different geometries, alloys, and kinetics. Materials (Basel). 2019;12:1506.*

9 *Gagliardi J, Versiani MA, De Sousa-Neto MD et al. Evaluation of the shaping characteristics of ProTaper Gold, ProTaper Next, and ProTaper Universal in curved canals. J Endod. 2015;41:1718-24.*

10 *Çırakoglu NY, Özbay Y. Apically extruded debris associated with ProTaper Next , ProTaper Gold and TruNatomy systems : An in vitro study. J Dent Res Dent Clin Dent Prospects. 2021;15(1):30-4.*

11 *Tanalp J, Kaptan F, Sert S et al. Quantitative evaluation of the amount of apically extruded debris using 3 different rotary instrumentation systems. Oral Surgery, Oral Med Oral Pathol Oral Radiol Endod. 2006 Feb 1;101(2):250-7.*

12 *Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral Surgery, Oral Med Oral Pathol. 1971;32:271-5.*

13 *Keskin C, Sarıyılmaz E. Apically extruded debris and irrigants during root canal filling material removal using Reciproc Blue, WaveOne Gold, R-Endo and ProTaper Next systems. J Dent Res Dent Clin Dent Prospects. 2018;12(4):27276.*

14 *Lu Y, Wang R, Zhang L et al. Apically extruded debris and irrigant with two Ni-Ti systems and hand files when removing root fillings: A laboratory study. Int Endod J. 2013;46:1145-30.*

15 *Uslu G, Özyürek T, Yılmaz K et al. Apically Extruded Debris during Root Canal Instrumentation with Recip-*

roc Blue, HyFlex EDM, and XP-endo Shaper Nickel-titanium Files. J Endod. 2018;44:456-9.
16 Siqueira JF, Rocas IN, Favieri A et al. Incidence of postoperative pain after intracanal procedures based on an antimicrobial strategy. J Endod. 2002;28:457-60.
17 Van Der Sluis LWM, Gambarini G, Wu MK et al. The influence of volume, type of irrigant and flushing method on removing artificially placed dentine debris from the apical root canal during passive ultrasonic irrigation. Int Endod J. 2006;39(6):472-6.
18 Lambrianidis T, Tosounidou E, Tzoanopoulou M. The effect of maintaining apical patency on periapical extrusion. J Endod. 2001;27(11):696-8.
19 Toyoğlu M, Altunbaş D. Influence of Different Kinematics on Apical Extrusion of Irrigant and Debris during Canal Preparation Using K3XF Instruments. J Endod. 2017;43:1565-8.
20 Capar ID, Arslan H, Akcay M et al. An in vitro comparison of apically extruded debris and instrumentation times with ProTaper Universal, ProTaper Next, Twisted File Adaptive, and HyFlex instruments. J Endod. 2014;40(10):1638-41.
21 Elnaghy AM, Elsaka SE, Mandorah AO. In vitro comparison of cyclic fatigue resistance of TruNatomy in single and double curvature canals compared with different nickel-titanium rotary instruments. BMC Oral Health. 2020;20:38.
22 Riyahi AM, Bashiri A, Alshahrani K et al. Cyclic Fatigue Comparison of TruNatomy, Twisted File, and ProTaper Next Rotary Systems. Int J Dent. 2020;(2020).
23 Borges ÁH, Pereira TM, Porto AN et al. The influence of cervical preflaring on the amount of apically extruded debris after root canal preparation using different instrumentation systems. J Endod. 2016;42(3):465-9.
24 Silva EJNL, Carapiá MF, Lopes RM et al. Comparison of apically extruded debris after large apical preparations by full-sequence rotary and single-file reciprocating systems. Int Endod J. 2016;49(7):700-5.
25 Tinoco JM, De-Deus G, Tinoco EMB et al. Apical extrusion of bacteria when using reciprocating single-file and rotary multifile instrumentation systems. Int Endod J. 2014;47(6):560-6.
26 Koçak MM, Çiçek E, Koçak S et al. Comparison of ProTaper Next and HyFlex instruments on apical debris extrusion in curved canals. Int Endod J. 2016;49(10):996-1000.
27 Mustafa R, Al Omari T, Al-Nasrawi S et al. Evaluating in-Vitro Performance of Novel Nickel-Titanium Rotary System (TruNatomy) based on debris extrusion and preparation time from Severely Curved Canals. J Endod. 2021;1-6.
28 Altundasar E, Nagas E, Uyanik O et al. Debris and irrigant extrusion potential of 2 rotary systems and irrigation needles. Oral Surgery, Oral Med Oral Pathol Oral Radiol Endod. 2011;112:e31-5.
29 De Hemptinne F, Slaus G, Vandendael M et al. In Vivo Intracanal Temperature Evolution during Endodontic Treatment after the Injection of Room Temperature or Preheated Sodium Hypochlorite. J Endod. 2015;41:1112-5.

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ORIGINAL ARTICLE

Anatomical proximity of maxillary teeth and local factors associated with the thickness of the maxillary sinus mucosa: a retrospective study

ABSTRACT

Aim: *This cross-sectional study aimed to assess the proximity of root apexes to the maxillary sinus and to verify the correlation between sinus mucosal thickening with the distance from the root apex to the sinus floor, endodontic treatment, age, tooth, sex, and presence of periapical lesion.*

Methodology: *169 cone-beam computed tomography images were selected, and 696 teeth were assessed, 600 without endodontic treatment, and 96 endodontically treated. The images were initially classified according to the study conducted by Kwak et al. (2004) to assess the proximity of the tooth roots to the maxillary sinus, and multiple logistic regression was subsequently applied to identify probable factors influencing the thickening of the sinus mucosa.*

Results: *The vertical relationships between tooth roots and the sinus floor among the second premolars indicated a predominance of classification I (57.7%); whereas, in the first and second molars there was a predominance of types II (48.4%) and III (34.2%), respectively. The logistic regression did not indicate significant relationships between sinus mucosal thickening and the distance from the root apexes to the sinus floor, presence of endodontic treatment, and type of tooth (p>0.05). Age, presence of periapical lesions, and sex were associated with the presence of sinus thickening (p<0.05; odds ratio=1.03, 2.99, and 5.11, respectively).*

Conclusions: *The presence of thickening in maxillary sinuses was correlated with the following factors: age, sex, and presence of periapical lesions.*

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Introduction

The desired outcome for any endodontic treatment involves preventing or eradicating pulp and periradicular infections and complete sealing of the root canal system, providing comfort and a better quality of life for patients subject to this type of therapy (1). Currently, it is possible to observe with greater clarity the proximity of the root apexes of posterior upper teeth to the maxillary sinus. Cone-beam computed tomography (CBCT) is currently considered one of the most accurate image resources in the visualization of structures - such as the maxillary sinus - and possible changes in the sinus mucosa. Also, CBCT avoids inconveniences during the analyses, such as overlapping images, distortions, or vertical and horizontal enlargements (7, 10), becoming valuable and effective for determining the clinical relationship between the maxillary sinus floor and the root apexes of posterior upper teeth (11-13), increasing the number of cases diagnosed due to image accuracy (10).

Changes in the maxillary sinus mucosa generated by odontogenic infections are the result of the anatomical relationship between teeth and sinus. The roots of the posterior upper teeth are usually in close opposition to the maxillary sinus, with their apexes being projected towards the floor of this structure. This fact causes elevations or prominences in the thin layer of bone that separates them, which is considered a fusion of the lamina dura and the floor of the maxillary sinus (2). It is known that the upper first and second molars are usually pointed out as the teeth with greater proximity to the maxillary sinus (3-5). In addition, these two types of teeth have a higher prevalence of periapical lesions, when compared with the other teeth of the oral cavity (even when already endodontically treated), due to the high probability of having an extra canal (6). These lesions generate the risk of dissipating bacterial infections, thus damaging the maxillary sinus floor due to the extent of periradicular lesions when present (7).

Odontogenic sinusitis is characterized by chronic inflammation of the paranasal sinuses. It occurs when the Schneiderian membrane is irritated or perforated, as a result of dental infections, maxillary trauma, a foreign body within the maxillary sinus, supernumerary teeth, or periapical granuloma (8). The deposition of foreign substances - including those used in endodontics - when inside the maxillary sinus, can also give rise to various pathophysiological responses, and induce chronic inflammation. These foreign bodies can promote sinus pain and pressure, acute and chronic sinusitis resulting from irritation and thickening of the mucous membranes of the sinus, pain during chewing, and tenderness on palpation (9). Based on the above, the goals of this retrospective study were to assess the proximity of root apexes to the maxillary sinus and to verify the correlation between sinus membrane thickening with the distance from the root apex to the sinus floor, endodontic treatment, age, tooth, sex, and presence of periapical lesion.

Materials and Methods

After approval by the local Research Ethics Committee (approval number 773.236), 169 CBCT images obtained from a private clinic of oral and maxillofacial radiology were assessed. Each tomographic image was analyzed in parasagittal sections of the upper premolar and molar regions, both on the left and right sides.

To compose the sample for the study, the images were selected based on the following inclusion criteria: images of patients who had at least 20 years of age; and that provided a complete view of the maxillary sinus and the roots of the posterior upper teeth. Since this study was done using CBCT images and there was no way to confirm periodontal diseases based only on the images, teeth with periodontal diseases were not excluded.

The sample calculation was performed using the GPower 3.1.9.4 software (Heinrich-Heine-Universität Düsseldorf , Germany) (14) and the incidence of root protrusion within the maxillary sinus of upper second premolars and upper first and second molars, with the maxillary sinus as the primary outcome. Based on the study conducted by Jang et al (15) a power of 0.80 and an α level of 0.05 were used to detect a difference in

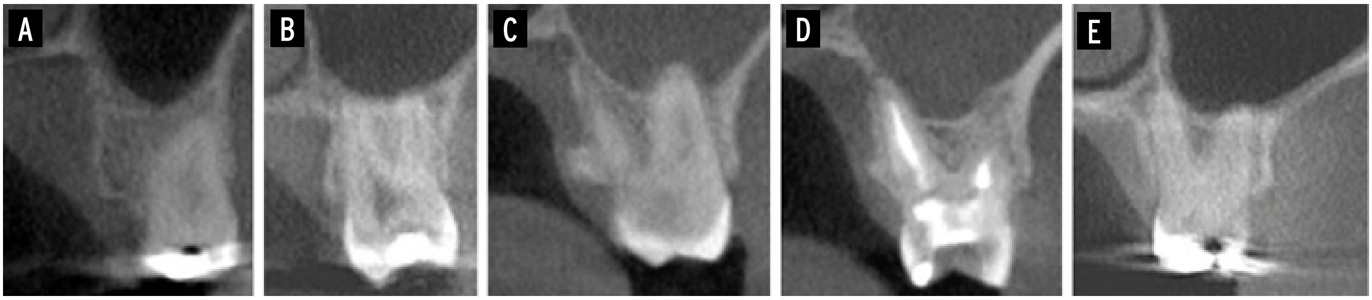


Figure 1
CBCT images exemplifying the different anatomic relationship between maxillary sinuses and molars.
A) Type I=maxillary sinus floor located above the buccal and palatal root apexes**; B)** Type II=maxillary sinus floor in contact with buccal and palatal root apexes; **C)** Type III=apical projection of one or two buccal roots into the sinus floor; **D)** Type IV=apical projection of palatal roots into the sinus floor; **E)** Type V=apical projection of the buccal and palatal roots into the sinus floor.

proportions of 0.0714 between groups. To that end, 660 teeth were needed. In the present study, 696 teeth were scanned, 600 had had no endodontic treatments, and 96 had been endodontically treated.
In the first analysis, we classified the images according to the tooth roots' proximity to the maxillary sinuses. Thus, patients' molars and premolars of the right and left hemi-faces were classified according to the study conducted by Kwak et al. (16). The molars were classified as: type I=maxillary sinus

Table 1

Vertical relationships between the sinus floor and the roots of the upper teeth

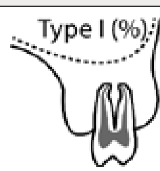
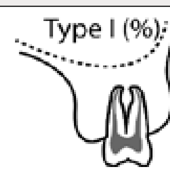
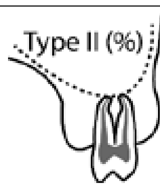
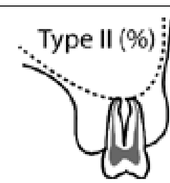
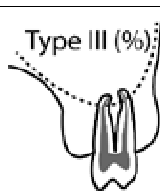
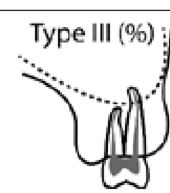
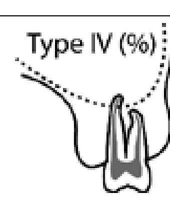
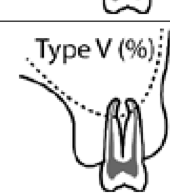
	Second premolars		First molars	Second molars
	112 (57.7)		63 (28)	92 (33.2)
	71 (36.5)		109 (48.4)	73 (26.3)
	11 (5.6)		28 (12.4)	95 (34.2)
	-		19 (8.4)	9 (3.2)
	-		6 (2.6)	8 (2.8)
Total	**194 (100%)**		**225 (100%)**	**277 (100%)**

Figure 2
CBCT images exemplifying the different anatomic relationship between maxillary sinuses and Second premolars. **A)** Type I=maxillary sinus floor located above the root apexes; **B)** Type II=maxillary sinus floor in contact with the root apexes; **C)** Type III=apical projection of the root into the sinus floor.

floor located above the buccal and palatal root apexes; type II=maxillary sinus floor in contact with buccal and palatal root apexes, but without projection of the roots into the floor of the sinus (laterally projected to the maxillary sinus); type III=apical projection of one or two buccal roots into the sinus floor; type IV=apical projection of palatal roots into the sinus floor, and type V=apical projection of the buccal and palatal roots into the sinus floor (Table 1, Figure 1).
For the second premolars, the classification was adapted as follows: type I=maxillary sinus floor located above the root apexes; type II=maxillary sinus floor in contact with the root apexes, but without apical projection into the sinus floor (roots laterally projected into the sinus); type III=apical projection of the root into the sinus floor (Table 1, Figure 2). For the evaluator's calibration, an intra-observer reliability analysis was performed using Weighted Cohen's Kappa coefficient of agreement until indexes above 0.9 were obtained.
A second analysis was performed using multiple logistic regression to determine the relationships between the thickening of the sinus mucosa and the distance from the root apex to the sinus floor, endodontic treatment, age, tooth, sex, and presence of periapical lesions. To that end, 96 teeth endodontically treated were assessed, and 52 untreated teeth from the initial sample of 600 teeth were selected at random. This way, the sample was composed of 139 molar roots endodontically treated, and 117 without previous endodontic treatments. The presence of

Table 2

Vertical relationships between the sinus floor, presence/absence of thickening, treatment, and roots of the upper teeth

	Type I	Type II	Type III	Type IV	Type V	Total
Second premolars (194)						
Treated (n)	24	16	4	-	-	44
Thickening (%)	13 (54.1)	4 (66.6)	1 (25)	-	-	18 (40.9)
Untreated (n)	88	55	7	-	-	150
Thickening (%)	20 (22.7)	13 (23.6)	1 (14.2)	-	-	34 (22.6)
First molars (225)						
Treated (n)	14	6	3	2	2	27
Thickening (%)	6 (42.8)	5 (83.3)	0 (0)	0 (0)	0 (0)	11 (40.7)
Untreated (n)	49	103	25	17	4	198
Thickening (%)	12 (24.4)	30 (29.1)	7 (28)	7 (41.17)	1 (25)	57 (28.78)
Second molars (277)						
Treated (n)	9	3	9	2	2	25
Thickening (%)	3 (33.3)	3 (100)	1 (11.1)	1 (50)	1 (50)	9 (36)
Untreated (n)	83	70	86	7	6	252
Thickening (%)	25 (30.1)	17 (24.2)	20 (23.25)	5 (71.42)	0 (0)	67 (26.5)

Table 3
Simple and multiple logistic regression of the association between the presence of maxillary sinus thickening and the explanatory variables

Explanatory variables	Non-adjusted odds ratio (95% CI)	*p*-value	Adjusted odds ratio (95% CI)	*p*-value
Age	1.0299 (1.00 to 1.06)	0.0222	1.0301 (1.00 to 1.06)	0.0442
Periapical Lesion				
Present	3.0612 (1.48 to 6.35)	0.0026	2.9951 (1.29 to 6.97)	0.0109
Absent	1		1	
Endodontic Treatment				
Present	1.7783 (0.85 to 3.72)	0.1257		
Absent	1			
Teeth				
Premolars	1.0417 (0.52 to 2.09)	0.9083		
First molars	1.2231 (0.60 to 2.51)	0.5827		
Second molars	0.7725 (0.37 to 1.63)	0.4984		
Anatomical classification	0.7361 (0.52 to 1.05)	0.0901		
Sex				
Male	3.4848 (1.72 to 7.07)	0.0005	5.1109 (2.29 to 11.41)	<0.0001
Female	1		1	

apical lesions was observed in 63 roots of teeth endodontically treated, and in one case of untreated teeth. In the premolar group, there were 43 roots with endodontic treatment, and 12 without endodontic treatment, with apical lesions in 27 and in one case, respectively. No extrusion of filling material was observed involving the root apexes.
The analyses of the present study's images were performed using the InVivoDental by Anatomage (Copyright 2005© Anatomage, USA, All Rights Reserved). The images were interpreted initially by doing a comprehensive observation of the area and selecting the area of higher proximity of the tooth apex with the maxillary sinus. Then three parasagittal sections with 1-mm interval difference between them were assessed for the data obtaining. A standard sequence for analysis was established, starting with the second premolar, then the first molar, and, finally, the second molar of one quadrant, and thus successively to the other quadrant.

Results

The vertical relationships between the roots of the posterior upper teeth and the sinus floor exhibited a predominance of type I among the second premolars, whereas, in the first and second molars, there was a predominance of type II and III, respectively (Table 1).
The logistic regression indicated that there were no significant relationships between the thickening of the sinus mucosa and the distance from the root apexes to the sinus floors (p=0.0901), presence of endodontic treatment (p=0.1257), and type of tooth (Premolars p=0.9083; First Molars p=0.5827; Second Molars p=0.4984).
The prevalence of teeth treated with thickening was 40.9% for second premolars, 40.7% for first molars, and 36% for second molars. Among the untreated teeth, the prevalence was 22.6% for second premolars, 28.7% for first molars, and 26.5% for second molars (Table 2).

The variables age (p=0.0442), presence of periapical lesions (p=0.0109), and sex (p<0.0001) were associated with the presence of sinus thickening, with odds ratios of 1.03, 2.99, and 5.11, respectively (Table 3).

Discussion

The proximity of the posterior upper teeth with the sinus floor was investigated in the present study indicating a possible pattern in which the more posterior the teeth are, the greater the probability of intimate contact of the roots with the maxillary sinus. The variables correlated with maxillary sinus thickening were analyzed, too, highlighting a predilection for male patients. The CBCT was used to assess the proximity of the posterior teeth roots to the maxillary sinus. This method provides dentists with more accurate information about the maxillary sinus than radiographic images, which exhibit low accuracy and tend to overestimate the roots' protrusion into the sinus (17-19). Our study's root classification was proposed by Kwak et al. (16) and cited in several studies (7, 20, 21).
Pagin et al. (22) found that the prevalence of root protrusion within the maxillary sinuses was 2.8% for premolars, 11.9% for first molars, and 23.2% for second molars, corroborating the findings of the present study, i.e., in second premolars, protrusion (type III) was observed in 5.6% of cases, for first molars in 12.4% (type III), and second molars in 34.2% (type III) of cases. Likewise, Kang et al. (23) demonstrated that the presence of protrusion of the roots into the sinuses was greater when they went towards the posterior region (first premolars=1.5%; second premolars=14.48%; first molars=40.5%; and second molars=44.77%). In the present study, most second premolars (57.7%) were classified as type I, most first molars (48.4%) as type II, and most second molars (34.2%) as type III. These results are in line with those found in other studies (21) that observed prevalence of type I in second premolars (52.9%) and type II in first and second molars (54.6 and 61.7%, respectively). These results show the proximity of the root apexes to the maxillary sinus. Because of that, the endodontist needs to avoid over instrumentation of root canals, extrusion of filling material and debris (24), which can lead to consequent communication with the maxillary sinus, and sinus mucosa inflammation, which can also occur in cases of inadvertent injection or extrusion of irrigants (25).
As for the presence of sinus thickening, we found a prevalence of 27.8%, which is a low percentage compared to those of other studies (26, 27). This fact can be explained by the difference in ethnicity and the methods used. Gürhan et al. (28) have shown that mucosal thickening is associated with periapical lesions in almost 50% of all mucosal thickening cases. This factor demonstrates the importance of collaboration among endodontists and otolaryngologists to provide successful treatment and prevent maxillary sinusitis's recurrence.
Nascimento et al. correlated the maxillary sinus's thickening with inadequate endodontic treatment, resulting in the variable's lack of significance (27). In our study, the presence of endodontic treatment was assessed in a general and independent way, regardless of being appropriate or inappropriate. The variable was also non-significant, which can be explained by the fact that although the quality of the treatment was not assessed, in this study, the majority of root canal treatment (55.20%) did not present the presence of periapical lesions associated with them (confirmed by Chi-Square test), demonstrating signs of successful treatments.
The distance from the apex of the sinus and the tooth type did not influence the sinus's thickening. Teeth with periapical lesions were more likely to exhibit thickening of the maxillary sinus, in line with other studies' results (2, 7, 29, 30). These factors demonstrate that the presence of thickening is not related to the proximity of the sinus or the type of tooth but the presence of infection.
These findings demonstrate the endodontist's need for attention in the treatment and follow up of upper posterior teeth since if they develop or have periapical lesions, they can be a risk factor to the development of maxillary thickening (31,

32). Age was also a factor correlated with thickening, showing that the older the patients are, the greater the chance of thickening, corroborating with previous studies (33, 34).

This factor can be explained by the literature, which shows that older patients are more susceptible to dental problems, such as cavities, periodontitis, and missing teeth (11), increasing the maxillary thickening probability.

Male patients were more likely to exhibit thickening of the maxillary sinus when compared to female patients, a fact also observed by later studies (27, 35, 36). Although the study did not collect habits data and is not the study's objective, based on previous studies, smoking rates among men vary between can 43.3% to 65.3% against 9.3% to 15.5% between women (37) since there is a positive association between sinusitis and cigarette smoking (38, 39) and this study have not excluded smokers patients, the authors of this study believe it can be an explanation to the results found in this research. Another possible explanation is that men have more dental disease that irritates the maxillary sinus membrane (28).

Conclusions

It is important to emphasize that only one observer analyzed the slices by only one reading which can be a limitation of our study. The second molars, followed by the first molars and then the second premolars, are the teeth that have shown the higher proximity with the maxillary sinus. A correlation between age, sex, and presence of periradicular lesions with thickening of the sinus mucosa was found.

Clinical Relevance

Identifying the proximity of the root apexes of posterior maxillary teeth to the maxillary sinus is clinically important before endodontic treatments. Recognizing the factors that can increase the chance of thickening of the maxillary sinus mucosa can potentially lead to more successful treatments.

Conflict of Interest

None.

Acknowledgments

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References

1 *Neelakantan Prasanna, Liu Pei, Dummer Paul M.H., McGrath Colman. Oral health–related quality of life (OHRQoL) before and after endodontic treatment: a systematic review. Clin Oral Investig 2020;24:25-36.*
2 *Peñarrocha-Oltra Sonia, Soto-Peñaloza David, Bagán-Debón Leticia, Bagán-Sebastián José V., Peñarrocha-Oltra David. Association between maxillary sinus pathology and odontogenic lesions in patients evaluated by cone beam computed tomography. A systematic review and meta-analysis. Med Oral Patol Oral y Cir Bucal. 2020;25: 34-48.*
3 *Fry RameshRam, Patidar DineshChand, Goyal Samta, Malhotra Aayush. Proximity of maxillary posterior teeth roots to maxillary sinus and adjacent structures using Denta scan®. Indian J Dent. 2016;7:126.*
4 *Tian Xiao Mei, Qian Liang, Xin Xian Zhen, Wei Bin, Gong Yao. An analysis of the proximity of maxillary posterior teeth to the maxillary sinus using cone-beam computed tomography. J Endod. 2016;42:371-7.*
5 *Wolf Marius Karl, Rostetter Claudio, Stadlinger Bernd, Locher Michael, Damerau Georg. Preoperative 3D imaging in maxillary sinus: Brief review of the literature and case report. Quintessence Int (Berl). 2015;46:627-31.*
6 *Costa F. F.N.P., Pacheco-Yanes J., Siqueira J. F., et al. Association between missed canals and apical periodontitis. Int Endod J. 2019;52:400-6.*
7 *Sakir Merve, Ercalik Yalcinkaya Sebnem. Associations between Periapical Health of Maxillary Molars and Mucosal Thickening of Maxillary Sinuses in Cone-beam Computed Tomographic Images: A Retrospective Study. J Endod. 2020;46:397-403.*
8 *Workman Alan D., Granquist Eric J., Adappa Nithin D. Odontogenic sinusitis: Developments in diagnosis, microbiology, and treatment. Curr Opin Otolaryngol Head Neck Surg. 2018;26:27-33.*
9 *Lechien Jerome R., Filleul Olivier, Costa de Araujo Pedro, Hsieh Julien W., Chantrain Gilbert, Saussez Sven. Chronic Maxillary Rhinosinusitis of Dental Origin: A Systematic Review of 674 Patient Cases. Int J Otolaryngol. 2014.*
10 *Vestin Fredriksson Malin, Öhman Anders, Flygare Lennart, Tano Krister. When Maxillary Sinusitis Does Not Heal: Findings on CBCT Scans of the Sinuses With a Particular Focus on the Occurrence of Odontogenic Causes of Maxillary Sinusitis. Laryngoscope Investig Otolaryngol. 2017;2:442-6.*

11 Aksoy Umut, Orhan Kaan. Association between odontogenic conditions and maxillary sinus mucosal thickening: a retrospective CBCT study. Clin Oral Investig. 2019;23:123-31.
12 Wuokko-Landén Annina, Blomgren Karin, Välimaa Hannamari. Acute rhinosinusitis–are we forgetting the possibility of a dental origin? A retrospective study of 385 patients. Acta Otolaryngol. 2019;139:783-7.
13 Gu Yechen, Sun Chao, Wu Daming, Zhu Qingping, Leng Diya, Zhou Yang. Evaluation of the relationship between maxillary posterior teeth and the maxillary sinus floor using cone-beam computed tomography. BMC Oral Health. 2018;18:1-7.
14 Faul Franz, Erdfelder Edgar, Lang Albert Georg, Buchner Axel. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav. Res. Methods. 2007;39:175-91.
15 Jang J. K., Kwak S. W., Ha J. H., Kim H. C. Anatomical relationship of maxillary posterior teeth with the sinus floor and buccal cortex. J Oral Rehabil. 2017;44:617-625.
16 Kwak H. H., Park H. D., Yoon H. R., Kang M. K., Koh K. S., Kim Hee Jin. Topographic anatomy of the inferior wall of the maxillary sinus in Koreans. Int J Oral Maxillofac Surg. 2004;33:382-8.
17 Sun Wentian, Xia Kai, Tang Li, Liu Chenlu, Zou Ling, Liu Jun. Accuracy of panoramic radiography in diagnosing maxillary sinus-root relationship: A systematic review and meta-analysis. Angle Orthod. 2018;88:819-29.
18 Niknami Mahdi, Mirmohammadi Mahdi, Pezeshki Azade. Evaluation of the Prevalence of Mucous Retention Pseudocyst and its Correlation with the Associated Risk Factors Using Panoramic Radiography and Cone-Beam Computed Tomography. J Dent (Tehran). 2018;15:123-9.
19 Toraman M, Peker I, Degerli S, Ilker A. Comparison of Cone-Beam Computed Tomography and Panoramic. Rev Instanbul Univ Odontol. 2016;50:8-14.
20 Zhang Xi, Li Yan, Zhang Yi, et al. Investigating the anatomical relationship between the maxillary molars and the sinus floor in a Chinese population using cone-beam computed tomography. BMC Oral Health. 2019;19:1-8.
21 Razumova Svetlana, Brago Anzhela, Howijieh Ammar, Manvelyan Ashot, Barakat Haydar, Baykulova Malina. Evaluation of the relationship between the maxillary sinus floor and the root apices of the maxillary posterior teeth using cone-beam computed tomographic scanning. J Conserv Dent. 2019;22:139-143.
22 Pagin Otávio, Centurion Bruna Stuchi, Rubira-Bullen Izabel Regina Fischer, Alvares Capelozza Ana Lúcia. Maxillary sinus and posterior teeth: Accessing close relationship by cone-beam computed tomographic scanning in a Brazilian population. J Endod. 2013;39:748-51.
23 Kang Sung Hyun, Kim Bom Sahn, Kim Yemi. Proximity of posterior teeth to the maxillary sinus and buccal bone thickness: A biometric assessment using cone-beam computed tomography. J Endod. 2015;41:1839-46.
24 Dobroś Katarzyna, Zarzecka Joanna. Dental assessment of odontogenic maxillary sinusitis, aided by Cone Beam Computed Tomography. Folia Med Cracov. 2020;60:85-96.
25 Laverty Dominic Peter. A case report of accidental extrusion of sodium hypochlorite into the maxillary sinus during endodontic retreatment and review of current prevention and management. J Restor Dent. 2014;2:96.
26 Lu Yu, Liu Zhongjun, Zhang Lan, et al. Associations between maxillary sinus mucosal thickening and apical periodontitis using cone-beam computed tomography scanning: A retrospective study. J Endod. 2012;38:1069-74.
27 Nascimento Eduarda Helena Leandro, Pontual Maria Luiza A., Pontual Andrea A., Freitas Deborah Q., Perez Danyel E.Cruz, Ramos-Perez Flávia M.M. Association between Odontogenic Conditions and Maxillary Sinus Disease: A Study Using Cone-beam Computed Tomography. J Endod. 2016;42:1509-15.
28 Gürhan C., Şener E., Mert A., Şen G. B. Evaluation of factors affecting the association between thickening of sinus mucosa and the presence of periapical lesions using cone beam CT. Int Endod J. 2020;53:1339-47.
29 Tassoker Melek. What are the risk factors for maxillary sinus pathologies? A CBCT study. Oral Radiol. 2020;36:80-4.
30 Nunes Carla A.B.C.M., Guedes Orlando Aguirre, Alencar Ana Helena G., Peters Ove A., Estrela Cyntia R.A., Estrela Carlos. Evaluation of Periapical Lesions and Their Association with Maxillary Sinus Abnormalities on Cone-beam Computed Tomographic Images. J Endod. 2016;42:42-6.
31 Eggmann Florin, Connert Thomas, Bühler Julia, Dagassan-Berndt Dorothea, Weiger Roland, Walter Clemens. Do periapical and periodontal pathologies affect Schneiderian membrane appearance? Systematic review of studies using cone-beam computed tomography. Clin Oral Investig. 2017;21:1611-30.
32 Shanbhag Siddharth, Karnik Prabodh, Shirke Prashant, Shanbhag Vivek. Association between periapical lesions and maxillary sinus mucosal thickening: A retrospective cone-beam computed tomographic study. J Endod. 2013;39:853-7.
33 Huang Yen Ting, Hu Suh Woan, Huang Jing Yang, Chang Yu Chao. Assessment of relationship between maxillary sinus membrane thickening and the adjacent teeth health by cone-beam computed tomography. J Dent Sci. 2021;16:275-9.
34 Zhang Bo, Wei Yiping, Cao Jie, et al. Association between the dimensions of the maxillary sinus membrane and molar periodontal status: A retrospective CBCT study. J Periodontol. 2020;91:1429-35.
35 Hirsch Annemarie G., Nordberg Cara, Bandeen-Roche Karen, et al. Radiologic sinus inflammation and symptoms of chronic rhinosinusitis in a population-based sample. Allergy.2020;75:911-920.
36 Ren Song, Zhao Haijiao, Liu Jingbo, Wang Qingxuan, Pan Yaping. Significance of maxillary sinus mucosal thickening in patients with periodontal disease. Int Dent J. 2015;65:303-10.
37 Gilmore A, Pomerleau J, McKee M, Rose R, Haerpfer CW, Rotman D, Tumanov S. Prevalence of smoking in 8 countries of the former Soviet Union: results from the living conditions, lifestyles and health study. Am J Public Health. 2004;94:2177-87.
38 Douglas D. Reh, Thomas S. Higgins and Timothy L. Smith. Impact of tabacco smoke on chronic rhinosinusitis. Int Forum Allergy Rhinol. 2013;2:362-9.
39 Lieu Judith E.C., Feinstein Alvan R. Confirmations and surprises in the association of tobacco use with sinusitis. Arch Otolaryngol - Head Neck Surg. 2000;126:940-6.

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ORIGINAL ARTICLE

Effect of different methods of fiber post cleaning on post resistance to dislodgement from the root canal

ABSTRACT

Aim: *To evaluate the effect of different methods of fiber post cleaning on post resistance to dislodgement after cementation.*
Methodology: *Sixty bovine incisors were divided into six groups according to the cleaning method applied to the fiber posts. GC: no cleaning; GES: autoclave sterilization; GHP: 2.5% sodium hypochlorite; GCL: 2% chlorhexidine digluconate; GAL: 70% alcohol; GAF: 35% phosphoric acid. The posts were cemented in the canals using a self-adhesive resin cement. The specimens were sectioned perpendicularly along the long axis of the root with an average thickness of 1.61 mm at the cervical, middle, and apical root thirds and subjected to the push-out test. After the test, they were examined under a stereomicroscope to determine failure mode. Data were analyzed using one-way ANOVA and the Tukey test (α=0.05).*
Results: *The comparisons with the GC group revealed statistical differences only in the middle and apical thirds of the GCL group and in the apical third of the GHP group. Only the apical thirds were different from the middle and cervical thirds in the GC group, and the cervical thirds, from the middle and apical thirds of the GES group.*
Conclusions: *The resistance to dislodgement of fiber posts cemented in root canals was not affected by the different cleaning methods under study.*

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Introduction

Resources for a direct restoration of weakened and endodontically treated teeth include fiber posts, which have an elasticity module similar to that of dentin, and restorative materials (1, 2). The cementation protocols for this type of post include numerous pre-placement clinical procedures, of which the operator should have a sound knowledge and technical mastery, conducted under strict biosafety control. Handling and clinical adjustment of the post by the manufacturer or the dentist without proper biosafety care before cementation may result in the accumulation of microorganisms on the surface of the post, which may initiate and perpetuate contamination of the root canal system (3). Correct cleaning of the post before cementation reduces the risk of reinfection and endodontic treatment failure.

Although fiber posts are manufactured under aseptic conditions, they can be contaminated through manual contact, or by aerosols. Furthermore, in routine clinical procedures, it may be necessary to change the size of the fiber post that has been tried in a root canal. Therefore, cleaning is required to use the fiber post again (4). Some substances such as sodium hypochlorite (5) and chlorhexidine (6) may be used to clean intraradicular posts. They are excellent antimicrobial irrigants to be used during endodontic treatments. Alcohol, already used to clean posts before cementation, also has a bactericidal and virucidal action against certain strains (7). Phosphoric acid, in contrast, reduces the microbial load on surfaces, but does not eliminate it completely (8). However, no studies have yet examined whether the use of these substances has any deleterious effects, such as the presence of residual oxygen, the formation of precipitates, or changes in the surface roughness of posts, which may compromise the adhesive bonding of posts cemented in root canals. There are only studies that directly assess the effect of these substances on the dentin substrate (9-11).

This study evaluated the effect of different methods of fiber post cleaning on post resistance to dislodgement after cementation. The null hypothesis is that the different methods of fiber post cleaning do not cause changes in the bond strength of fiberglass posts within the intraradicular dentin.

Materials and Methods

Sample selection and preparation

This study included 60 bovine primary incisors with root canals that had an apical diameter equivalent to that of a #20 K-file (Dentsply/Maillefer Instruments S.A., Ballaigues, Switzerland). After cleaning, the teeth had their crowns sectioned at the cementoenamel junction using a low-speed carbide disc. Roots were standardized to a length of 17 mm, and working length (WL) was set at 1 mm short of root length (WL=16 mm). All samples were prepared manually with first and second series K-type stainless steel endodontic instruments (Dentsply/Maillefer Instruments S.A., Ballaigues, Switzerland). Chemomechanical preparation was carried out in the following sequence of K-type instruments: #20, #25, #30, #35, #40, and #45 (Dentsply/Maillefer Instruments S.A., Ballaigues, Switzerland). All instruments were used along the WL.

At each instrument change, the canals were irrigated with 2 mL of 2.5% sodium hypochlorite (Iodontec Indústria e Comércio de Produtos Odontológicas Ltda., Porto Alegre, Brazil) using a plastic syringe (BD Solumed, São Paulo, Brazil) and 25-mm 30-ga NaviTip needles (Ultradent, Indaiatuba, Brazil).

After the preparation, the canals were irrigated with 17% trisodium EDTA (Biodinamica, Ibiporã, Brazil) for three minutes under agitation using #45 files. After that, they were rinsed with distilled water (Iodontosul-Industrial Odontológica do Sul LTDA, Porto Alegre, Brazil) and dried with absorbent paper cones (Tanari Indústria Ltda., Manaus, Brazil).

All canals were filled with gutta-percha cones and a resin-based sealer (AH Plus®,

Table 1
Experimental groups

Groups	n	Disinfection method
GC	10	None
GES	10	Autoclave sterilization
GHP	10	2.5% sodium hypochlorite (Iodontosul, Industrial Odontológica do Sul LTDA, Porto Alegre, Brazil)
GCL	10	2% chlorhexidine digluconate (Maquira Indústria de Produtos Odontológicos S.A., Maringá, Brazil)
GAL	10	70% alcohol (LBS Laborasa Indústria Farmacêutica Ltda., São Paulo, Brazil)
GAF	10	35% phosphoric acid (FGM, Joinville, Brazil)

Table 2
Disinfectants and application method according to fiber post group

Groups	Disinfectant	Application method
GHP	2.5% sodium hypochlorite	Posts were immersed in 10 mL of the solution
GCL	2% chlorhexidine digluconate	Posts were immersed in 10 mL of the solution
GAL	70% alcohol	Posts were immersed in 10 mL of the solution
GAF	35% phosphoric acid	Gel was applied to posts in a Petri dish

Dentsply/Maillefer Instruments SA, Ballaigues, Switzerland) using a #60 McSpadden® condenser (Dentsply/Maillefer Instruments SA, Ballaigues, Switzerland) and the hybrid technique developed by Tagger. All samples were restored using a temporary filling paste (Cimpat®, Septodont, Saint-Maur-des-Fossés, France) and then kept in distilled water for two days until the paste set completely.
After that, the canals were cleaned with 2 mL of distilled water and dried with absorbent paper points (Dentsply Maillefer Instruments SA, Ballaigues, Switzerland) to prepare the space for the post to be cemented.
The drill that comes with the post and has the same diameter was used to remove 13 mm of the obturation, leaving 3 mm of apical sealing.

Division of experimental groups
The teeth were divided into six groups (Table 1), using simple random sampling and the Excel software (Microsoft Excel, Microsoft Corporation, Redmond, WA).

Protocols for fiber post cleaning
Sixty #1 tapered Exacto® fiber posts (Angelus, Londrina, Brazil) were used in the study (10 per group). The posts in GC did not receive any antimicrobial treatment. The samples in GES were sterilized in an autoclave: they were placed in a sterilization pouch (Medstéril, São Paulo, Brazil), sealed using a sealing machine (RSR 2000, RON Micromecânica Ltda., São Paulo, Brazil) and placed in a Vitale 12 autoclave (Cristófoli, Curitiba, Brazil) for a 40-minute cycle at a temperature of 240 ºF (126 ºC) and 20 psi of pressure.
The posts in GHP, GCL, GAL and GAF were kept in contact with the disinfectant for 5 minutes (Table 2). After that, all were rinsed with 20 mL of saline and dried at room temperature.

Post cementation and specimen preparation
All posts were cemented according to the manufacturer's directions. An adhesive (Single Bond Universal®, 3M ESPE, St Paul, MN) was applied to the posts for 20 seconds using a microbrush, and posts

Table 3
Bond strength values in the push-out test according to root thirds in the different groups

Experimental Group	Root thirds			P
	Cervical	Middle	Apical	
	MPa (± SD)	MPa (± SD)	MPa (± SD)	
GC	9.87[Aa] ± (4.18)	6.89[Aab] ± (3.30)	4.37[Ab] ± (4.42)	P<0.05
GES	12.12[Aa] ± (3.28)	9.28[ABb] ± (3.01)	7.66[ABb] ± (2.40)	P<0.05
GHP	10.5[Aa] ± (2.56)	10.17[ABa] ± (3.71)	9.96[Ba] ± (4.62)	P=0.949
GCL	11.29[Aa] ± (2.56)	13.46[Ba] ± (6.06)	10.23[Ba] ± (4.80)	P=0.309
GAL	10.64[Aa] ± (3.53)	11.53[ABa] ± (4.46)	8.96[ABa] ± (4.40)	P=0.386
GAF	11.96[Aa] ± (4.43)	10.29[ABa] ± (3.83)	8.29[ABa] ± (4.08)	P=0.158
P	**P=0.676**	**P<0.05**	**P<0.05**	

Means followed by different uppercase letters in the column and means followed by different lowercase letters in the line differ significantly in the analysis of variance at the 5% significance level.

were then dried with air spray for 5 seconds. The posts were cemented using a self-adhesive resin cement (RelyX U200®, 3M ESPE, St. Paul, MN) applied to the root canal with a syringe (Sistema Centrix, DFL, Rio de Janeiro, Brazil) and a fine metal tip to fill the 13 mm of unobstructed canal. The posts were inserted into the root canal and light-cured using an EC450 unit (ECEL, Ribeirão Preto, Brazil) at an irradiance greater than 400 mW/cm^2 for 20 seconds; chemical curing took six more minutes.
The roots were kept in distilled water after cementation, and, 15 days later, were sectioned perpendicularly along the long axis of the root in three 1.61-mm ± 0.30-mm-thick slices using a diamond saw (Labcut 1010, Extec Corp., Enfield, CT). The slices were standardized to 4 mm in the cervical third, 8 mm in the middle third and 12 mm in the apical third (Figure 1). They were labeled and stored in an oven at 37° C and 100% relative humidity for seven days.

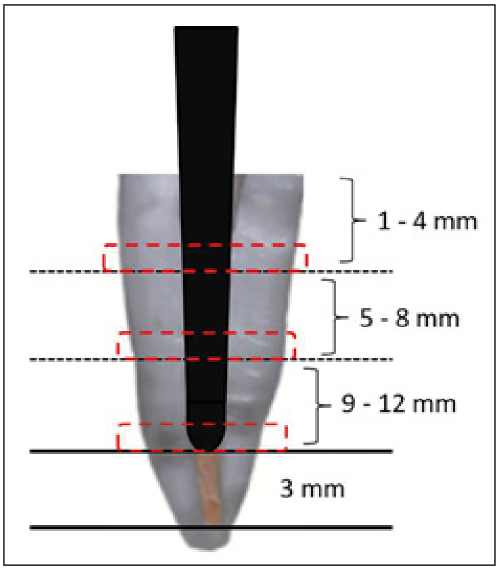

Figure 1
Schematic diagram of root slices.

Push-out test
The specimens were placed on a stainless steel support that had a central perforation 2 mm in diameter. As the posts were conical, the load was applied to the apex in the direction of the cervical third, so that the post was pushed towards the widest portion of the root canal.
The load was applied only to the post surface using a pin measuring about 1 mm in diameter in a universal testing machine (EZ-SX, Shimadzu, Kyoto, Japan). The load cell was 500 N, and the crosshead speed, 1 mm/min. The values were recorded in N and later converted to MPa.
The internal upper and lower diameters of the canal and the thickness of the sections (cone trunk area) were measured to estimate the canal area used for the calculation of bond strength values.

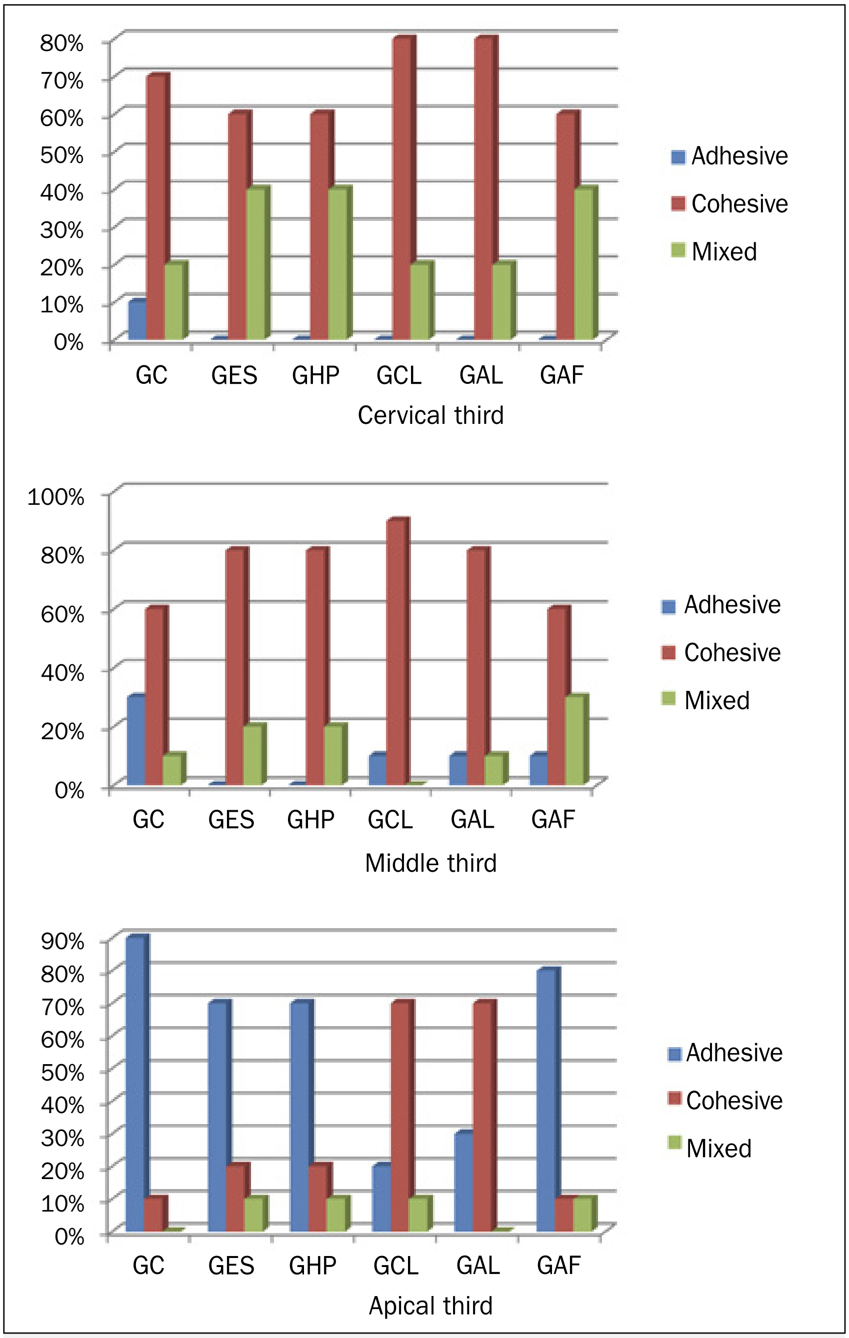

Figure 2
A graph showing failure patterns (%) after tested protocols.

After the push-out test, the fractured specimens were analyzed under an X20 stereomicroscope (Stemi 2000, Karl Zeiss, Germany) to determine the adhesive, cohesive, or mixed failure pattern.

Statistical analysis
The Shapiro-Wilk test was used to check for data normality. One-way ANOVA and the Tukey test for multiple comparisons were used to analyze the results of resistance to dislodgement. The level of significance was set at 5% ($P \leq 0.05$). Statistical analyses were performed using the GraphPad Prism 7 program (GraphPad Software Inc., San Diego, CA).

Results

Mean values of resistance to dislodgement (MPa) in the different groups and canal thirds are shown in Table 3. There was a statistical difference between the GC group and the groups disinfected with chlorhexidine (GCL) in the middle and apical thirds and with sodium hypochlorite (GHP) in the apical third. The comparisons of canal thirds in each group revealed a statistical difference only in GC when the apical third was compared with the middle and cervical thirds, and GES, in the comparisons of cervical thirds with the middle and apical thirds.
Graph in figure 2 shows the percentage of failure in the samples for each root third. There was a higher percentage of cohesive failures in the cervical and middle thirds in all groups. However, most failures in the apical third were of the adhesive type at the post-cement interface, except in GCL and GAL, in which samples had a higher percentage of cohesive failures.

Discussion

In the analysis of factors that may determine the endodontic and restorative success of a tooth, one must take into account, in addition to the choice of the best material to functionally and aesthetically replace the lost structure, the decontamination of this material before being inserted into the root canal. It is prudent to have a biosafety protocol on intraradicular pins so that they are effective in their functions and that at the same time they do not recontaminate the canal.
Although some disadvantages have been reported in the literature, such as the

distribution of non-uniform tensions, the push-out test was chosen in this study because it is more reliable than other techniques for the evaluation of resistance to dislodgement of fiber posts from root canal dentin (12). All root thirds were tested to understand, after excluding other variables, the mechanism of changes during the interaction between the post and the cement. According to the results obtained, the null hypothesis of the present study was accepted, the methods used to clean posts did not have a negative effect on the resistance to dislodgement of fiber posts cemented in root canals. In fact, the comparison of the GC group with the other groups revealed a statistically significant increase in bond strength in the middle and apical thirds of GCL, and in the apical third of GHP. So far, studies in the literature have only investigated the treatment of dentin surfaces with disinfectants and their effect on cemented posts. Although treatments applied to dentin cannot be compared with dentin treatments, their results revealed some differences. The use of chlorhexidine as a root canal irrigant before post cementation seems to increase the bond strength of the posts. Farina et al (13) found that the bond strength of a self-etching adhesive to dentin was greater in the group that received 2% chlorhexidine followed by 17% EDTA as intracanal irrigation than in the groups that was irrigated with different concentrations of sodium hypochlorite. Durski et al (14), in a study that pretreated all samples with 2% chlorhexidine, found that the posts cemented with the RelyX Unicem® self-adhesive system had greater bending forces in all thirds than those that received the RelyX ARC® total-etch cement, in both immediate and long-term analyses. According to a study analyzing the use of sodium hypochlorite conducted by Ertas et al (15), 5 mL of 5.25% sodium hypochlorite for five minutes in the root canal prepared to receive a post did not decrease the bond strength of the cemented post. Cecchin et al (16) found that sodium hypochlorite does not affect post bond strength immediately after bonding and for 12 months.

Sterilization is the best resource to eliminate all forms of microorganisms (17). Post sterilization in an autoclave did not affect the bond strength of post to root canal. Yagci et al (4) analyzed the effect of sterilization using ethylene oxide and autoclave sterilization on the tensile strength, flexion and elasticity modulus of fiber posts. Results revealed that that type of sterilization did not affect the three criteria negatively, which somewhat corroborates our findings. In contrast, Canelas et al (18) found that autoclave sterilization and the application of a disinfectant containing glutaraldehyde resulted in a statistically significant decrease in fiber post strength and a greater risk of fracture than in the control group. According to those authors, the exposure to high-pressure steam during autoclave sterilization might compromise the physical properties of the fiber posts because of the degradation of the bond between the resin matrix and the fibers. According to their manufacturer's instructions, Exacto® posts may be autoclaved up to two times, as more times may affect the strength of their material. In addition, questions remain about how long a patient should wait for autoclave sterilization to be completed. Posts should be disinfected before intraradicular cementation, as well as after their necessary adjustment to the tooth structure. Posts are adjusted to the desired length usually using drills and tips at high rotation under refrigeration. Therefore, there is a considerable increase in clinical time when transoperative autoclave sterilization is used, and this time should be included in treatment plans.

Cleaning with alcohol and phosphoric acid did not compromise post bond strength in the canal. Many manufacturer's protocols for the cementation of fiber posts call for cleaning the posts with alcohol before the application of silane to degrease their surface, and not to disinfect them. According to the Center of Diseases Control and Prevention, 70% alcohol is an intermediate level germicide (19). In our study, the posts were immersed in alcohol for five minutes for cleaning, and this clinical protocol seems to suggest that post bond strength in the canal is not compromised. The five-minute immersion time was defined to standardize all study protocols.

Moreover, alcohol is a volatile substance and would have to be replaced if a longer time had been used. Baldissera et al (20) found that 70% alcohol remained active and eliminated all microorganisms on periapical radiographic film when a minimum immersion time of three minutes was used. The application of phosphoric acid to post surfaces improves the chemical interaction between the post surface and the restorative material (21, 22). However, the decrease in adhesive strength of intraradicular posts seems to be associated with the degradation of dentin collagen fibrils after intracanal acid etching (23). In our study, phosphoric acid was applied to the fiber post to reduce superficial microbial contamination (8), and post bond strength in the canal was not affected. Albashaireh et al (24) found that pretreating fiber posts with 37% phosphoric acid for 15 seconds had no significant effect on fiber post resistance to dislodgement.

The comparison of resistance to dislodgement of cemented posts from root thirds revealed differences in the thirds closest to the root apex from those located in the cervical third only in GC and GES. This finding is in accordance with reports in the literature (25, 26). Durski et al (14) also found that the use of total etching and self-adhesive resin cements resulted in higher fiber post bond strength in the cervical third, whereas the apical third had significantly lower push-out values. Root dentin has morphological differences along the canal (27), as the density of dentinal tubules is reduced (28) and its diameter is smaller (29) in the apical region, which may justify the difference between root thirds. The other groups did not show any differences in bond strength between the root thirds, although their values (Table 3) decreased from the cervical to the apical third. In the studies conducted by Faria and Silva et al (30), with fiber posts, and by Kahnamouei et al (31), with quartz posts, resistance to dislodgement was the same in the comparisons between root thirds. In both studies, the posts were cemented in the root canal with self-adhesive systems.

The analysis of predominant failure mode revealed a higher percentage of cohesive failures in the middle and cervical thirds than of mixed and adhesive failures in all groups. These results are in agreement with findings by Lindblad et al (32), who evaluated the effect of chlorhexidine as a root canal irrigant before fiber posts were cemented using different types of cements. They found that chlorhexidine had no negative effect on the resistance to dislodgement of cemented posts. In contrast, the examination of the apical third in our study revealed a predominance of adhesive failures, except in the groups of samples disinfected with alcohol and chlorhexidine, which had a higher percentage of cohesive failures. Lindblad et al (32) also found a higher percentage of cohesive and mixed failures, except in the group that received everStickPOST for cementation and chlorhexidine as an intracanal irrigant. No plausible explanation was found in the literature for the fact that cohesive failures were predominant in the apical third when these substances were used.

The use of a disinfectant on the fiberglass posts before their cementation in the root canal is necessary to ensure the biosafety of the operative field. Our study found that bond strength of posts cemented in the canal was not affected by the cleaning methods under evaluation. However, further studies should examine other clinical protocols with varying disinfectant concentrations and times to evaluate whether they affect post properties and function after restorations.

Conclusions

The cleaning methods examined in this study did not have a negative effect on the resistance to dislodgement of fiber posts cemented in the root canal.

Clinical Relevance

The cleaning methods examined not influence intraradicular posts adhesion.

Conflict of Interest

The authors declares that there is no conflict of interest.

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References

1 Schwartz RS, Robbins JW. Post placement and restoration of endodontically treated teeth: a literature review. J Endod. 2004;30:289-301.
2 Al-Omiri MK, Mahmoud AA, Rayyan MR, et al. Fracture resistance of teeth restored with post-retained restorations: an overview. J Endod. 2010;36:1439-49.
3 Berger CR, Cavina DA. Pinos intrarradiculares não metálicos. In: Gomes JC et al. Estét Clín Odontol. 1 ed. Curitiba: Ed Maio. V 1, p. 395-426, 2004.
4 Yagci F, Ustun Y, Zortuk M, et al. Effect of sterilization on bond strength and mechanical properties of fiber posts. J Adhes Dent. 2019;21:143-148.
5 Gazzaneo I, Vieira GCS, Pérez AR, et al. Root canal disinfection by single- and multiple- instrument systems: effects of sodium hypochlorite volume, concentration, and retention time. J Endod. 2019;45:736-741.
6 Zandi H, Rodrigues RC, Kristoffersen AK, et al. Antibacterial effectiveness of two root canal irrigants on root-filled teth with infection: a randomized clinica trial. J Endod. 2016;42:1307-13.
7 Venturelli AC, Torres FC, Rodrigues RAP, et al. Avaliação microbiológica da contaminação residual em diferentes tipos de alicates ortodônticos após desinfecção com álcool 70%. Rev Dent Press Ortodon Ortop Facial. 2009;14:43-52.
8 Luglié PF, Delitala PP, Zanetti S, et al. An in vivo bacteriological study on the effects of acid etching at the bottom of cavities. Minerva Stomatol. 1998;47:19-26.
9 Breschi L, Gobbi P, Falconi M, et al. Effect of dentinal pretreatments on coronal dentin primary carious lesions: a field emission SEM study. Clin Oral Investig. 2003;7:140-7.
10 Gandolfi MG, Taddei P, Pondrelli A, et al. Demineralization, collagen modification and remineralization degree of human dentin after EDTA and citric acid treatments. Materials (Basel). 2018;12:25.
11 Suzuki TYU, Pereira MA, Gomes Filho JE, et al. Do irrigation solutions influence the bond interface between glass fiber posts and dentin? Braz Dent J. 2019;30:106-116.
12 Goracci C, Sadek FT, Monticelli F, et al. Influence of substrate, shape, and thickness on microtensile specimens' structural integrity and their measured bond strengths. Dent Mater. 2004;20:643-54.
13 Farina AP, Cecchin D, Barbizam JV, et al. Influence of endodontic irrigants on bond strength of a self-adhesive. Aust Endod J. 2011;37:26-30.
14 Durski M, Metz M, Crim G, et al. Effect of chlorhexidine treatment prior to fiber post cementation on long-term resin cement bond strength. Oper Dent. 2018;43:E72-E80.
15 Ertas H, Ok E, Uysal B, et al. Effects of diferente irrigating solutions and disinfection methods on push-out bond strengths of fiber posts. Acta Odontol Scand. 2014;72:783-7.
16 Cecchin D, Almeida JF, Gomes BP, et al. Deproteinization technique stabilizes the adhesion of the fiberglass post relined with resin composite to root canal. J Biomed Mater Res B Appl Biomater. 2012;100:577-83.
17 Rutala WA. APIC guideline for selection and use of disinfectants. 1994, 1995, and 1996 APIC Guidelines Committee. Association for professional in infection control and epidemiology, Inc. Am J I nfect Control. 1996;24:313-42.
18 Canelas R, Salgado H, Vaz M, et al. Flexural strength of glass fiber posts after sterilization by two different methods. Rev Port Estomatol Med Dent Cir Maxilofac. 2014;55:227-231.
19 Rutala WA, Weber DJ, HICPAC. Guideline for disinfection and sterilization in healthcare facilities, 2008.
20 Baldissera EZ, Fontanella V, Torriani MA. Avaliação da desinfecção de filmes radiográficos periapicais utilizando diferentes soluções. Rev Odonto Ciênc. 2006;21:153-7.
21 Valandro LF, Yoshiga S, de Melo RM, et al. Microtensile bond strength between a quartz fiber post and a resin cement: effect of post surface conditioning. J Adhes Dent. 2006;8:105-11.
22 Monticelli F, Osorio R, Sadek FT, et al. Surface treatments for improving bond strength to prefabricated fiber posts: a literature review. Oper Dent. 2008;33:346-55.
23 Malacarne J, Carvalho RM, de Goes MF, et al. Water sorption/solubility of dental adhesive resins. Dent Mater. 2006;22:973-80.
24 Albashaireh ZS, Ghazal M, Kern M. Effects of endodontic post surfasse treatment, dentin conditioning, and artificial aging on the retention of glass fiber-reinforced composite resin posts. J Prosthet Dent. 2010;103:31-9.
25 Zicari F, De Munck J, Scotti R, et al. Factors affecting the cement-post interface. Dent Mater. 2012;28:287-97.
26 Chang HS, Noh YS, Lee Y, et al. Push-out bond strengths of fiber-reinforced composite posts with various resin cements according to the root level. J Adv Prosthodont. 2013;5:278-286.
27 Mumcu E, Erdemir U, Topcu FT. Comparison of micro push-out bond strengths of two fiber posts luted using simplified adhesive approaches. Dent Mater J. 2010;29:286-96.
28 Akgungor G, Akkayan B. Influence of dentin bonding agentes and polymerization modes on the bond strength between translucent fiber posts and three dentin regions within a post space. J Prosthet Dent. 2006;95:368-78.
29 Ferrari M, Mannocci F, Vichi A, et al. Bonding to root canal: structural characteristics of the substrate. Am J Dent. 2000;13:255-60.
30 Faria-e-Silva AL, Menezes MS, Silva FP, et al. Intra-radicular dentin treatments and retention of fiber posts with self-adhesive resin cements. Braz Oral Res. 2013;27:14-9.
31 Kahnamouei MA, Mohammadi N, Navimipour EJ, et al. Push-out bond strength of quartz fibre posts to root canal dentin using total-etch and self-adhesive resin cements. Med Oral Patol Oral Cir Bucal. 2012;17:337-44.
32 Lindblad RM, Lassila LV, Salo V, et al. Effect of chlorhexidine on initial adhesion of fiber-reinforced post to root canal. J Dent. 2010;38:796-801.

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ORIGINAL ARTICLE

Accuracy of a minimally invasive surgical guide in microsurgical endodontics: a human cadaver study

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ABSTRACT

Aim: *In the last decade, endodontic microsurgery has achieved high qualitative standards and excellent success rates. Technology and highly innovative materials have reduced pre- and intra-surgical complexity. To date, operator experience continues to be an important prognostic factor. This study aimed to evaluate the accuracy of root resections achieved by two operators with different experience in endodontic microsurgery using a surgical guide.*
Methodology: *A comparative study was conducted on 40 roots (20 roots/operator) in two defrosted cadaver heads. Preoperative CBCT and intraoral scans were used to plan and manufacture a bony-supported surgical guide equipped with oriented steel sleeves and buccal flanges. Two operators with different levels of endodontic skills and abilities executed osteotomies and root resections. Planned and postoperative CBCT images were superimposed to measure the linear deviation of the surgical access point from the planned target. A t-test was performed to compare linear deviations from the planned target between experienced and non-experienced operators. Statistical significance was set at 5% ($p<0.05$). Maximum length of resected apex, periodontal ligament, and sufficient osteotomy to complete the root-end preparation and filling were qualitatively evaluated by a third experienced surgeon.*
Results: *Overall, the mean linear deviation was 1.23 ± 0.38 mm. No statistically significant differences emerged between operators, even in posterior teeth. All root resections were considered clinically successful.*
Conclusions: *Guided endodontic microsurgery is an accurate and unbiased method to execute apical access, even in posterior teeth, and is not subject to the surgeon's experience.*

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Introduction

Endodontic microsurgery is indicated for the treatment of periapical lesions of endodontic origin that do not respond to or cannot be treated with conventional therapy (1, 2). The primary goal of endodontic microsurgery is to eradicate the causes of persistent apical pathology and reduce postoperative discomfort. Persistence of bacteria within the anatomical complexity of the root canal, extra-radicular infection, foreign body reactions to gutta-percha root filling materials and radicular cysts may result in endodontic failures (3).

Small osteotomies and optimal root resections are two prerequisites to reduce the risk of endodontic failures. Given the correlation between small osteotomies and favourable postoperative healing outcomes, the osteotomy should be sufficiently large to allow instrumentation access to the root canal and small enough to reduce hard tissue trauma (4). An adequate osteotomy facilitates root-end canal preparation and subsequent removal of soft tissue lesion surrounding the apical access.

Moreover, an optimal root resection allows the operator to resect the root-end completely and detect multiple or aberrant canals with subsequent ease of retrograde preparation (5).

Therefore, root resection should be performed at 3 mm from the apex, with a bevel angle perpendicular to the long axis of the root and a cavity of at least 3 mm depth (2) The apical length of 3 mm is not an absolute value, but an ideal length to balance the need to remove apical ramifications and lateral canals and to maintain a favourable crown-root ratio (6). The length and angle of the root-end resection are critical prognostic factors for endodontic microsurgery success (2), because they impact the accessibility to the infection site, a crucial element for the success of the whole surgical procedure.

Proximity to the mandibular nerve or the maxillary sinus, the cortical bone thickness or a palatal root could represent significant hindrances in performing endodontic microsurgery. For this reason, accuracy and precision of osteotomy and root-end resection are fundamental to reduce the risk of damages to hard and soft tissues and neighbouring structures and perform an optimal root-end preparation (7-9).

New technologies, innovative materials and surgical expertise have been considered the main components to achieve a success rate greater than 90% in the medium-long period (10-12). In the last decades, technologies and innovative materials have increased the equipment needed for many practitioners, thus reducing many technological difficulties. Notwithstanding, the lack of surgical experience and specific endodontic skills continue to be an issue in preventing many endodontists from performing traditional endodontic surgery. Approximately 77% of residents in U.S. endodontic residency programs execute fewer than 20 apical resections during their training (13) and 25-30% do not perform surgery in the mandibular premolar-molar region (14).

To date, root access and visualization, tooth position, and lack of proper training have been considered the main challenges in the apical surgery procedure (14-16). Surgical guides, similar to those adopted in implantology, have been tested to reduce the operator's uncertainties and increase the precision and accuracy of the surgical approach. Many studies demonstrated how surgical guides could improve the precision of osteotomies and the accuracy of the root-end resection (17-24). Case reports also highlighted how the combination of Cone Beam Computed Tomographic (CBCT) imaging and guided endodontic microsurgery can potentially minimise the risk of intra- and post-operative complications (25).

In light of this, our study aimed to demonstrate how a surgical guide can increase the precision and accuracy of osteotomies and root-end resection for practitioners with a limited surgical endodontic experience. The accuracy level achieved respectively by an experienced surgeon and a sixth-year dental student was compared. The hypothesis was that using a surgical

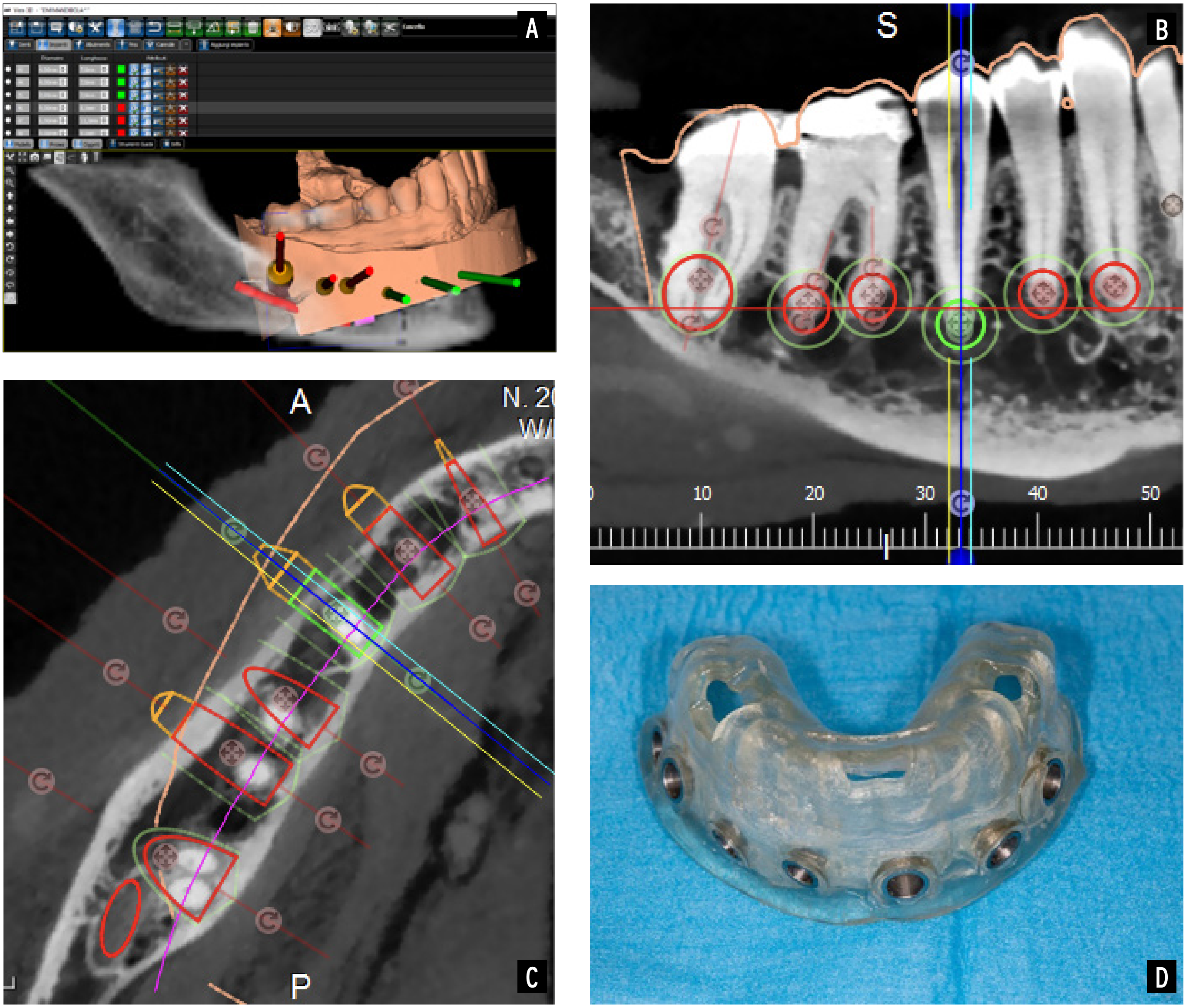

Figure 1
Planning and design of the surgical guide in the 3Diagnosis 4.1 software. **A)** Matching between STL and DICOM file; **B)** Identification of apexes; **C)** Positioning of virtual cylinders; **D)** Surgical guide.

guide for osteotomy and root-end resection allows the inexperienced operator to accurately access a root to a pre-planned location with the same accuracy level as that of an experienced operator.

Materials and Methods

A surgeon experienced in implants and endodontic microsurgery and a sixth-year dental student at the School of Dentistry of the University of Brescia participated in the study.
Two cadaver heads were obtained from ICLO (Teaching and Research Center, Verona, Italy). The use of anatomical parts derived from cadavers complies with the regulations of the National Bioethics Committee of the Italian Republic and the Helsinki Declaration. Ethics Committee Approval was not necessary.
Preoperative CBCT scans (5GXL, NewTom, Verona, Italy) and intraoral scans (Trios3, 3Shape A/S, Copenaghen, Denmark) of specimens were obtained. Scattering effect in CBCT was eliminated using a radio translucent bite (EvoBite, 3Diemme, Cantù, CO, Italy). A three-dimensional model of specimens was created using 3Diagnosis 4.1 software (3Diemme Bioimaging Technologies, Cantù, CO, Italy) (Figure 1A). Axial, panoramic and cross-sectional

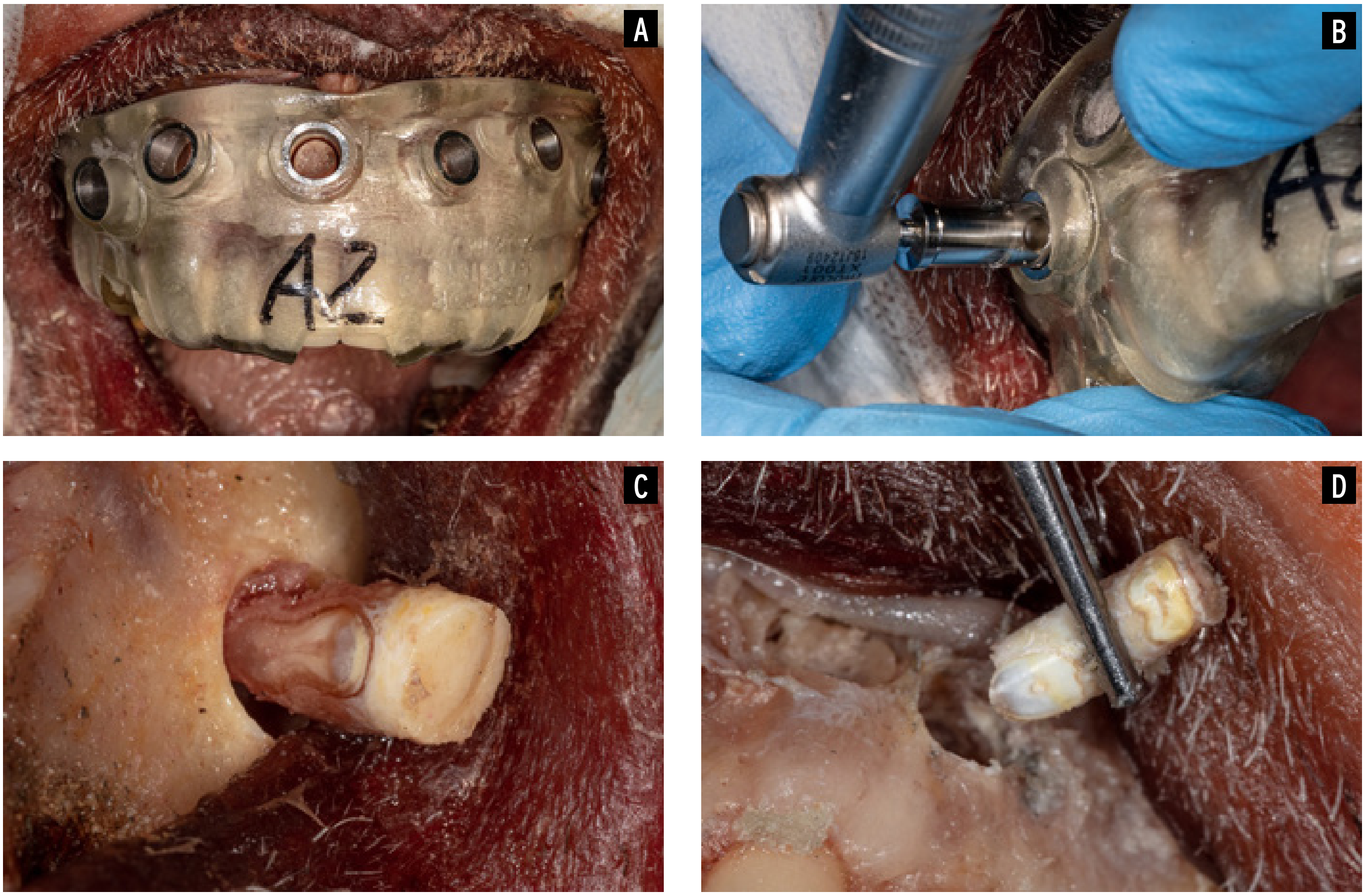

Figure 2
Surgical Access. **A)** Positioning of the guide on the arch, **B)** Cortical window and apical resection with only one milling operation, **C)** and **D)** Bone carrots extraction from the cortical table.

views were used to evaluate the functionality of dental structures and design the surgical guide. A software for guided implant surgery was used to position virtual cylinders (23) on the root's apical third (Figure 1B, 1C). The diameter of these cylinders varied between 4 and 5 mm, while their length ranged from 5 to 20 mm as per the specific clinical scenario. Each virtual cylinder was positioned at 3 mm from the apex in the coronal direction (panoramic view), perpendicular to the long axis of the root (cross view) and correctly oriented in the mesiodistal direction (axial view) according to physiologic and anatomic limits. In the cross-sectional view, the virtual cylinders were placed such that they overcame the root by at least 1 mm.
The experienced endodontist supervised the whole virtual planning designed by the student.
Surgical guides were also designed and produced in the 3Diagnosis 4.1 software and fabricated at Idi Evolution (Concorezzo, MB, Italy) (Figure 1D). Each surgical guide was equipped with oriented 5 mm-long rounded steel sleeves in order to control the path and depth of the trephine and with a diameter range of 4 to 6 mm depending on the characteristics of the apex. A buccal flange was designed following the profile of the bone table to improve guide adherence and protect soft tissues due to its role as passive retractor of the mucogingival flap.
During the surgical intervention, soft tissues were removed from the specimen mimicking flap reflection in a clinical scenario. The guide was positioned over the occlusal surface of the teeth (Figure 2A).
Osteotomy and root resection were performed on forty roots (20 roots/operator) with unique access using a trepan bur (length 18 mm: n° 227.204.050 – external diameter 5 mm and internal diameter

4.1 mm – or n° 227.204.060 – external diameter 6 mm and internal diameter 5.1 mm; Komet Dental, Lemgo, Germany) (Figure 2B and 2C).
The resection of the root was made simultaneously to the bone using the same trepan bur. Given the different hardness of the tissues, we slightly increased the speed as well as the thrust in according to the tissue strength. No vibrations were noted during the whole process. Bone carrots and resected apices were removed from the cortical table (Figure 2D). Optimal tissue irrigation was maintained during the whole surgical procedure.
Postoperative CBCT scans were taken for each specimen using the same settings of the preoperative CBCT scans. Pre- and post-operative scans were superimposed using 3D GeoMagic Qualify 3D Systems® software (3Diemme Bioimaging Technologies, Cantù, CO, Italy). The deviation of the postoperative access point from the pre-planned point was measured. Then, the linear deviation was determined as the distance between the planned access point (value 0) and the executed surgical access point.
To quantify the clinical success of the procedure, roots and resected apices were examined using HS Moller-Wedel International Model V.M. 900® operating microscope (AT x10, x12 magnification) (Moeller Wedel Optical Rosengarten, Wedel, Germany). The root surfaces were then treated with methylene blue to stain the periodontal ligament and root canal selectively.
A third experienced surgeon assessed the success or failure of the endodontic microsurgery. Success was defined with respect to the following four parameters: (1) maximum length of resected apex 3 mm; (2) root canal present and centred; (3) periodontal ligament characterised by an unbroken circular line around the root surface; (4) sufficient osteotomy to complete the root-end preparation and root-end filling. Roots that did not conform to any one of the parameters mentioned were classified as failures.
Sample size calculation using G*Power 3.1 for Macintosh (Heinrich-Heine, Dusseldorf, Germany) estimated a minimum of 18 roots per group (alpha=0.05, power=0.8). However, because of the randomness of small samples, a minimum sample size of 20 per group was adopted for this study (20). Roots treated by the experienced endodontist were considered the control group. An external researcher randomly assigned the 40 roots to each operator. Linear deviation (mm) was reported as mean ± standard deviation. A T-test on independent samples was performed to evaluate the statistically significant differences between experienced and non-experienced operators. Statistical significance was set at 5% ($p<0.05$). All statistical analyses were performed using the STATA16 software (StataCorp., College Station, TX, USA).

Results

The sample comprised 40 roots (53% lower arch and 47% upper arch; 65% single-rooted teeth and 35% multi-rooted teeth). A total of 28% of teeth were molars or premolars.
Overall, mean linear deviation was 1.23 ± 0.38 mm (range: 0.48-2.17 mm). The mean distances achieved by the experienced and non-experienced operator was not statistically different ($deviation_{experienced}$=1.19 ± 0.37, 95% CI: 1.01-1.36; $deviation_{non\text{-}experienced}$ 1.27 ± 0.39, 95%CI: 1.08-1.45; t=0.6638, p=0.5108).
No statistically significant difference emerged between the two operators for posterior teeth ($deviation_{experienced}$=1.05 ± 0.31, 95% CI: 0.73-1.38; $deviation_{non\text{-}experienced}$ 1.42 ± 0.43, 95%CI: 0.89-1.96; t=1.6596, p=0.1314) and in lower or upper arch (Table 1).

Discussion

Endodontic microsurgery is a predictable surgical approach to explore and solve the cause of non-healing in root canal-treated teeth and eliminate persistent apical pathology effectively. The main goals of this procedure are the long-term survival of asymptomatic teeth and the healing of the periapical tissues (26).

Table 1
Descriptive statistics and t-test on independent samples between experienced and inexperienced operator

Group	Total sample (n=40)	Posterior teeth (n=11)	Anterior teeth (n=29)	Lower arch (n=21)	Upper arch (n=19)
Experienced operator	1.19 ± 0.37	1.05 ± 0.31	1.24 ± 0.39	1.03 ± 0.34	1.34 ± 0.35
Inexperienced operator	1.27 ± 0.39	1.42 ± 0.43	1.21 ± 0.38	1.12 ± 0.28	1.44 ± 0.45
p-value	0.5108*	0.1314*	0.8391*	0.5238*	0.5798*
Shapiro-Wilk test for normality of the variable "linear deviation" (p-value)				z=-1.835 (0.9667)	

Data are presented as mean ± standard deviation. Test t-statistics and Shapiro-Wilk test were reported.
*P-value of each test is reported into parenthesis. *Student's t-test.*

Precise and accurate osteotomies and optimal root resections are considered prerequisites to achieve postoperative favourable healing outcomes in the medium-long period (10, 15, 24, 27, 28). Handling and controlling these intra-operative factors are, therefore, the main objectives of the surgical procedure.
To date, the lack of specific surgical endodontic skills and abilities continue to be considered a critical hindrance, preventing less experienced endodontists from using this predictable technique though technology and innovative materials have improved the effectiveness of endodontic microsurgery.
This study aimed to demonstrate how a surgical guide can increase the accuracy of osteotomies and root-end resections executed by practitioners with a limited surgical experience as well as improving existing capabilities. For this goal, the level of accuracy achieved by two operators with different levels of skills and abilities in executing respectively twenty osteotomies and root resections was compared.
Preoperative CBCT and intra-oral scans were used to plan the surgical approach and design the surgical guides. Mean linear deviation was used as a quantitative parameter to determine the deviation of the trephine by the planned path.
Overall, both operators reported a mean linear deviation equal to 1.23 ± 0.38 mm, thus confirming the excellent level of accuracy achieved by the guided endodontic microsurgery. This result is comparable with that achieved by Ackerman et al. (2019), who demonstrated that the accuracy level of the guided endodontic surgery (1.47 ± 0.75 mm) was statistically significant higher (p<0.01) than that registered using the "freehand" technique (2.64 ± 1.39 mm) (29).
From the comparison between the experienced and non-experienced operators, no statistically significant difference between the two operators in achieving an optimal level of accuracy emerged. The surgical guide reduced the less experienced operator's uncertainties, thus ensuring comparable results between operators with different endodontic skills (linear deviation experienced operator was 1.19 ± 0.37 mm; linear deviation non-experienced operator was 1.27 ± 0.39 mm).
Antal et al. (2019) suggested that the accuracy of the surgical approach without a guide is a direct effect of the surgeons' ability to keep in mind the three-dimensional image (23). In the "freehand" approach, the surgeon should balance the need to identify the point of execution of the cortical window, especially when a fistula is absent (30) with the need to limit tissue damages and keep a sufficient visual and operational space (31).
The presence of a surgical guide allows overcoming intra-operative difficulties. Thanks to the sleeves placed next to the root apices and oriented according to the root morphology, the guide becomes a tool for transferring preoperative information, as apex location and size, the thickness of the cortical bone, and orientation of the

root in the surgical context, thus overcoming the surgical uncertainties due to limited experience (32).
Comparing linear deviation achieved by both operators in posterior teeth, no statistically significant difference emerged ($p>0.05$) between the two operators. Although the tooth and anatomical complexities can increase surgical difficulties (16), the surgical guide resulted in a fundamental tool to keep a high level of accuracy in more complex surgical conditions.
Both operators achieved 100% success. All resected roots were conformed to the four predefined parameters. During the planning phase, the non-experienced operator reported a certain level of difficulties in using planning software, especially for the first planning phases as CBCT and intra-oral scans superimposition. Therefore, although the surgical guide reduced the difficulties of the non-experienced operator in minimizing osteotomy and in executing the root resection correctly, some difficulties related to the use of technological devices remained. Some studies highlighted an extensive learning curve of microsurgical endodontics (27, 31). In this work, this extensive learning curve was transferred from the surgical phase to the preoperative one.
Guided endodontic microsurgery is an innovative approach to minimise intra-operative risks and improve postoperative healing outcomes. For a non-experienced operator, using a surgical guide reduces uncertainties because it allows reproducing easily all planned parameters. Moreover, in the most complex situations, the surgical guide can simulate the surgical intervention on 3D models, thus assuring an adequate training level.
Some problems related to the use of the surgical approach continue to remain. The surgical guide could not be readily applicable in patients with reduced mouth opening (33-35), dental elements with thin roots (24) or with some anatomical complexities. Trephines with small diameters could help to overcome some of these problems, but a particular caution should be exercised.
Despite the significant findings, some limitations also emerged. In a clinical scenario, the small retraction of the cheek, additional soft tissues or their consistency can increase the level of difficulty.

Conclusions

This study demonstrated that using a surgical guide equipped with a buccal flange and oriented sleeves allows accurate and precise identification of the lesion site, improving the execution of retrograde endodontic treatments by operators with less endodontic skills and even in contexts with a particular clinical complexity. In endodontic microsurgery, using a surgical guide assures total precision in achieving the target site and allows complete and simultaneous removal of the lesion.

Clinical Relevance

Guided endodontic microsurgery can help non-experienced surgeons to achieve higher success rates in their everyday endodontic clinical practice.

Conflict of Interest

None.

Acknowledgements

None.

References

1 Eliyas S, Vere J, Ali Z, Harris I. Micro-surgical endodontics. Brit Dent J. 2014; 216:169-77.
2 Kim S, Kratchman S. Modern endodontic surgery concepts and practice: A Review. J Endod 2006;32:601-23.
3 Nair PNR. On the causes of persistent apical periodontitis: a review. Int Endod J 2006;39:249-81.
4 Castellucci A. Microsurgical endodontics. (Edra Spa, ed.). Edra - Masson; 2019.
5 Gutmann JL, Pitt Ford TR. Management of the resected root end: a clinical review. Int Endod J 1993;26:273-83.
6 Sacco R, Greenstein A, Patel B. Endodontic microsurgery. In: Springer International Publishing, ed. Endodontic Treatment, Retreatment, and Surgery. Springer International Publishing; 2016:311-312.
7 Floratos S, Kim S. Modern endodontic microsurgery concepts: a clinical update. Dent Clin North Am 2017;61:81-91.

8 Rubinstein RA, Kim S. Long-term follow-up of cases considered healed one year after apical microsurgery. J Endod 2002;28:378-83.
9 Rubinstein RA, Kim S. Short-term observation of the results of endodontic surgery with the use of a surgical operation microscope and super-EBA as root-end filling material. J Endod 1999;25:43-8.
10 Huang S, Chen NN, Yu VSH et al. Long-term Success and Survival of Endodontic Microsurgery. J Endod 2020;46:149-57.
11 Kohli MR, Berenji H, Setzer FC et al. Outcome of Endodontic Surgery: A Meta-analysis of the Literature-Part 3: Comparison of Endodontic Microsurgical Techniques with 2 Different Root-end Filling Materials. J Endod 2018;44:923-31.
12 Pinto D, Marques A, Pereira JF et al. Long-Term Prognosis of Endodontic Microsurgery-A Systematic Review and Meta-Analysis. Medicina (Kaunas) 2020;56:447.
13 Blacher JD, Safavi KE, Aseltine RH, Kaufman BM. Defining endodontic residents' clinical experiences: a national survey. J Dent Educ 2019;83:504-9.
14 Creasy JE, Mines P, Sweet M. Surgical trends among endodontists: the results of a web-based survey. J Endod 2009;35:30-4.
15 Zhou W, Zheng Q, Tan X et al. Comparison of mineral trioxide aggregate and iRoot BP plus root repair material as root-end filling materials in endodontic microsurgery: a prospective randomized controlled study. J Endod 2017;43:1-6.
16 Song M, Jung IY, Lee SJ et al. Prognostic factors for clinical outcomes in endodontic microsurgery: A retrospective study. J Endod. 2011;37:927-33.
17 Giacomino CM, Ray JJ, Wealleans JA. Targeted endodontic microsurgery: a novel approach to anatomically challenging scenarios using 3-dimensional–printed guides and trephine burs - a report of 3 cases. J Endod 2018; 44:671-7.
18 Strbac GD, Schnappauf A, Giannis K et al. Guided modern endodontic surgery: a novel approach for guided osteotomy and root resection. J Endod 2017;43:496-501.
19 Kim J-E, Shim J-S, Shin Y. A new minimally invasive guided endodontic microsurgery by cone beam computed tomography and 3-dimensional printing technology. Rest Dent Endod 2019;44:e29.
20 Fan Y, Glickman GN, Umorin M et al. A novel prefabricated grid for guided endodontic microsurgery. J Endod 2019;45:606-10.
21 Liu Y, Liao W, Jin G et al. Additive manufacturing and digital design assisted precise apicoectomy: A case study. Rapid Prototyping J 2014;20:33-40.
22 Pinsky HM, Champleboux G, Sarment DP. Periapical surgery using CAD/CAM guidance: preclinical results. J Endod 2007;33:148-51.
23 Antal M, Nagy E, Braunitzer G et al. Accuracy and clinical safety of guided root end resection with a trephine: a case series. Head Face Med 2019;15:30.
24 Moreno-Rabié C, Torres A, Lambrechts P, Jacobs R. Clinical applications, accuracy and limitations of guided endodontics: a systematic review. Int Endod J;2020;53:214-31.
25 Benjamin G, Ather A, Bueno MR et al. Preserving the neurovascular bundle in targeted endodontic microsurgery: a case series. J Endod 2020;47:509-19.
26 Jonasson P, Ragnarsson M. Surgical retreatment. In: Springer International Publishing, ed. Apical Periodontitis in Root-Filled Teeth. Springer International Publishing; 2018:73-74.
27 van der Meer WJ, Vissink A, Ng YL, Gulabivala K. 3D Computer aided treatment planning in endodontics. J Dent2016;45:67-72.
28 Ahn SY, Kim NH, Kim S et al. Computer-aided design/computer-aided manufacturing–guided endodontic surgery: guided osteotomy and apex localization in a mandibular molar with a thick buccal bone plate. J Endod 2018;44:665-70.
29 Ackerman S, Aguilera FC, Buie JM et al. Accuracy of 3-dimensional–printed endodontic surgical guide: a human cadaver study. J Endod 2019;45:615-8.
30 Kim J-E, Shim J-S, Shin Y. A new minimally invasive guided endodontic microsurgery by cone beam computed tomography and 3-dimensional printing technology. Rest Dent Endod 2019;44:e29.
31 Ye S, Zhao S, Wang W et al. A novel method for periapical microsurgery with the aid of 3D technology: A case report. BMC Oral Health. 2018;28:1-7.
32 Popowicz W, Palatyńska-Ulatowska A, Kohli MR. Targeted endodontic microsurgery: computed tomography–based guided stent approach with platelet-rich fibrin graft: a report of 2 cases. J Endod 2019;45:1535-42.
33 Connert T, Zehnder MS, Weiger R et al. Microguided endodontics: accuracy of a miniaturized technique for apically extended access cavity preparation in anterior teeth. J Endod 2017;43:787-90.
34 Lara-Mendes STO, Barbosa C de FM, Machado VC, Santa-Rosa CC. A New approach for minimally invasive access to severely calcified anterior teeth using the guided endodontics technique. J Endod 2018;44:1578-82.
35 Torres A, Shaheen E, Lambrechts P et al. Microguided endodontics: a case report of a maxillary lateral incisor with pulp canal obliteration and apical periodontitis. Int Endod J 2019;52:540-9.

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ORIGINAL ARTICLE

Investigation on the frequency of streak artifacts resulted from different sealers in cone-beam computed tomography images

ABSTRACT

Aim: *This ex-vivo study aimed to investigate streaking artifacts produced by three different sealers to prevent false-positive diagnosis of vertical root fractures (VRF) in clinical settings using cone-beam computed tomography (CBCT).*
Materials and Methods: *The present experimental study included 60 mandibular teeth, single-rooted premolars prepared using a Protaper F3 file and randomly classified into 4 groups, which were obturated using gutta-percha F3 cones alone (control group) or with one of the sealers: MTA Fillapex (FA), Sealapex, and AH26. The teeth underwent CBCT scan with a 5×8 cm field of view (FOV), and the images were qualitatively evaluated in axial sections by two observers and were coded as follows: Code 1: absence of dark streaks, Code 2: slight dark streaks, Code 3: pronounced dark streaks not extending to the root surface, Code 4: dark streaks extending to the root surface, resembling a fracture.*
Data were analyzed using SPSS software version 20. Chi-square test was used for artifact frequency comparison at P≤0.05 level of significance.
Results: *According to both observers, there was no significant inter-group difference in artifact frequency (P>0.05), while Code 3 was the most common artifact observed in all groups.*
Conclusions: *Dark streaks not extending to the root surface (code 3) were the most common artifact in the teeth obturated using gutta-percha cones alone or with sealers MTA Fillapex (FA), Sealapex, and AH26.*

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Introduction

Root canal treatment is performed for apical periodontitis prevention and treatment (1, 2). Complete elimination of bacteria from the root canal system, selection of filling material (2), and the quality of root canal filling (3) are the important factors effective in achieving this goal.
Radiography play an important role in evaluating the root treatment outcomes and the etiology of the endodontic failures (4, 5). One of the main challenges of dental procedures is the Correct diagnosis of root fracture because early VRF detection prevents extensive damage to the dental supporting tissues.
In most cases, accurate diagnosis is only possible after evaluating the clinical signs and features and symptoms of the periapical radiographs and CBCT images (6, 7). Two-dimensional (2D) radiographs have some limitations in VRF diagnosis. these radiographs can only detect VRFs if the plane of fracture line is parallel to the radiation direction (8).
Recently, application of cone-beam computed tomography (CBCT) imaging has become common in endodontic treatments, overcoming the limitations of 2D imaging modalities. Some applications of CBCT include detection of strip perforation (5), VRF detection, root canal filling evaluation and detection of periapical lesions and evaluation of their healing course (3).
Most root filling materials such as gutta-percha and sealers cause different forms of artifacts (9, 10). These linear artifacts can lead to the false-positive misdiagnosis of dental root fractures (11). Root canal sealers can be classified according to their composition: calcium hydroxide, glass-ionomer, resin, silicone-based sealers, zinc oxide eugenol (12) and mineral trioxide aggregate(MTA)-based sealers (13, 14).
All sealers should have sufficient radio-opacity to allow evaluating the quality of root canal filling by radiography. Therefore, radio-opaque materials are added to sealers to help differentiate between the sealer and dental tissue or even gaps within the root canal filling (15, 16). Considering the differences in radiopacity between the sealers, these filling materials also have different atomic composition and interaction with X-rays. The scattered radiation combined with the lower milliamperage of CBCT can compromise the quality of the scan, inducing image artifacts and leading to inaccurate or false diagnoses (15).
These artifacts in CBCT images are due to the beam-hardening effect, in which there is a preferential absorption of lower-energy photons compared to higher-energy photons in an X-ray beam, leading to the creation of lines that mimic the appearance of a root fracture (4) beam hardening may occur in two forms. Cupping artifacts and white streaks associated with dark bands may be appear near of dense materials. Dark bands may mimic root fracture in the CBCT images, thus reducing its accuracy of this modality in root fracture detection (17).
According to the studies, small FOV provides images with higher resolution and lower artifacts than large FOV. Moreover, smaller voxel sizes improve the quality of CBCT images (4, 18).
However, streak artifacts can still be present in CBCT images even if small FOVs and various voxel sizes are used because of the radio-opaque materials, such as metals, gutta-percha, and sealers (16, 18-24).
In some studies, authors have evaluated the dark bands in the root canal-treated teeth CBCT images.
Gholampour et al. (25) investigated the artifacts caused by three different sealers, including zinc oxide-eugenol (ZOE)-based sealer, ceramic-based sealer, and resin in CBCT with two different resolutions. They concluded that Gutta-percha alone produced more artifacts than gutta-percha with sealers; moreover, ZOE-based sealer induced more artifacts than other sealers.
Brito-Junior et al (15) investigated the streak artifacts caused by various root canal sealers (Endofill, Sealer 26, Fill apex, AH Plus) in CBCT images with variable voxel resolution. They concluded that the type of sealer and voxel resolution can influence the presence of streaking artifacts observed in CBCT images.
Freitas-e-Silvae et al. (26) investigated the

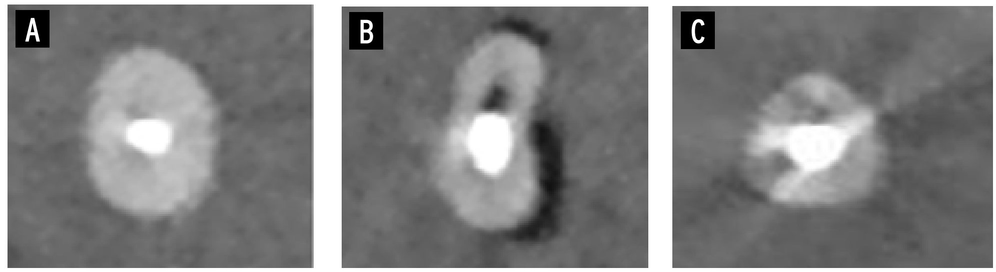

Figure 1
Axial slices showing streaking artifacts on cervical root sections according 4 codes that were studied **A)** Code 2: slight dark streaks, **B)** Code 3: pronounced dark streaks not extending to the root surface, **C)** Code 4: dark streaks extending to the root surface, resembling a fracture from left to right respectively.

effect of three different sealers (fill canal, sealer 26, AH plus) in the VRF diagnosis and concluded that endodontic sealers do not influence the detection of VRF. There is little information available on detecting streak artifacts resulted from sealers. Therefore, such information can be helpful in decreasing the potential risk of false-positive VRF detection.

Therefore, the present experimental study intended to evaluate the frequency of artifacts resulted from sealers containing calcium hydroxide, epoxy resin, and MTA in small-volume CBCT images of obturated teeth. The null hypothesis was no significant difference exists between the artifacts resulted from different sealers.

Materials and Methods

The present study was an ex vivo study including 60 single-rooted mandibular premolars (from humans aged 18-50) with mature apexes and similar lengths that were recently extracted due to periodontal or orthodontic indications. Exclusion criteria included teeth with internal or external root resorption, cracks, fractures, extensive restorations (beyond the CEJ), root canal obstruction, dilaceration, and other anomalies. All the samples were evaluated and confirmed to fulfill the inclusion and exclusion criteria using digital radiography in mesiodistal and buccolingual dimensions. For surface disinfection, the teeth were immersed in 5.25% sodium hypochlorite solution (Chloraxid, Cerkamed, Poland) for 2 hours (3). Then, they were kept in distilled water until imaging. They were re-evaluated using an operating microscope (Pico, Zeiss Co., Jena, Germany) to ensure the absence of any crack or fractures. Moreover, those with round root canals were the only teeth selected (3, 8).

All teeth were prepared by a postgraduate student in endodontics (last year resident). Anatomical crowns of all samples were cut off in CEJ perpendicular to the longitudinal axis of the teeth using a carborundum disc and air turbine (KaVo Dental, Biberach, Baden-Württemberg, Germany). To determine the working length, the #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) was introduced into the canal until its tip was visible at the apex; 1 mm was subtracted from this length to determine the working length. Instrumentation was performed by the same operator that prepared the teeth.

All the canals were prepared using ProTaper rotary files (Dentsply Maillefer, Ballaigues, Switzerland) until the F3 size. During preparation, root canals were irrigated using 2 ml of 5.25% sodium hypochlorite solution for 1 minute. Following preparation, 2 ml of a 17% EDTA solution (Aria Dent, Tehran, Iran) was applied for 1 minute, followed by 3 ml 5.25% sodium hypochlorite solution and 3 ml distilled water to eliminate residues of the smear layer. Then, the root canals were dried with paper points (Diadent, Chongiu, Korea).

Root canal filling

The roots were randomly divided into 4 groups (n 15).

Table 1
Frequency distribution of artifact types observed by all groups (n=60)

		Code 2	Code 3	Code 4
Control	Frequency	2	8	5
	Percentage	13.3%	53.3%	33.3%
Sealapex	Frequency	2	7	6
	Percentage	13.3%	46.7%	40%
MTA Fillapex	Frequency	1	10	4
	Percentage	6.7%	66.7%	26.7%
AH26	Frequency	1	9	5
	Percentage	6.7%	60%	33.3%

The sealers were prepared according to the manufacturer's instructions and were inserted into the canals using a Lentulo spiral until reaching the working length. Then, the obturation was performed using the single-cone technique and the gutta-percha F3 cones (Maillefer, Ballaiges, Switzerland). The sealer used in each group was different from other groups in composition. Study groups were as follows.
Group 1: Gutta-percha without sealer (Control group)
Group 2: Gutta-percha and Sealapex (SybronEndo, Orange, CA, USA)
Group 3: Gutta-percha and MTA Fillapex (Angelus, Londrina, PR, Brazil)
Group 4: Gutta-percha and AH26 (Denstply, De Trey, Konstanz, Germany)
After obturation, the samples were kept in distilled water until mounting for CBCT acquisition.

CBCT acquisition
The teeth were numbered from 1 to 60 and were randomly mounted in four putty molds along their longitudinal axis. For CBCT acquisition, the molds were placed in a container with water to simulate soft tissue. CBCT images were obtained using NewTom Giano extraoral imaging system (Vila Silverstrini, Verona, Italy) with the following settings in high-resolution exposure conditions: 0.3 mm voxel size, 90 kVp, 0.6 mA, and 10 s exposure time (pulsed). The samples were placed in the center of the FOV (5×8 cm). The images were reconstructed and saved using the NNT software. Axial images were obtained from the coronal to the apical areas of the teeth with slices thickness being 0.15 mm.

CBCT image evaluation
CBCT images were displayed on a 19-inch screen, colour, 1366x768 pixels resolution (Samsung, Seoul, Korea) and were evaluated by two blinded observers, including a maxillofacial radiologist with 10 years' experience and an endodontist with 8 years' experience. Streak or linear artifacts were in axial sections detected and were coded as follows. Code 1: absence of dark streaks; Code 2: slight dark streaks that were not obvious; Code 3: pronounced dark streaks not extending to the root surface; Code 4: dark streaks extending to the root surface that resembled a fracture. Finally, the data were recorded on a computer and used for statistical analysis.
The Chi-square test was used to compare the frequency (ratio) of artifacts in the 4 groups. The intra-and interobserver degree of agreement in artifact detection was measured using the κ agreement coefficient. The significance level was considered 5% ($p<0.05$) for all tests, and the statistical analysis was performed using SPSS version 20.

Results

The highest frequency of artifacts was observed in relation to Code 2 in the control group (13.3%) and sealapex sealer group (13.3%), in relation to Code 3 in MTA fillapex group (66.7%) and in relation to Code

4 in sealapex sealer (40%). Code 3 was the most common artifact in all the groups. Due to the presence of artifacts in all groups, Code 1 was not included in the analysis.
According to the Chi-square test no statistically significant difference was observed in the frequency of different types of artifacts in the experimental groups. The intraobserver (kappa 0.83 [95% CI 0.82, 0.89]; and interobserver agreement (Kappa 0.70 [95% CI: 0.72, 0.74] respectively, were good.

Discussion

CBCT imaging is the technique indicated for VRF diagnosis when 2D images do not provide adequate information, especially in the root canal-treated teeth (26).
Studies have demonstrated that artifacts caused by root fillings materials may reduce the accuracy, sensitivity, and specificity of CBCT imaging in VRF diagnosis. Thus, an attempt to identify CBCT artifacts related to different filling materials seems to be important for diagnosing root fractures (15). The presence of radiopacifiers and other chemical substances in the formulation of different sealers such as bismuth oxide, bismuth subcarbonate, barium sulfate, and zinc oxide can lead to differences in density (26).
Root canal filling materials, such as gutta-percha cones and sealers, can make obvious streak artifacts that mimic the lines of root fracture. Therefore, a definite diagnosis of VRF has always been questionable due to the artifacts resulted from various materials in the root canal, leading to a false-positive diagnosis (11).
According to some studies, sealers are the main material causing artifacts mimicking root fractures in CBCT (15, 26) which is contrary to the present study. The present study showed that gutta-percha alone or in combination with sealers (sealapex, MTA fillapex, and AH26) causes obvious streak artifacts, which are mostly seen as pronounced dark streaks not extending to the root surface in the axial CBCT images (Code 3). Some studies have shown that root canal filling materials do not influence on VRF diagnosis (21, 26, 28). For instance, Melo SL et al. (21) showed that longitudinal root fractures diagnostic ability using CBCT was not influenced by the presence of posts or gutta-percha. Additionally, Dutra Kl et al. (28) showed that the presence of gutta-percha caused a low beam hardening artifact which did not hinder the VRF diagnosis.
Several studies have evaluated influence of root fillings on the detection of VRFs using CBCT images, although the filling material used had been restricted to only gutta-percha (19, 24).
Gutta-percha and metallic posts are frequently used, and they are responsible for beam-hardening artifacts because of their high density, which reduces the ability to diagnose root cracks and fractures, obscuring root canal morphology (29).
Gutta-percha cones created distinct streaking artifacts on CBCT axial slices, which are consistent with the present findings (15).
Freitas-e-Silva et al. (26) showed that due to the high amount of intra-canal gutta-percha, the use of different sealers does not affect on the vertical root fracture diagnosis.
Gholampour et al. (25) concluded that gutta-percha alone produced more artifacts compared with gutta-percha and sealer (resin sealers, ceramic sealers, and ZOE-based sealers). They suggested that the higher number of artifacts created by gutta-percha could be due to the higher density of gutta-percha compared to the density of the gutta-percha and sealer combination.
Using a 0.076 mm voxel size, Brito-Junior et al. (15) found no significant difference in the frequency of streak artifacts in root canals filled with sealers AH26, AH plus, and Fillapex. However, the findings of the mentioned study in a larger voxel size (0.2 mm), which was close to the voxel size used in the present study (0.3 mm), were not compatible with ours. Voxel size of CBCT imaging is related to contrast and resolution (22). According to Brito-Junior et al. (15), it seems that smaller voxel size decreases the artifacts, thereby increasing the diagnostic accuracy of root fracture detection in root-filled teeth. Another difference of the present study with the study by Brito-Junior et al. was the larger sample size of the present study and different image evaluation methods used in the two studies. Brito-Junior et al. only investigated the absence

or presence of the artifacts, while we classified artifacts into 4 codes, which allowed more precise and detailed evaluation and subsequent higher accuracy of the potential results.

Iikubo et al. (11) investigated the pure effect of voxel size and FOV on the artifacts created by gutta-percha-filled root canals. They evaluated the artifacts on CBCT images obtained using two modes: I-mode (FOV: 102 mm, voxel size: 0.2 mm) and D-mode (FOV: 51 mm, voxel size: 0.1 mm). The artifacts were more common in I-mode, which had a larger voxel size and FOV. Therefore, it was shown that a smaller voxel size and FOV could decrease artifacts in CBCT images. However, the present study used a fixed FOV and voxel size while it investigated three types of sealers. Obviously, lower FOV and voxel size increase the image resolution by decreasing the radiation scattering (4).

However, smaller size voxels can increase background noises, reducing the quality of CBCT images (20). Also, root canal filling removal before imaging can increase the diagnostic accuracy of CBCT (30).

According to Celikten et al. (3), the CBCT device and associated software play an important role in streak artifact reduction. They evaluated the artifacts resulted from the three different sealers using different brands of CBCT devices and found that the NewTom VGi EVO and Accuitomo 170 devices seemed to perform equally and significantly better than the other machines tested. However, the present study used the same CBCT device to evaluate the artifacts from three sealer types. Also, Rabelo et al. (31) investigated different parameters related to exposure and reported that different exposure conditions did not affect the frequency of artifacts.

Neves et al. (6) investigated the effects of four different modes in the Accuitomo 170 CBCT device on the artifacts and the accuracy of VRF detection in unfilled teeth and teeth root-filled with gutta-percha, metal posts, and fiber posts. They reported that CBCT modes had no effects on the VRF diagnosis, while gutta-percha and metal posts had adversely affected the VRF diagnosis. Our study used a fixed, high-resolution mode; however, our findings on the ability of gutta-percha in causing artifacts were compatible with those of Neves et al. because we found artifacts even in the control group, which contained gutta-percha without sealer.

Despite all these studies, little information is available on detecting the streak artifacts resulted from sealers. Such information can be helpful in decreasing the potential risk of false-positive detection of VRF. Therefore, it is recommended to conduct further studies with larger sample sizes and different voxel sizes.

Conclusions

In the present study, we found no significant difference between the Sealapex, MTA Fillapex, AH26, and control groups in the frequency of streak artifacts in CBCT images.

Clinical Relevance

The result of this study showed that endodontic sealers do not influence the detection of VRFs.

Conflict of Interest

The authors deny any conflict of interest related to this study.

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References

1 Siqueira J, Rôças I, Ricucci D, Hülsmann M. Causes and management of post-treatment apical periodontitis. British dental journal. 2014;216(6):305-12.
2 Lim M, Jung C, Shin D-H, Cho Y-b, Song M. Calcium silicate-based root canal sealers: a literature review. Restorative Dentistry & Endodontics. 2020;45(3).
3 Celikten B, Jacobs R, de Faria Vasconcelos K, Huang Y, Shaheen E, Nicolielo LFP, et al. Comparative evaluation of cone beam CT and micro-CT on blooming artifacts in human teeth filled with bioceramic sealers. Clinical oral investigations. 2019;23(8):3267-73.
4 Durack C, Patel S. Cone beam computed tomography in endodontics. Brazilian dental journal. 2012;23(3):179-91.
5 Abdinian M, Moshkforoush S, Hemati H, Soltani P,

Moshkforoushan M, Spagnuolo G. Comparison of cone beam computed tomography and digital radiography in detecting separated endodontic files and strip perforation. Applied Sciences. 2020;10(23):8726.

6 Neves FS, Freitas DQ, Campos PSF, Ekestubbe A, Lofthag-Hansen S. Evaluation of cone-beam computed tomography in the diagnosis of vertical root fractures: the influence of imaging modes and root canal materials. Journal of Endodontics. 2014;40(10):1530-6.

7 Tamse A, Kaffe I, Lustig J, Ganor Y, Fuss Z. Radiographic features of vertically fractured endodontically treated mesial roots of mandibular molars. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2006;101(6):797-802.

8 Mohammadpour M, Bakhshalian N, Shahab S, Sadeghi S, Ataee M, Sarikhani S. Effect of titanium and stainless steel posts in detection of vertical root fractures using NewTom VG cone beam computed tomography system. Imaging Science in Dentistry. 2014;44(2):89-94.

9 Ardakani FE, Razavi SH, Tabrizizadeh M. Diagnostic value of cone-beam computed tomography and periapical radiography in detection of vertical root fracture. Iranian endodontic journal. 2015;10(2):122.

10 Helvacioglu-Yigit D, Kocasarac HD, Bechara B, Noujeim M. Evaluation and reduction of artifacts generated by 4 different root-end filling materials by using multiple cone-beam computed tomography imaging settings. Journal of endodontics. 2016;42(2):307-14.

11 Iikubo M, Osano T, Sano T, Katsumata A, Ariji E, Kobayashi K, et al. Root canal filling materials spread pattern mimicking root fractures in dental CBCT images. Oral surgery, oral medicine, oral pathology and oral radiology. 2015;120(4):521-7.

12 ØRstavik D. Materials used for root canal obturation: technical, biological and clinical testing. Endodontic topics. 2005;12(1):25-38.

13 Scarparo RK, Haddad D, Acasigua GAX, Fossati ACM, Fachin EVF, Grecca FS. Mineral trioxide aggregate–based sealer: analysis of tissue reactions to a new endodontic material. Journal of Endodontics. 2010;36(7):1174-8.

14 Assmann E, Scarparo RK, Böttcher DE, Grecca FS. Dentin bond strength of two mineral trioxide aggregate–based and one epoxy resin–based sealers. Journal of endodontics. 2012;38(2):219-21.

15 Brito-Júnior M, Santos L, Faria-e-Silva A, Pereira R, Sousa-Neto M. Ex vivo evaluation of artifacts mimicking fracture lines on cone-beam computed tomography produced by different root canal sealers. International endodontic journal. 2014;47(1):26-31.

16 Decurcio DA, Bueno MR, Alencar AHGd, Porto OCL, Azevedo BC, Estrela C. Effect of root canal filling materials on dimensions of cone-beam computed tomography images. Journal of Applied Oral Science. 2012;20(2):260-7.

17 Salineiro FCS, Talamoni IP, Velasco SK, Barros FM, Cavalcanti MdGP. Artifact induction by endodontic materials: a CBCT analysis. Clinical and Laboratorial Research in Dentistry. 2019.

18 del Carpio-Perochena A, Kishen A, Felitti R, Bhagirath AY, Medapati MR, Lai C, et al. Antibacterial properties of chitosan nanoparticles and propolis associated with calcium hydroxide against single-and multispecies biofilms: an in vitro and in situ study. Journal of endodontics. 2017;43(8):1332-6.

19 Hassan B, Metska ME, Ozok AR, van der Stelt P, Wesselink PR. Detection of vertical root fractures in endodontically treated teeth by a cone beam computed tomography scan. Journal of endodontics. 2009;35(5):719-22.

20 Hassan B, Metska ME, Ozok AR, van der Stelt P, Wesselink PR. Comparison of five cone beam computed tomography systems for the detection of vertical root fractures. Journal of endodontics. 2010;36(1):126-9.

21 Melo SLS, Bortoluzzi EA, Abreu Jr M, Corrêa LR, Corrêa M. Diagnostic ability of a cone-beam computed tomography scan to assess longitudinal root fractures in prosthetically treated teeth. Journal of endodontics. 2010;36(11):1879-82.

22 Costa FF, Gaia BF, Umetsubo OS, Cavalcanti MGP. Detection of horizontal root fracture with small-volume cone-beam computed tomography in the presence and absence of intracanal metallic post. Journal of endodontics. 2011;37(10):1456-9.

23 Costa FF, Gaia BF, Umetsubo OS, Pinheiro LR, Tortamano IP, Cavalcanti MGP. Use of large-volume cone-beam computed tomography in identification and localization of horizontal root fracture in the presence and absence of intracanal metallic post. Journal of endodontics. 2012;38(6):856-9.

24 Khedmat S, Rouhi N, Drage N, Shokouhinejad N, Nekoofar MH. Evaluation of three imaging techniques for the detection of vertical root fractures in the absence and presence of gutta-percha root fillings. International endodontic journal. 2012;45(11):1004-9.

25 Gholampour A, Soleymani A, Bijani A, Haghanifar S. A comparison of image artifacts with gutta-percha and different sealers on root filled teeth using cone beam computed tomography: An in vitro study. Caspian Journal of Dental Research. 2020;9(2):42-9.

26 Freitas-e-Silva A, Mármora B, Barriviera M, Panzarella FK, Raitz R. CBCT Performance and Endodontic Sealer Influence in the Diagnosis of Vertical Root Fractures. The journal of contemporary dental practice. 2019;20(5):553.

27 Patel S, Wilson R, Dawood A, Foschi F, Mannocci F. The detection of periapical pathosis using digital periapical radiography and cone beam computed tomography–Part 2: a 1-year post-treatment follow-up. International endodontic journal. 2012;45(8):711-23.

28 Dutra KL, Pachêco-Pereira C, Bortoluzzi EA, Flores-Mir C, Lagravère MO, Corrêa M. Influence of intracanal materials in vertical root fracture pathway detection with cone-beam computed tomography. Journal of Endodontics. 2017;43(7):1170-5.

29 Vasconcelos KdF, Nicolielo L, Nascimento M, Haiter-Neto F, Bóscolo F, Van Dessel J, et al. Artefact expression associated with several cone-beam computed tomographic machines when imaging root filled teeth. International endodontic journal. 2015;48(10):994-1000.

30 Hekmatian E, Fathollahzade H, Sheikhi M. Detection of vertical root fractures using cone-beam computed tomography in the presence and absence of Gutta-Percha. The Scientific World Journal. 2018;2018.

31 Rabelo KA, Cavalcanti YW, de Oliveira Pinto MG, Sousa Melo SL, Campos PSF, de Andrade Freitas Oliveira LS, et al. Quantitative assessment of image artifacts from root filling materials on CBCT scans made using several exposure parameters. Imaging Science in Dentistry. 2017;47(3):189-97.

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ORIGINAL ARTICLE

Comparative efficacy of depotphoresis and diode laser for reduction of microbial load and postoperative pain, and healing of periapical lesions: a randomized clinical trial

ABSTRACT

Aim: *To compare the efficacy of depotphoresis and diode laser (DL) for reduction of microbial load and postoperative pain, and healing of periapical lesions in teeth with necrotic pulp.*
Methods: *Ninety patients (98 roots) with pulp necrosis and chronic periapical lesions were randomized into three groups (n=30) of depotphoresis, diode laser, and control. Bacterial samples were collected from all roots at each treatment phase (S1: immediately after access cavity preparation, S2: immediately after cleaning and shaping, S3: one week after intra-canal medicament). Analysis of bacterial reduction was performed using "Colony Forming Unit Counting" method. Level of pain was measured before and at 6, 12, 24, 48 and 72 hours after treatment using a visual analog scale (VAS). Cone-beam computed tomography (CBCT) images were obtained before and 6 months after treatment to assess the healing of periapical lesions based on their apicocoronal, mesiodistal and buccolingual diameter. Kruskal-Wallis and The Mann-Whitney test was used to determine the colony forming units and Compare the level of pain at different times between the groups of study, whilst the Univariate analyses using the chi-square or Fisher exact test were used to show the correlation of the outcomes with variables to identify the potential predisposing factors ($P<0.05$).*
Results: *At S1, no significant difference was noted among the three groups in microbial load. At S2 and S3, there was a statistically significant lower bacterial count in DL ($P=0.041$) and depotphoresis group ($P=0.001$) respectively, compared to other groups. All patients had mild pain at all time points post-treatment. Also the size of the preoperative periapical lesions had no significant effect on the outcome of endodontic treatment ($p>0.05$).*
Conclusions: *Root canal disinfection by depotphoresis and diode laser significantly decreased the microbial load as well as the post-endodontic pain and resulted in complete healing of some lesions in a short time.*

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Introduction

The main goal of endodontic treatment in teeth with necrotic pulp and chronic periapical lesions is to create a germ-free environment in the root canal system, and the adjacent periodontal tissue.

Endodontists generally have two main goals in root canal treatment. The short-term goal is to prevent/control pain, and the long-term goal is to achieve clinical and radiographic healing. To achieve this goal, the microbial load in the root canal system should be minimized (1). There are two main obstacles against achieving this goal namely the complex root canal anatomy and the unique properties of the bacterial flora in the root canal system. The microorganisms in the root canal system are inaccessible in some cases despite the use of advanced endodontic instruments (2). The residual bacteria in the root canal system can proliferate between the treatment sessions and reach their baseline preoperative count (3).

The treatment success has several criteria such as resolution of symptoms, periapical healing on radiographs, or histological evidence of healing. A number of factors affect the success of endodontic treatment such as the severity of condition, the instrumentation technique, and the technology used for treatment (4)

In the recent years, use of laser in endodontics has gained increasing popularity, yielding acceptable results as an adjunct for disinfection of the root canal system and reduction of bacterial load (5, 6). Several studies have confirmed the optimal efficacy of laser therapy for reduction of post-endodontic pain as well (7, 8).

Depotphoresis is another method of root canal treatment in which, the root canal is filled with Cupral (a copper-calcium-hydroxide based compound) and the electric current is guided into the root canal system with a fine probe. This technique dissolves the contents of the root canal by alkaline proteolysis, eliminates the oligopeptides formed in the root canal system, causes proteolysis, and eliminates the acidic biological remnants in the periapical region. Cupral penetrates into the dentinal tubules and disinfects them, and induces osteogenesis in the periapical region (9). Addition of copper ions to calcium hydroxide plays an important role in the process of tissue regeneration, and also exerts anti-inflammatory and disinfecting effects (10). Moreover, the electrically activated copper ions used in combination with calcium hydroxide exert significantly faster antibacterial effects in dentinal tubules compared with pure calcium hydroxide without electrical activation (11). However, it should be noted that studies on this topic are limited (9).

Cone-beam computed tomographic (CBCT) imaging is often used for diagnosis and treatment planning in endodontics. Also, CBCT enables the measurement of periapical lesions in three orthogonal planes (12). Moreover, evidence shows the superiority of CBCT for monitoring of the healing course of periapical lesions compared with periapical radiography (13).

The novel root canal disinfection techniques, such as DL and depotphoresis, have improved the outcome of endodontic treatment.

Yalgi et al. (9) found that depotphoresis is effective in reducing postoperative pain and in the treatment of chronic apical periodontitis.

Some authors (14, 15) proposed that DL may be a successful adjunct to endodontic treatment of necrotic cases with chronic periapical lesions in terms of postoperative pain and root canal disinfection.

This study aimed to compare the effects of depotphoresis and DL on microbial count, postoperative pain, and healing of periapical lesions after 6 months by using CBCT.

Materials and Methods

The study population comprise of 90 patients presenting to the Endodontics Department of School of Dentistry, Zahedan University of Medical Sciences who required endodontic treatment of teeth with pulp necrosis associated with chronic apical periodontitis. The patients were

between 18 to 60 years, and the diagnosis of pulp necrosis with chronic apical periodontitis was confirmed by radiographic examination and negative response to cold test and electric pulp test, and no bleeding when exposing the pulp.
The protocol of this prospective, three-arm, parallel-group, single-blind, single-center, randomized clinical trial and the informed consent form were approved by the Research Ethics Committee of Zahedan University of Medical Science (IR.ZAUMS.REC.1397.278).
The study protocol was registered at https://en.irct.ir/trial/3284 (Iranian Registry of Clinical Trials identification number IRCT20180718040517N1).
This study was conducted and reported in accordance with the consolidated standards of reporting trials (CONSORT) (19). All enrolled patients signed informed consent forms after the nature of the study, its objectives, procedures, benefits and potential risks were explained to them.

Sample size calculation
A pilot study was designed to determine the size of the study population. Data obtained from the pilot study indicated that the sample size for each group should be a minimum of 25. Considering the possibility of dropouts, 30 patients were allocated to each group (a total of 90) assuming the effect size of 0.82, power of 80%, and 0.05 level of significance. The patients were enrolled from the outpatient clinic of the Department of Endodontics, Faculty of Dentistry between December 2018 and June 2020. One postgraduate student of endodontics performed the procedures.

Inclusion and exclusion criteria
The patients were between 18 to 60 years, and the diagnosis of pulp necrosis was confirmed by negative response to cold test and electric pulp test, and no bleeding when exposing the pulp. Diabetic patients, immunocompromised patients, pregnant women, and those with a history of analgesic intake in the past 3 days or antibiotic intake in the past month were excluded. Teeth with periodontal disease, or previous access cavity and those that could not be isolated by rubber dam were excluded as well.

Randomization, allocation concealment and masking of examiners
The patients were allocated to the three study arms with simple randomization. Randomization was performed online (endo.dent.zaums.ac.ir) right before the treatment onset. After recording the patients' demographics, eligible patients were automatically randomized into the three study groups of depotphoresis, diode laser, and control by using a computergenerated system. All the allocated patients received a unique patient identification code before starting the treatment. In the event of withdrawal from the study, the randomization code was not reused. Patient blinding was implemented. In Control group, in 15 patients, the fiber optic was placed inside the root canals without activation and and in 15 other patients, red clip of depotphoresis was placed on the patient's cheek and blue clip was places above the tooth's root canal without any current.
In the DL group, without any current, Red and blue clips, were placed inside the patient's mouth, as mentioned earlier. All patients and the operator wore protective glasses during all stages of the operation in all groups.
In the depotphoresis group, a mock application of laser was made with the power off.

Interventions
In the first session, the level of pain of patients was recorded before treatment using a visual analog scale (VAS). After dental flossing and dental plaque removal by pumice paste, rubber dam isolation was performed, and the tooth and the treatment area were disinfected with 30% H_2O_2 (v/v) for 30 s followed by 2.5% NaOCl. The access cavity was prepared with sterile high-speed bur (Tizcavan, Tehran, Iran) without water spray. After completion of access cavity preparation and caries removal (prior to exposure of the pulp chamber), the tooth, the clamp,

and the rubber dam were disinfected again with 2.5% NaOCl; 5% sodium thiosulfate was then used to neutralize sodium hypochlorite. Dental pulp was then exposed. Next, three sterile paper points were placed in the canal for 1 min to collect the first microbial sample (prior to root canal preparation). The collected sample (S1) was transferred into a tube containing HBI buffer and frozen at -20 °C.
A sterile #15H-file (Dentsply/Maillefer, Ballaigues, Switzerland) was then introduced into the canal, and the working length was determined by an apex locator (ROOT ZX; J. Morita, Tokyo, Japan) and confirmed radiographically. The narrow root canals were prepared with 25/8% Reciproc file (VDW, Munich, Germany) while the wide canals were prepared with 40/6% Reciproc file along with Reciproc Silver electric motor. Also, 2.5% NaOCl and 17% EDTA (Aria Dent, Tehran, Iran) were used for root canal irrigation. After chemomechanical preparation of the root canals, sterile saline was injected into the canals by a 27-gauge needle to a level below the orifice. Next, #30 Hedstrom file (Dentsply, Maillefer, Ballaigues, Switzerland) was used for filing and agitation of the canal content. This was done to enhance the release of dentin chips into the saline. Subsequently, three sterile paper points were introduced into the canal one by one and remained there for 60 s to collect the second sample (S2). Under aseptic conditions, the collected sample was transferred into a tube containing HBI buffer by a sterile hemostat and frozen at -20 °C. It was transferred to the lab on the same day.
Depotphoresis (Humamchemic GmbH, Alfeld, Germany) group: Cupral paste was prepared according to the manufacturer's instructions (to prepare Cupral solution, 1 unit of Cupral was mixed with 9 units of calcium hydroxide) and delivered into the coronal third of the canal by a Lentulo spiral. The positive electrode was connected to the patient's buccal mucosa by a clamp. The negative electrode was placed in the pulp chamber and the electric current was initiated and gradually increased (the current suggested by the manufacturer is 0.8-1.5 mA/5 min). The tooth was temporarily restored with Cavit (Golchay, Tehran, Iran) while calcium hydroxide Cupral remained in the canal as medicament.

Laser group
After root canal preparation, it was rinsed with saline and cleaned with paper points. Next, 940 nm diode laser (EPIC X, BIOLASE, Irvine, CA, USA) hand-piece with 200 µm tip diameter (EZTIP400&300) was introduced into the canal to 1 mm from the apex and was then pulled back with a circular motion at a speed of 2 mm/s towards the orifice. After 20 s of laser irradiation in pulse-mode, dental substrate was allowed to rest for 10 s. Laser irradiation was repeated 3 times. The laser parameters included λ=940 nm and 2 W power. The second samples were then collected (S2). The root canals were filled with a mixture of calcium hydroxide and saline, delivered into the canal by a Lentulo spiral (Dentsply Maillefer) as medicament, and temporarily restored with Cavit (Golchay, Tehran, Iran) between the treatment sessions.

Control group
After root canal disinfection and instrumentation, a mixture of calcium hydroxide and saline was delivered into the canal by a Lentulo spinal as medicament and temporarily restored with Cavit (Golchay, Tehran, Iran) between the treatment sessions.

Post-endodontic pain assessment
After completion of the first treatment session, the patients received a VAS form (graded from 0 to 10). They were instructed on how to fill out the VAS form and were requested to express their level of pain by selecting the score that best described their pain severity at 6, 12, 24, 48 and 72 h, post-treatment. A recall visit was also scheduled for them 7 days after treatment. Independent examiners who were blinded to the group allocation of patients evaluated the VAS forms.

Second treatment session
After removing the intracanal medica-

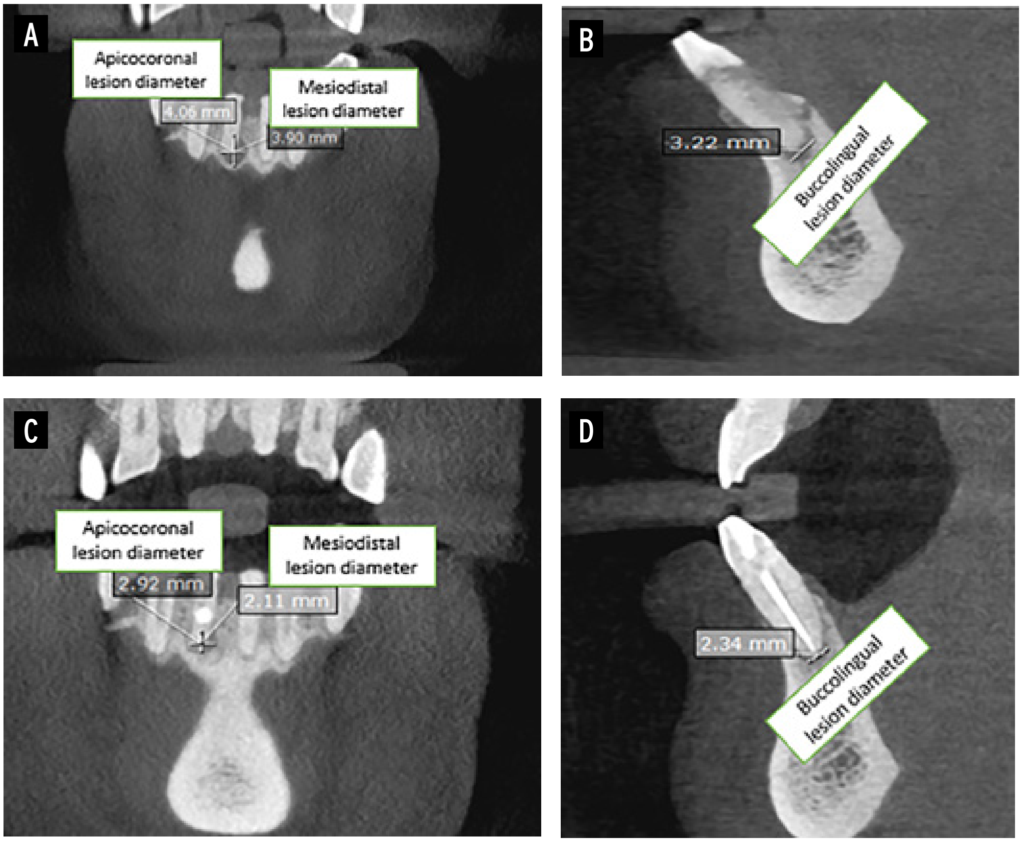


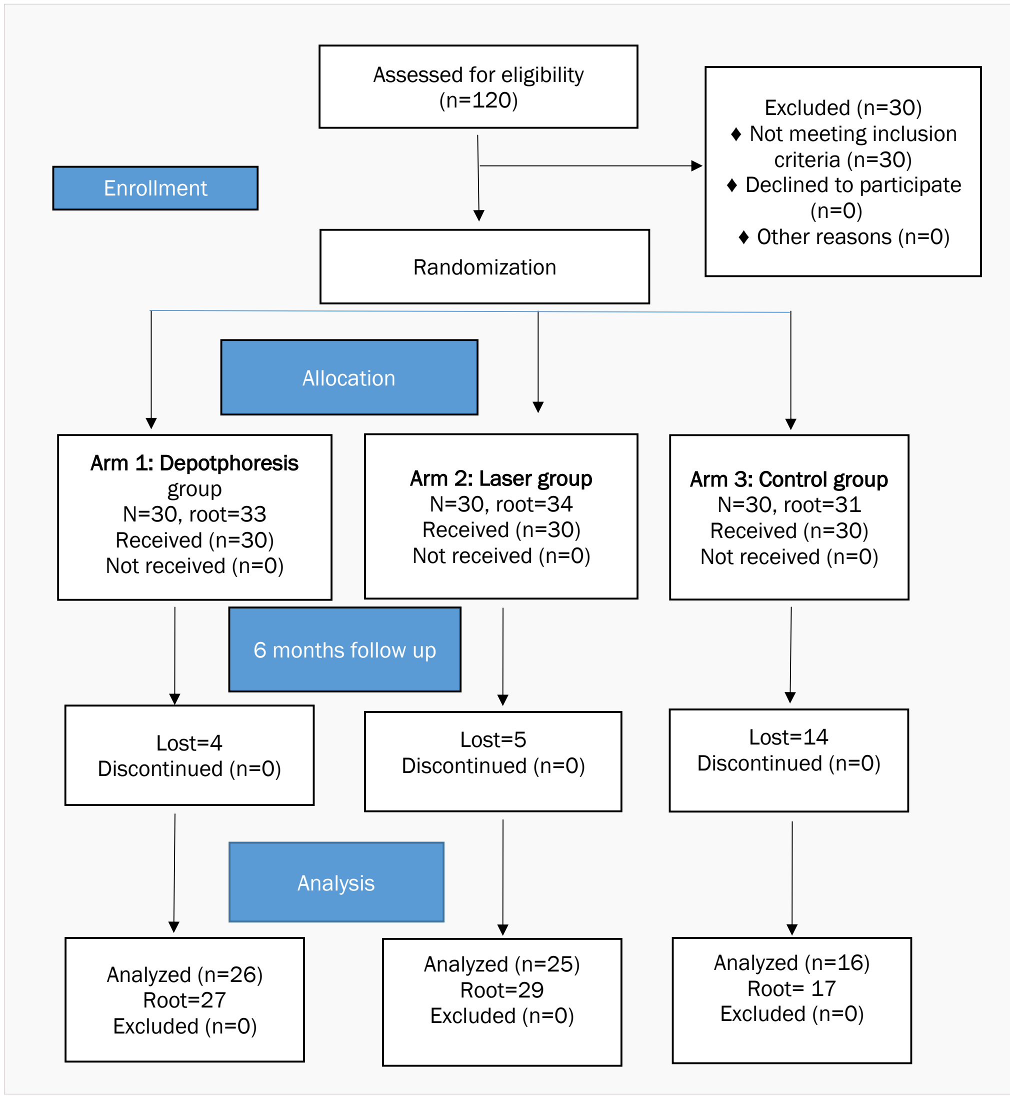
Figure 1
A, B Measurement of the preoperative diameter of the lesion and **C, D** diameter of the lesion after 6 months.

ments (calcium Cupral in depotphoresis group and calcium hydroxide in laser and control groups), the third sampling (S3) was performed as explained earlier. The teeth were then obturated and filled with composite resin. All endodontic treatments were performed by a post-graduate student of endodontics within 8 months.

Microbial analysis
The microbiological assessment was conducted by the "Colony Forming Unit Counting" method. Samples were transported to the laboratory within two hours after collection for microbiologic assessment. Samples in RTF vials were mixed well with a vortex for 30 seconds to facilitated bacterial dispersion. 10-fold serial dilutions were made in Phosphate Buffer Saline (PBS) solution. 10 ml of the sample was transferred to a sterile tube. 10 tubes containing 9 ml sterile saline were placed in a tube holder. An aliquot of 1 ml from the original sample was then transferred into the first tube containing 9ml of sterile saline. This process was repeated for each of the remaining 9 tubes. At the end of the 10-fold dilutions, 10 tubes covering the dilution range of $1:10^{-1}$ through to $1:10^{-10}$ had been made. For each tube, 1ml of the diluted sample was transferred to BHI agar plates and cultured under aseptic conditions. The plates were incubated at 37° C for 24 hours for the bacteria to grow. The number of bacterial colonies in each plate was visually quantified and reported as colony forming units per milliliter (CFU/ml). The number of bacteria (CFU) per milliliter of sample was calculated by dividing the number of colonies by the dilution factor. At last the outer numbers were thrown out and mean of the rest of numbers were calculated.

Radiographic technique
The healing of periapical lesions was evaluated on CBCT scans. Prior to the treatment onset, the respective tooth underwent CBCT. All primary and follow-up CBCT scans were performed by Acteon CBCT scanner (Acteon Group, Norwich, United Kingdom). All CBCT scans were obtained

Figure 2
Consort flowchart of the study.



with 40 mm^3 field of view and 0.2 µm voxel size with the exposure settings of 8 mA, 85 kVp and 10 s exposure time. All CBCT images were analyzed using OnDemand 3D software (CyberMed, Seoul, Republic of Korea).

Radiographic assessment
The following parameters were evaluated. Diameter of lesions: the maximum diameter of periapical lesions was measured in three directions of apicocoronal (Ly), mesiodistal (Lx) and buccolingual (Lz) parallel to the standard axis according to Kim et al (16) (Figure 1) If the lesion did not have a bony margin (for example, if the cortical plate or sinus wall had been perforated), the examiner would be asked to estimate the size of the lesion based on the visible bone margin at each side of the bone defect. The radiographic findings were analyzed according to Patel et al. (17) with some differences. Since the present study focused on root canal treatment of the teeth with chronic apical periodontitis, the codes 1 and 6 from the study by Patel et al. (17) were not applicable to our study. The CBCT images were evaluated by two endodontists, and in case of disagreement, a third endodontist was asked to cast the final judgment.

Statistical analysis
Data were analyzed with SPSS 23.0 (SPSS

Table 1
Bacterial count in 98 root canals with chronic apical periodontitis immediately after access cavity preparation (S1), after chemo-mechanical preparation (S2) and at one week after intracanal medicament (S3)

Group	immediately after access cavity preparation (S1)		immediately after cleaning and shaping (S2)		one week after intra canal medicament (S3)		*P* value
	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation	
Laser group	6080000±14150000		4323±2569		3075±2870		.000
Depotphoresis group	3070000±6602844		9370±33450		801±1089		.000
Control group	5770000±13610000		18400±22895		9998.6±15414		.000
P value*	.565		.041		.001		

Inc., Chicago, IL, USA). Bacterial colony forming unit and the comparison of pain scores between the three groups at each time interval were analyzed using the Kruskal-Wallis and Mann-Whitney U tests. Univariate analyses using the chi-square or Fisher exact test were performed to show the correlation of outcomes with variables to identify the potential predisposing factors. Multivariate analysis using a logistic regression model was performed with associated variables. P<0.05 was considered statistically significant.

Results

Of 90 patients, 71 (78%) were females and 19 (21%) were males. The mean age of patients was 34 years (range 18 to 60 years). A total of 90 teeth (98 roots) including anterior and posterior maxillary and mandibular teeth were evaluated; 67 patients (74 roots) showed up for the follow-up. Consort flowchart Shown in Figure 2.

Colony count
Table 1 reveals bacterial colony count before (S1) and after root canal preparation (S2) and One week after intra canal medicament (S3) observed in all groups. All groups presented effective bacterial reduction.
The results of the bacterial count of the DL group and Depotphoresis group showed statistically significant reduction in the bacterial count at S2 (p=.041) and S3 (p=.001) compared to other groups respectively.

Severity of pain
Figure 3 shows the severity of pain in the three groups. The mean pain score revealed statistically significant lower pain levels in the Dephotphoresis group compared with the control group at 6, 12, 24 and at 48 hours (P=0.02, P=0.007, P=0.001 and P=0.004 respectively), but had no significant difference with the values in the laser group (P>0.05). Also preopera-

Table 2
Frequency distribution of patients who showed up for the follow-up

		Depotphoresis		Laser		Control	
		Count	%	Count	%	Count	%
Gender	Male	10	38.46	6	24.00	1	6.25
	Female	16	61.54	19	76.00	15	93.75
Number of lesions		27		29		17	
Involved Jaw	Maxilla	9	34.62	11	44.00	5	31.25
	Mandible	17	65.38	14	56.00	11	68.75
	Age	25.62±11.36		32.44±13.44		26.29±12.45	

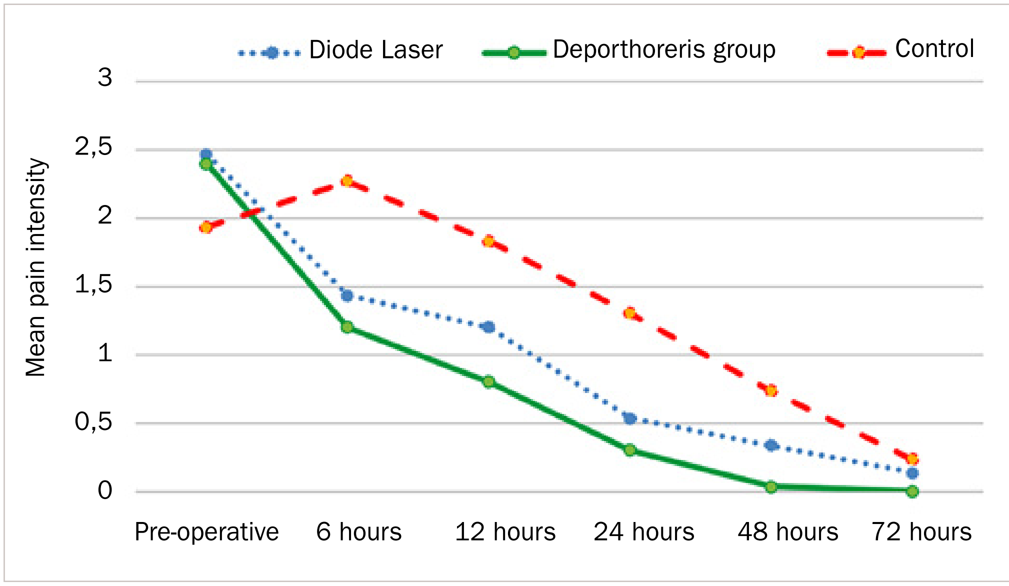


Figure 3
Mean pain score in the three groups at different time points.

tively there was no statistical significance difference between the evaluated groups (P=0.564).

Clinical and radiographic assessments at 6 months after treatment

Sixty-seven patients (74 roots) showed up for the follow-up session (recall rate=74%, Table 2). All endodontically treated teeth were asymptomatic and functional at the follow-up session. Coronal restorations were intact. The follow-up CBCT scans showed that all apical lesions experienced a reduction in size (were in the course of healing) or had completely healed. Thus, only codes 4 and 5 were used in this study. Table 3 shows the frequency of completely healed or healing lesions with ≤5 mm diameter and >5 mm diameter in apicocoronal, mesiodistal, and buccolingual directions in the three groups.

The current results revealed no significant difference in healing status of the lesions with mesiodistal and buccolingual diameter ≤5 mm and >5 mm in depotphoresis group (P>0.05). However, this difference was significant between lesions with apicocoronal diameter ≤5 mm and >5 mm (P=0.037) such that 33.33% of such lesions had completely healed. No significant difference was noted in healing status of the lesions with diameter ≤5 mm and >5 mm in the laser group (P>0.05). Also, none of the lesions in the control group showed complete healing. Table 4 compares the abovementioned parameters among the three groups. Except in depotphoresis group that the success rate was higher in the cases with lesions ≤5 mm in apicocoronal diameter (P=0.042), there was no positive correlation between the outcome of the therapy and the size of the periapical lesions diameters in all groups (p>0.05).

Discussion

In this study, the antibacterial results showed statistically significant lower bacterial count in the S2 samples of DL group and in the S3 samples of depotphoresis group than the other groups respectively.

The results of this study showed that the Depotphoresis group had statistically significant lower pain levels than the control group at all tested time intervals (6, 12, 24, 48 and 72 hours). There were no significant differences between DL group and Depotphoresis group.

The success rate was higher in the cases with lesions ≤5 mm in diameter in Depotphoresis group at Apicocoronal directions; however, there was no statistically significant difference between the three groups in the Buccolingual and mesiodistal directions.

As mentioned earlier, statistically significant reduction in the bacterial count was

Table 3
Frequency distribution of patients based on preoperative and outcome variables

Categories	Variables		Healing		Healed		P value
			Count	%	Count	%	
Depotphoresis	Mesiodistal lesion diameter (Lx)	size>5 mm	13	76.47	4	23.53	.136
		size>5 mm	10	100			
	Buccolingual lesion diameter (Ly)	size≤5 mm	13	86.67	2	13.33	.299
		size>5 mm	12	100			
	Apicocoronal diameter (Lz)	size≤5 mm	10	66.67	5	33.33	.037
		size>5 mm	12	100			
Laser	Mesiodistal lesion diameter (Lx)	size≤5 mm	12	100			.335
		size>5 mm	15	88.24	2	11.76	
	Apicocoronal lesion diameter (Ly)	size≤5 mm	7	100			.331
		size>5 mm	20	90.91	2	9.09	
	Buccolingual lesion diameter (Lz)	size≤5 mm	12	100			.569
		size>5 mm	15	88.24	2	11.76	
Control	Mesiodistal lesion diameter (Lx)	size≤5 mm	6	100			
		size>5 mm	11	100			
	Apicocoronal lesion diameter (Ly)	size≤5 mm	2	100			
		size>5 mm	15	100			
	Buccolingual lesion diameter (Lz)	size≤5 mm	4	100			
		size>5 mm	13	100			

P value=comparison of frequency of healed and healing lesions within each treatment group.
P value=comparison of the frequency of healing status.*

noted in all three groups after root canal preparation and disinfection (S2), which can be related to the effect of chemomechanical preparation of the root canal system and the disinfecting property of the interventions.

Microbiologists believe that diode laser irradiation results in permanent degradation of the cell membrane and changes the cell wall due to the direct effect of heat on the bacteria (14). Clinical use of different types of diode laser with near-infrared wavelength for disinfection of the root canal system has been well documented (18). These lasers penetrate deep (by up to 1000 µm) into dentin (19). Despite the attenuation of laser light when passing through the enamel prisms and dentinal tubules, it preserves its bactericidal effects (20).

In the present study, the reduction in bacterial count in the laser and depotphoresis groups was significantly greater than that in the control group at 1 week after treatment (S3). In the Depotphoresis group, Calcium hydroxide Cupral and in the DL group, Calcium hydroxide were used as intracanal medicament. The results of previous studies regarding the efficacy of calcium hydroxide as intracanal medicament are controversial (21, 22).

Some studies have confirmed its efficacy while some others have questioned it (23, 24). Due to the low solubility of calcium hydroxide and its low penetration depth into dentinal tubules, its long-term application is required for disinfection of dentinal tubules and reduction of inflammatory root resorption; which can decrease the fracture resistance of dentin and increase the risk of root fracture (11). Considering the drawbacks of calcium hydroxide, attempts are ongoing to improve its antibacterial properties. Evidence shows that use of silver or copper in combination with calcium hydroxide improves its antibacterial properties (25). Calcium hydroxide Cupral is used in depotphoresis (11). A previous study revealed

Table 4
Comparison of the frequency of healing and completely healed lesions with ≤5 and >5 mm initial diameter in the study groups

			≤5 mm			>5 mm		
			Depotphoresis	**Laser**	**Control**	**Depotphoresis**	**Laser**	**Control**
Mesiodistal lesion diameter (Lx)	**Healing**	Count	13	12	6	10	15	11
		%	76.47	100	100	100	88.24	100
	Healed	Count	4				2	
		%	23.53				11.76	
	P value		-	-	-	-	.001	-
	P value*		**0.271**			**0.277**		
Buccolingual lesion diameter (Lz)	**Healing**	Count	13	7	2	12	20	15
		%	86.67	100	100	100	90.91	100
	Healed	Count	2				2	
		%	13.33				9.09	
	P value			-	-	-	.001	-
	P value*		**0.52**			**0.278**		
Apicocoronal lesion diameter (Ly)	**Healing**	Count	10	12	4	12	15	13
		%	66.67	100	100	100	88.24	100
	Healed	Count	5				2	
		%	33.33				11.76	
	P value			-	-	-	.001	-
	P value*		**0.042**			**0.214**		

P value=comparison of frequency of healed and healing lesions within each study group.
P value=comparison of the frequency of healing status.*

that electrical stimulation of copper applied in combination with calcium hydroxide resulted in significantly higher antibacterial activity than the use of pure calcium hydroxide without electric stimulation (26). Knappvost et al. (26) reported similar results by addition of copper to calcium hydroxide and its electrical stimulation. They showed that calcium hydroxide/copper was 100 times more bactericidal than calcium hydroxide alone, and its efficacy did not decrease over time. These results are in accordance with our findings.
Another objective of the present study was to assess the level of pain in the three groups. The results showed a reduction in pain severity in all three groups after treatment. The most common factors related to post-endodontic pain include presence of microorganisms in the root canal system, and procedural errors such as over-instrumentation or inadequate cleaning, shaping or disinfection of the root canal. Nonetheless, a high number of patients experience post-endodontic pain without the aforementioned errors (27). Evidence shows that diode laser can effectively decrease post-endodontic pain (8, 27, 28). Diode laser exerts its anti-inflammatory effect by reduction of prostaglandin E2, bradykinin, histamine, acetyl choline, serotonin, and substance P, and decreases the chronic pain as such (29).
Chow et al. (29) in a systematic review suggested that laser light (energy density >300 mW/cm^2) absorbed by nociceptors can inhibit the pain signal transmission

through the A-delta and C fibers. Thus, it can decrease the speed of conduction and the action potential threshold of neurons and suppress neurogenic inflammation as such (29). In the present study, root canal irradiation was performed with laser in pulse mode to minimize the risk of thermal damage to the external root surface, which was effective for reduction of post-endodontic pain.

Yalgi et al. (9) used depotphoresis for endodontic treatment of necrotic teeth with chronic apical periodontitis in 30 patients. Twenty patients who had symptomatic pain at baseline had no pain after 3 days. However, studies on depotphoresis are limited. Another objective of the present study was to compare the healing rate of periapical lesions among the study groups. A total of 67 patients (74.4%) showed up for the follow-up session. Although higher recall rate is ideal, 75% is also acceptable. There was no case of treatment failure in the follow-up session; however, the frequency of healing lesions was significantly higher than that of healed lesions, which may be due to the short duration of follow-up (6 months).

In this study, each root was considered as one unit although Friedman (30) et al. stated that this method would result in over-estimation of the success rate, some others were against this statement (16, 31). Some studies found no positive correlation between the size of periapical lesions and the treatment outcome. (32, 33). Nonetheless, size of lesion had a significant effect on treatment success in some other studies. (31, 34, 35).

The negative effect of larger lesions on treatment success is due to the higher diversity of microorganisms and their association with longstanding infections because the bacteria in such lesions have greater penetration into the dentinal tubules. Moreover, these lesions may be associated with cystic transformation. (36) On the other hand, larger lesions in some patients have a slower response to ecological changes caused by the treatment protocol (37).

Evidence shows many cases of complete healing in presence of viable bacteria in the root canal at the time of obturation because the residual bacteria may be eliminated due to the toxicity of root filling materials, inaccessibility/unavailability of nutrients, or impairment of bacterial ecology. Alternatively, the residual bacteria may not have adequate quantity or virulence to continue the periradicular inflammation or may not have access to the periradicular tissues (38).

Conclusions

Both depotphoresis and DL groups, showed satisfactory bactericidal effects in cases of necrotic teeth with periapical lesions. Depotphoresis and intracanal diode laser irradiation have the ability to decrease the postoperative pain experienced after root canal treatment. Also the size of the preoperative periapical lesions had no significant effect on the outcome of endodontic treatment.

Clinical Relevance

DL and depotphoresis are effective in reducing intracanal bacteria count and postoperative pain after endodontic treatment in necrotic teeth with chronic apical lesions.

Conflict of Interest

None.

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References

1 *Verma N, Sangwan P, Tewari S, Duhan J. Effect of different concentrations of sodium hypochlorite on outcome of primary root canal treatment: a randomized controlled trial. Journal of endodontics. 2019;45(4):357-63.*

2 Bonsor S, Nichol R, Reid T, Pearson G. Microbiological evaluation of photo-activated disinfection in endodontics (an in vivo study). British dental journal. 2006;200(6):337-41.
3 Afkhami F, Akbari S, Chiniforush N. Entrococcus faecalis elimination in root canals using silver nanoparticles, photodynamic therapy, diode laser, or laser-activated nanoparticles: an in vitro study. Journal of endodontics. 2017;43(2):279-82.
4 Baker BW. Systematic review of the published literature on success and failure rates of nonsurgical endodontic treatment. 2013.
5 Gutknecht N, Al-Karadaghi TS, Al-Maliky MA, Conrads G, Franzen R. The bactericidal effect of 2780 and 940 nm laser irradiation on Enterococcus faecalis in bovine root dentin slices of different thicknesses. Photomedicine and laser surgery. 2016;34(1):11-6.
6 de Souza EB, Cai S, Simionato MRL, Lage-Marques JL. High-power diode laser in the disinfection in depth of the root canal dentin. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2008;106(1):e68-e72.
7 Kreisler M, Al Haj H, Noroozi N, Willershausen B, d'Hoedt B. Efficacy of low level laser therapy in reducing postoperative pain after endodontic surgery-a randomized double blind clinical study. International journal of oral and maxillofacial surgery. 2004;33(1):38-41.
8 Kuzekanani M, Plotino G, Gutmann JL. Current applications of lasers in endodontics. Giornale Italiano di Endodonzia. 2019;33.
9 Yalgi VS. Treatment of Chronic Apical Periodontitis Using Depotphorese: A Clinical Trial. Indian Journal of Stomatology. 2013;4(4):130.
10 Gergova RT, Gueorgieva T, Dencheva-Garova MS, Krasteva-Panova AZ, Kalchinov V, Mitov I, et al. Antimicrobial activity of different disinfection methods against biofilms in root canals. Journal of investigative and clinical dentistry. 2016;7(3):254-62.
11 Fuss Z, Mizrahi A, Lin S, Cherniak O, Weiss E. A laboratory study of the effect of calcium hydroxide mixed with iodine or electrophoretically activated copper on bacterial viability in dentinal tubules. International endodontic journal. 2002;35(6):522-6.
12 Polinsky AS. Evaluation and Comparison of Periapical Healing Using Periapical Films and Cone Beam Computed Tomography: Post-Treatment Follow Up. 2019.
13 Diwan A, Sreedevi C, Nagaraj T, Raghava V, Sinha P, Moushmi C. Determination of internal anatomy of a permanent dentition: A review. Int J Contemp Dent Med Rev. 2015;2015:110115.
14 Morsy DA, Negm M, Diab A, Ahmed G. Postoperative pain and antibacterial effect of 980 nm diode laser versus conventional endodontic treatment in necrotic teeth with chronic periapical lesions: A randomized control trial. F1000Research. 2018;7.
15 Kaplan T, Sezgin GP, Kaplan SS. Effect of a 980-nm diode laser on post-operative pain after endodontic treatment in teeth with apical periodontitis: a randomized clinical trial. BMC oral health. 2021;21(1):1-9.
16 Kim D, Ku H, Nam T, Yoon T-C, Lee C-Y, Kim E. Influence of size and volume of periapical lesions on the outcome of endodontic microsurgery: 3-dimensional analysis using cone-beam computed tomography. Journal of endodontics. 2016; 42(8):1196-201.
17 Patel S, Wilson R, Dawood A, Foschi F, Mannocci F. The detection of periapical pathosis using digital periapical radiography and cone beam computed tomography-Part 2: a 1-year post-treatment follow-up. International endodontic journal. 2012;45(8):711-23.
18 Rôças IN, Siqueira Jr JF. Detection of antibiotic resistance genes in samples from acute and chronic endodontic infections and after treatment. Archives of Oral Biology. 2013;58(9):1123-8.
19 Montagner F, Jacinto RC, Signoretti FGC, de Mattos VS, Grecca FS, de Almeida Gomes BPF. Beta-lactamic resistance profiles in Porphyromonas, Prevotella, and Parvimonas species isolated from acute endodontic infections. Journal of endodontics. 2014;40(3):339-4.
20 Suliman Al-Badah A, SS Ibrahim A, Al-Salamah AA, Ibrahim SSS. Clonal diversity and antimicrobial resistance of Enterococcus faecalis isolated from endodontic infections. Electronic journal of Biotechnology. 2015;18(3):175-80.
21 Mohammadi Z, Shalavi S, Yazdizadeh M. Antimicrobial activity of calcium hydroxide in endodontics: a review. Chonnam medical journal. 2012;48(3):133-40.
22 Nascimento GG, Rabello DG, Corazza BJ, Gomes AP, Silva EG, Martinho FC. Comparison of the effectiveness of single-and multiple-sessions disinfection protocols against endotoxins in root canal infections: systematic review and meta-analysis. Scientific reports. 2021;11(1):1-10.
23 Balto KA. Calcium hydroxide has limited effectiveness in eliminating bacteria from human root canal. Evidence-based dentistry. 2007;8(1):15-6.
24 Peters L, Van Winkelhoff AJ, Buijs J, Wesselink P. Effects of instrumentation, irrigation and dressing with calcium hydroxide on infection in pulpless teeth with periapical bone lesions. International endodontic journal. 2002;35(1):13-21.
25 Yousefshahi H, Aminsobhani M, Shokri M, Shahbazi R. Anti-bacterial properties of calcium hydroxide in combination with silver, copper, zinc oxide or magnesium oxide. European journal of translational myology. 2018;28(3).
26 Tsesis I, Lin S, Weiss EI, Fuss Z. Dentinal pH changes following electrophoretically activated calcium hydroxide ions in the root canal space of bovine teeth. Dental Traumatology. 2005;21(3):146-9.
27 Genc Sen O, Kaya M. Effect of root canal disinfection with a diode laser on postoperative pain after endodontic retreatment. Photobiomodulation, photomedicine, and laser surgery. 2019;37(2):85-90.
28 Pawar SS, Pujar MA, Makandar SD, Khaiser MI. Postendodontic treatment pain management with low-level laser therapy. Journal of Dental Lasers. 2014;8(2):60.
29 Chow R, Armati P, Laakso E-L, Bjordal JM, Baxter GD. Inhibitory effects of laser irradiation on peripheral mammalian nerves and relevance to analgesic effects: a systematic review. Photomedicine and laser surgery. 2011;29(6):365-81.
30 Friedman S, Mor C. The success of endodontic therapy healing and functionality. CDA J. 2004;32(6):493-503.
31 Ng YL, Mann V, Gulabivala K. A prospective study

of the factors affecting outcomes of nonsurgical root canal treatment: part 1: periapical health. International endodontic journal. 2011;44(7):583-609.
32 Moazami F, Sahebi S, Sobhnamayan F, Alipour A. Success rate of nonsurgical endodontic treatment of nonvital teeth with variable periradicular lesions. Iranian endodontic journal. 2011;6(3):119.
33 Aksoy F. Outcomes of nonsurgical endodontic treatment in teeth with large periapical lesion. 2019.
34 Hoskinson SE, Ng Y-L, Hoskinson AE, Moles DR, Gulabivala K. A retrospective comparison of outcome of root canal treatment using two different protocols. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2002;93(6):705-15.
35 Chugal NM, Clive JM, Spångberg LS. A prognostic model for assessment of the outcome of endodontic treatment: effect of biologic and diagnostic variables. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2001;91(3):342-52.
36 Karamifar K, Tondari A, Saghiri MA. Endodontic periapical lesion: An overview on the etiology, diagnosis and current treatment Modalities. European Endodontic Journal. 2020;5(2):54.
37 Sabala CL, Benenati FW, Neas BR. Bilateral root or root canal aberrations in a dental school patient population. Journal of endodontics. 1994;20(1):38-42.
38 Paiva SS, Siqueira Jr JF, Rôças IN, Carmo FL, Leite DC, Ferreira DC, et al. Molecular microbiological evaluation of passive ultrasonic activation as a supplementary disinfecting step: a clinical study. Journal of endodontics. 2013;39(2):190-4.

Lettera DEL PRESIDENTE

Carissimi Soci e Amici,
finalmente nuove prospettive si stanno delineando nel nostro orizzonte.
Il Paese Italia sta ripartendo con rinnovato slancio e nuovi propositi, noi di SIE, che in questo anno complicato abbiamo lavorato alacremente, siamo pronti a sostenere con le nostre iniziative questa ripartenza.
Le nuove norme ministeriali, abbinate a una campagna vaccinale capillare e all'introduzione del green pass lasciano ben sperare a una chiusura di anno più ottimistica.
In questi ultimi mesi i nostri sforzi saranno focalizzati sull'evento per noi più importante: il 37° Congresso Nazionale che finalmente si svolgerà in presenza al Palazzo della Cultura e dei Congressi di Bologna dal 12 al 13 novembre p.v.
Questo importante appuntamento scientifico per noi non rappresenta solo un momento di formazione e aggregazione, che comunque manca da mesi, ma sancirà la svolta tanto attesa.
In questa fase post acuta della pandemia da Covid-19 è necessario ridefinire nuovi standard per poter ripartire in una modalità che fino a un anno fa era impensabile. In questo scenario di profondi mutamenti oggi abbiamo un'opportunità unica, mai avuta nel nostro passato, che ritengo di vitale importanza cogliere: oggi abbiamo la possibilità di ripartire ridisegnando un nuovo futuro della Società per darle una rinnovata identità che meglio si adatti alle nuove sfide che ci attenderanno.
Per raggiungere questo ambizioso traguardo dobbiamo mettere in campo "armi" quali il coraggio, la consapevolezza e l'azione.
Io come Presidente, sostenuto e aiutato da tutto il Consiglio Direttivo SIE, che ringrazio, mi sto prodigando perché questo cambiamento sia un momento tangibile della nostra storia, a voi Soci però spetta esserci per sostenerci in questo delicato quanto stimolante passaggio!

Vi aspetto a Bologna!
Un caro saluto

Dott. Roberto Fornara
Presidente SIE
Società Italiana di Endodonzia

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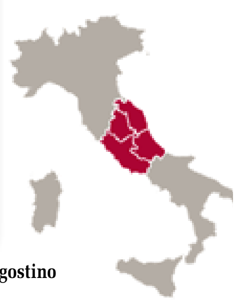

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COME DIVENTARE SOCIO ATTIVO/AGGREGATO

Scaricabile dal sito **www.endodonzia.it**

SOCIO AGGREGATO

Per avere lo status di Socio Aggregato si dovrà presentare la documentazione descritta nel sito www.endodonzia.it che sarà valutata dalla Commissione Accettazione Soci. La documentazione che verrà presentata dovrà mostrare con rigore, attraverso casi clinici, l'interessamento del candidato alla disciplina endodontica.
Un meccanismo a punti è stato introdotto per valutare l'ammissibilità del candidato allo "status" di Socio Aggregato: i punti saranno attribuiti in base al tipo di documentazione presentata. Possono accedere alla qualifica di Socio Aggregato tutti i Soci Ordinari della SIE, in regola con le quote associative degli ultimi tre anni, che completino e forniscano la documentazione alla Segreteria Nazionale (Via Pietro Custodi 3, 20136 Milano) entro i termini che verranno indicati all'indirizzo web: www.endodonzia.it.
La domanda dovrà essere firmata da un Socio Attivo, in regola con la quota associativa per l'anno in corso, il quale è responsabile della correttezza clinica e formale della documentazione presentata.

DOCUMENTAZIONE NECESSARIA PER DIVENTARE SOCIO AGGREGATO

Qualsiasi Socio Ordinario, con i requisiti necessari, può presentare la documentazione per ottenere la qualifica di Socio Aggregato. Un meccanismo a punti è stato introdotto per valutare il candidato: un minimo di 80 punti è richiesto per divenire Socio Aggregato.
La documentazione clinica per ottenere la qualifica di Socio Aggregato dovrà presentare almeno sei casi, di cui non più di tre senza lesione visibile nella radiografia preoperatoria e non più di uno di Endodonzia Chirurgica Retrograda.
Nella domanda non potranno essere presentati casi la cui somma superi i 120 punti per la qualifica di Socio Aggregato.
L'aspirante Socio Aggregato potrà presentare la documentazione clinica in più volte, con un minimo di 40 punti per presentazione, in un arco massimo di tre anni. Il mancato rinnovo della quota associativa, anche per un solo anno, annulla l'iter di presentazione dei casi.

SOCIO ATTIVO

Per avere lo status di Socio Attivo si dovrà presentare la documentazione descritta nel sito www.endodonzia.it che sarà valutata dalla Commissione Accettazione Soci. La documentazione che verrà presentata dovrà mostrare con rigore, attraverso documentazione scientifica e casi clinici, l'interessamento del candidato alla disciplina endodontica.
Un meccanismo a punti è stato introdotto per valutare l'ammissibilità del candidato allo status di Socio Attivo: i punti saranno attribuiti in base al tipo di documentazione clinica e scientifica presentata. Possono accedere alla qualifica di Socio Attivo tutti i Soci Ordinari della SIE, in regola con le quote associative degli ultimi tre anni, che completino e forniscano la documentazione alla Segreteria Nazionale (Via Pietro Custodi 3, 20136 Milano) entro i termini che verranno indicati all'indirizzo web: www.endodonzia.it.
La domanda di ammissione allo status di Socio Attivo rivolta al Presidente della SIE dovrà essere firmata da un Socio Attivo in regola con la quota associativa per l'anno in corso, il quale dovrà aver esaminato e approvato la documentazione. Quest'ultimo è responsabile della correttezza clinica e formale della documentazione presentata.

DOCUMENTAZIONE NECESSARIA PER DIVENTARE SOCIO ATTIVO

Qualsiasi Socio Ordinario, con i requisiti necessari, può presentare la documentazione per ottenere la qualifica di Socio Attivo. Il Socio Aggregato che volesse presentare la documentazione scientifica e clinica a integrazione di quella clinica già approvata dalla CAS per lo status di socio Aggregato, potrà farlo già dall'anno successivo all'ottenimento della sua qualifica.
Un meccanismo a punti è stato introdotto per valutare il candidato a Socio Attivo. Un minimo di 200 punti è richiesto per divenire Socio Attivo.
Nella domanda non potranno essere presentati casi la cui somma superi i 240 punti per la qualifica di Socio Attivo.
La documentazione scientifica potrà essere presentata, a completamento della documentazione clinica, solo per la domanda per divenire Socio Attivo e non potrà superare i 80 punti.
La documentazione clinica dovrà presentare un minimo di sei casi, di cui almeno 4 di molari pluriradicolati con delle precise tipologie: tra questi casi almeno uno deve essere un ritrattamento con lesione visibile nella radiografia preoperatoria e dei restanti tre almeno due devono avere una lesione visibile nella radiografia preoperatoria.
La documentazione clinica non deve presentare più di un caso di Endodonzia Chirurgica Retrograda con immagini e non più di uno senza immagini.
La documentazione scientifica non potrà presentare più di due articoli come coautore.

MODALITÀ DI DOCUMENTAZIONE DEI CASI CLINICI

Criteri e modalità per la valutazione dei casi clinici idonei ad accedere alle qualifiche di Socio Aggregato e di Socio Attivo sono espressi nell'apposita sezione del Regolamento della Società Italiana di Endodonzia (SIE) all'indirizzo web: www.endodonzia.it.

CRITERI DI VALUTAZIONE

I casi clinici verranno valutati nel loro complesso, coerentemente con gli scopi e fini della SIE, e devono essere presentati dai Candidati considerando non solo l'aspetto clinico, ma anche quello formale della documentazione presentata.
La documentazione scientifica verrà valutata considerando la classificazione ANVUR delle Riviste Scientifiche, i documenti scientifici dovranno essere tutti di pertinenza endodontica.

ADEMPIMENTI DEL CANDIDATO

La domanda di ammissione allo status di Socio Aggregato/Attivo, rivolta al Presidente della SIE, dovrà pervenire, insieme alla documentazione di seguito elencata, alla Segreteria della SIE con un anticipo di 20 giorni sulle date di riunione della CAS, sufficiente per poter organizzare il materiale dei candidati. Le date di scadenza saranno rese note sul sito. La domanda dovrà essere firmata da un Socio Attivo in regola con la quota associativa per l'anno in corso, il quale dovrà aver esaminato e approvato la documentazione. Quest'ultimo è responsabile della correttezza clinica e formale della documentazione presentata.

PRESENTAZIONE DEI CASI ALLA COMMISSIONE

La presenza del Candidato è obbligatoria durante la riunione della CAS; è altresì consigliabile la presenza del Socio presentatore.

LA COMMISSIONE ACCETTAZIONE SOCI

La CAS (Commissione Accettazione Soci) è formata cinque Membri di indiscussa esperienza clinica, quattro Soci Attivi con almeno cinque anni di anzianità in questo ruolo eletti a ogni scadenza elettorale dall'Assemblea dei Soci Attivi e Onorari e uno dei Past President della Società incaricato dal CD a ogni riunione. Compito della CAS è quello di esaminare e valutare la documentazione presentata dagli aspiranti Soci Aggregati e Soci Attivi. Per rispetto del lavoro dei Candidati e per omogeneità di giudizio, in ogni riunione CAS verranno valutati non più di 12 candidati a Socio Attivo; resta libero, invece, il numero dei candidati a Socio Aggregato valutabile in una singola riunione. Il Consiglio Direttivo (CD) incaricando la Commissione Accettazione Soci (CAS) la rende responsabile dell'applicazione delle regole descritte nell'articolo 2 del regolamento. Il giudizio della CAS è insindacabile.

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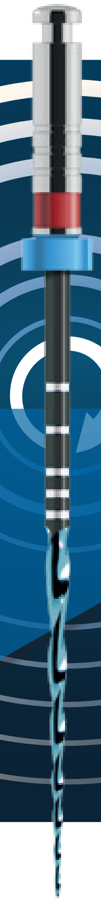

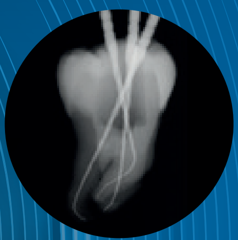

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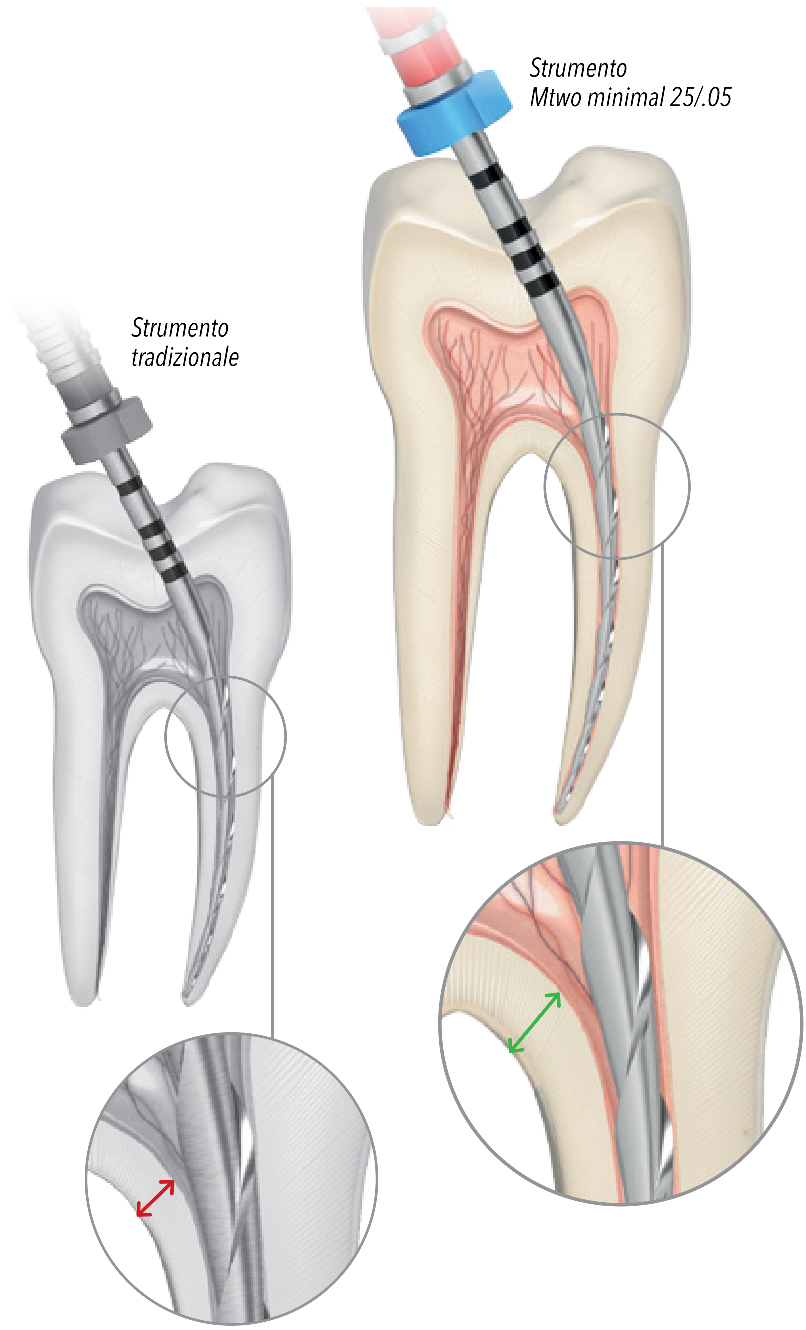
* confrontato con strumenti rotanti a sezione centrata

Mtwo minimal: l'endodonzia mini invasiva

Gli Mtwo hanno per primi introdotto agli inizi degli anni 2000 il concetto della riduzione della conicità man mano che il diametro in punta aumenta, dopo aver raggiunto l'apice (e quindi completato la sagomatura generale del canale) con lo strumento 25/.06, usando, a seconda del diametro apicale, gli strumenti 30/.05, 35/.04 e 40/.04. Dopo vent'anni durante i quali gli Mtwo hanno fatto scuola, ci rendiamo conto che non necessariamente, e non in tutti i canali, è utile arrivare al 25/.06, ma può bastare un 25/.05.
La serie minimal consente di arrivare a 25/.05 dopo lo scouting, con un solo strumento: il 17.05/.045.



Lo scouting Mtwo minimal

Lo scouting può essere affidato al tradizionale 10/.04, ma anche ai nuovi Mtwo minimal per canali più sottili: il 10/.035 e il 10/.03. Il 10/.03 è particolarmente adatto a canali che negli ultimissimi millimetri siano stretti e particolarmente difficili da penetrare; in questi casi la primissima esplorazione può essere eseguita con strumenti manuali in acciaio .08, per poi passare al 10/.03 che in pochi secondi percorrerà quei mm rendendoli pronti alle fasi successive di preparazione meccanica, altrettanto sicura e veloce.

La sequenza Mtwo minimal

Lo strumento 17.5/.045 riesce a raggiungere l'apice dopo lo scouting pressoché nella totalità dei casi, determinando un volume di preparazione che a sua volta permette sempre al 25/.05 di arrivare all'apice. La scelta del 17.5 è data dalla valutazione iniziale di un canale ritenuto di dimensioni tali da trovare nel 25/.05 lo strumento ideale per il completamento della preparazione: ideale perché ritenuto sufficiente, laddove il 25/.06 risulterebbe fin troppo grande.

Mtwo minimal per rifinitura apicale

In caso di canali sottili e, soprattutto con pareti sottili, che presentano apici di dimensioni superiori a 25, la rifinitura degli ultimi millimetri può essere affidata a strumenti con diametri di punta adeguati, ma con conicità .03, adatta a questi canali più piccoli. Questo nell'ottica costante di risparmiare dentina lungo le pareti canalari, riuscendo al contempo a completare la preparazione dei millimetri apicali secondo le dimensioni esistenti in ogni canale.
Anche questa volta gli Mtwo introducono misure di conicità inedite e mirate a un razionale assoluto: mantenere l'anatomia ma eliminare le cause della patologia con pochi, mirati, strumenti. Questa ulteriore possibilità di preparazione è da eseguire con velocità di rotazione contenuta, resa possibile (come nella sequenza standard) dalla efficienza e precisione di taglio degli strumenti che ben si adatta ai nuovi concetti di preparazione minimalista e sigillo con l'uso dei presidi più moderni.

Per info: Sweden & Martina
www.sweden-martina.com - Tel. +39.049.9124300

GUIDELINES FOR AUTHORS

Giornale Italiano di Endodonzia (GIE) was founded in 1987 and is the official journal of Società Italiana di Endodonzia, SIE (Italian Society of Endodontics) https://www.endodonzia.it/

It is a peer-reviewed journal, only available in electonic format and publishes original scientific articles, reviews, clinical articles and case reports in the field of Endodontology. Scientific contributions dealing with health, injuries to and diseases of the pulp and periradicular region, and their relationship with systemic well-being and health. Original scientific articles are published in the areas of biomedical science, applied materials science, bioengineering, epidemiology and social science relevant to endodontic disease and its management, and to the restoration of root-treated teeth. In addition, review articles, reports of clinical cases, book reviews, summaries and abstracts of scientific meetings and news items are accepted. Please read the instructions below carefully for details on the submission of manuscripts, the journal's requirements and standards as well as information concerning the procedure after a manuscript has been accepted for publication in Giornale Italiano di Endodonzia. Giornale Italiano di Endodonzia is indexed in Scopus, Science Direct, Embase and published online by Ariesdue, Milan, Italy and hosted by PAGEPress, Pavia, Italy. All articles are available on www.giornaleitalianoendodonzia.it.

We publish, monthly, new articles in the Early View section while the full Journal is issued twice a year, in June and November.

Authors are encouraged to visit **www.giornaleitalianoendodonzia.it** for further information on the preparation and submission of articles and figures.

Ethical guidelines

Giornale Italiano di Endodonzia adheres to the below ethical guidelines for publication and research.

Authorship and Acknowledgements

Authors submitting a paper do so on the understanding that the manuscript has been read and approved by all authors and that all authors agree to the submission of the manuscript to the Giornale Italiano di Endodonzia. Giornale Italiano di Endodonzia adheres to the definition of authorship set up by The International Committee of Medical Journal Editors (ICMJE). According to the ICMJE, authorship criteria should be based on 1) substantial contributions to conception and design of, or acquisiation of data or analysis and interpretation of data, 2) drafting the article or revising it critically for important intellectual content and 3) final approval of the version to be published. Authors should meet conditions 1, 2 and 3. It is a requirement that all authors have been accredited as appropriate upon submission of the manuscript. Contributors who do not qualify as authors should be mentioned under Acknowledgements.

Manuscript preparation

Manuscripts should be uploaded as Word (.doc) or Rich Text Format (.rtf) files (not write-protected) plus separate figure files: TIF, EPS, JPEG files are acceptable for submission.

The text file must contain the **abstract, main text, references, tables and figure legends**, but no embedded figures or title page. The title page should be provided as a separate file. In the main text, please reference figures as for instance **figure 1, figure 2** etc to match the tag name you choose for the individual figure files uploaded.

Please note that **manuscripts must be written in English**. Authors whose native language is not English are strongly advised to have their manuscript checked by a language editing service or by a native English speaker prior to submission.

Manuscript Types Accepted

Original Scientific Articles must describe significant and original experimental observations and provide sufficient detail so that the observations can be critically evaluated and, if necessary, repeated. Original Scientific Articles must conform to the highest international standards in the field.

Review Articles are accepted for their broad general interest; all are refereed by experts in the field who are asked to comment on issues such as timeliness, general interest and balanced treatment of controversies, as well as on scientific accuracy. Reviews should generally include a clearly defined search strategy and take a broad view of the field rather than merely summarizing the authors´ own previous work. Extensive or unbalanced citation of the authors´ own publications is discouraged.

Mini Review Articles are accepted to address current evidence on well-defined clinical, research or methodological topics. All are refereed by experts in the field who are asked to comment on timeliness, general interest, balanced treatment of controversies, and scientific rigor. A clear research question, search strategy and balanced synthesis of the evidence is expected. Manuscripts are limited in terms of word-length and number of figures.

Clinical Articles are suited to describe significant improvements in clinical practice such as the report of a novel technique, a breakthrough in technology or practical approaches to recognised clinical challenges. They should conform to the highest scientific and clinical practice standards.

Case Reports or **Case Series** illustrating unusual and clinically relevant observations are acceptable, but they must be of sufficiently high quality to be considered worthy of publication in the Journal. On rare occasions, completed cases displaying nonobvious solutions to significant clinical challenges will be considered. Illustrative material must be of the highest quality and healing outcomes, if appropriate, should be demonstrated.

Case reports should be written using the **Preferred Reporting Items for Case reports in Endodontics (PRICE) 2020 guidelines.** A PRICE checklist and flowchart (as a Figure) should also be completed and included in the submission material. The PRICE 2020 checklist and flowchart can be downloaded from: http://pride-endodonticguidelines.org/price/. It is recommended that authors consult the following papers, which explains the rationale for the PRICE 2020 guidelines and their importance when writing manuscripts:

- Nagendrababu V, Chong BS, McCabe P, Shah PK, Priya E, Jayaraman J, Pulikkotil SJ, Setzer FC, Sunde PT, Dummer PMH. *PRICE 2020 guidelines for reporting case reports in Endodontics: a consensus-based development.* Int Endod J. 2020 Feb 23. Doi: 10.1111/iej.13285. https://onlinelibrary.wiley.com/doi/10.1111/iej.13285.
- Nagendrababu V, Chong BS, McCabe P, Shah PK, Priya E, Jayaraman J, Pulikkotil SJ, Dummer PMH. *PRICE 2020 guidelines for reporting case reports in Endodontics: Explanation and elaboration.* Int Endod J. 2020 Mar 28. Doi: 10.1111/iej.13300. https://onlinelibrary.wiley.com/doi/abs/10.1111/iej.13300.

Manuscript Format

The **official language** of the publication is **English**. It is preferred that manuscript is professionally edited. All services are paid for and arranged by the author and use of one of these services does not guarantee acceptance or preference for publication.

Authors should pay special attention to the **presentation** of their research findings or clinical reports so that they may be communicated clearly.

Technical **jargon** should be avoided as much as possible and clearly explained where its use is unavoidable. **Abbreviations** should also be kept to a minimum, particularly those that are not standard. Giornale Italiano di Endodonzia adheres to the conventions outlined in *Units, Symbols and Abbreviations: A Guide for Medical and Scientific Editors and Authors.* If abbreviations are used in the text, authors are required to write full name+abbreviation in brackets [e.g. Multiple Myeloma (MM)] the first time they are used, then only abbreviations can be written (apart from titles; in this case authors have to write always the full name).

If names of equipments or substances are mentioned in the text, brand, company names and locations (city and state) for equipment and substances should be included in parentheses within the text.

The **background** and **hypotheses** underlying the study, as well as its main conclusions, should be clearly explained.
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- **Methodology:** describe the methods adopted.
- **Results:** give the main results of the study.
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THE STRUCTURE

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Conclusions should contain a summary of the findings.

Main Text of Review Articles

should be divided into Introduction, Review and Conclusions.
The Introduction section should be focused to place the subject matter in context and to justify the need for the review. The Review section should be divided into logical subsections in order to improve readability and enhance understanding. Search strategies must be described and the use of state-of-the-art evidence-based systematic approaches is expected. The use of tabulated and illustrative material is encouraged. The Conclusion section should reach clear conclusions and/or recommendations on the basis of the evidence presented.

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should be divided into Introduction, Review and Conclusions; please note that the **Conclusions section** should present clear statements/recommendations and suggestions for further work. The manuscript, including references and figure legends, should not normally exceed 4,000 words.

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(1) Somma F, Cammarota G, Plotino G, Grande NM, Pameijer CH. The effectiveness of manual and mechanical instrumentation for the retreatment of three different root canal filling materials. J Endod 2008;34:466-9.

Corporate author
British Endodontic Society - Guidelines for root canal treatment. Giornale Italiano di Endodonzia 1979;16:192-5.

Journal supplement
Frumin AM, Nussbaum J, Esposito M. Functional asplenia: demonstration of splenic activity by bone marrow scan (Abstract). Blood 1979;54 (Suppl. 1):26a.

Books and other monographs
Personal author(s)
Gutmann J, Harrison JW. Surgical Endodontics, 1st edn Boston, MA, USA: Blackwell Scientific Publications, 1991.

Chapter in a book
Wesselink P. Conventional rootcanal therapy III: root filling. In: Harty FJ, ed. Endodontics in Clinical Practice, (1990), 3rd edn; pp. 186-223. London, UK: Butterworth.

Published proceedings paper
DuPont B. Bone marrow transplantation in severe combined immunodeficiency with an unrelated MLC compatible donor. In: White HJ, Smith R, eds. Proceedings of the Third Annual Meeting of the International Society for Experimental Rematology; (1974), pp. 44-46. Houston, TX, USA: International Society for Experimental Hematology.

Agency publication
Ranofsky AL Surgical Operations in Short-Stay Hospitals: United States-1975 (1978). DHEW publication no. (PHS) 78-1785 (Vital and Health Statistics; Series 13; no. 34.) Hyattsville, MD, USA: National Centre for Health Statistics.

Dissertation or thesis
Saunders EM. In vitro and in vivo investigations into root-canal obturation using thermally softened gutta-percha techniques (PhD Thesis) (1988). Dundee, UK: University of Dundee.

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