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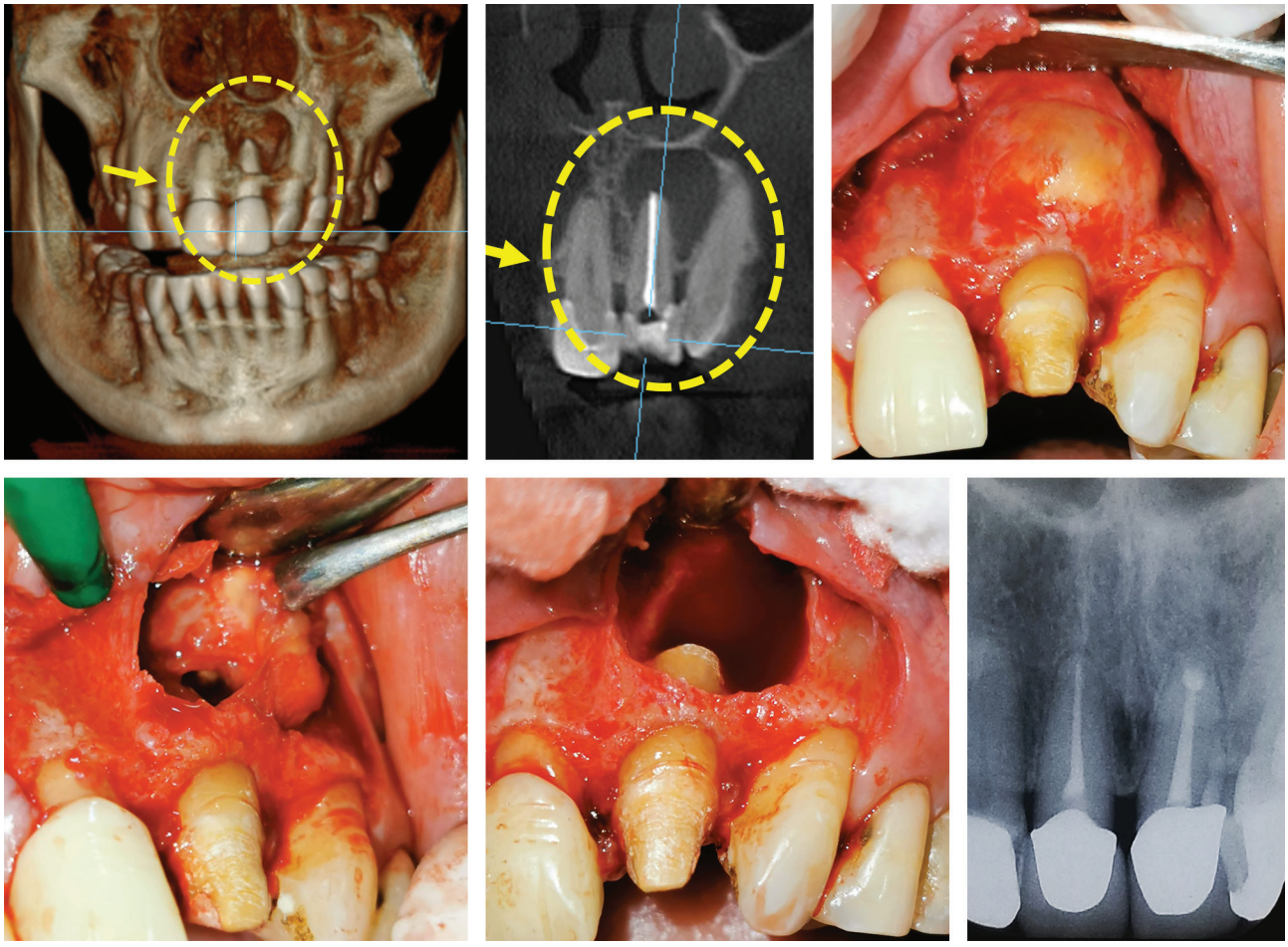

Official Journal of the Endodontic Society of the Philippines

CONTENTS

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THE ESP JOURNAL GUIDELINES FOR AUTHORS:

The ESP Journal calls for interested Endodontic specialists or specialists from other branches of dentistry, general dentists, academicians, researchers, and dental students, who would like to submit papers that would be relevant in the practice, research, and development of Endodontics in the global setting.

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The ESP Journal provides detailed information about the review and publication process.

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II. Authors Information:
The entry for author information should be: full name, title, and institutional affiliations (Position, Name of Institution, Department/College, City, Country).

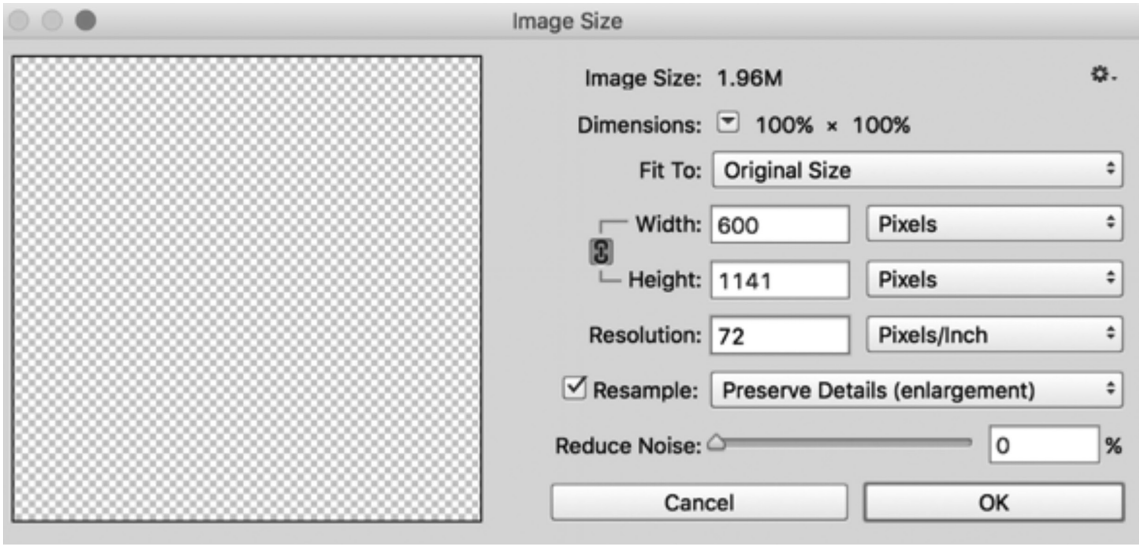
III. Abstract:
The abstract is a concise description of the problem, hypothesis, methods, results, and conclusion.
It should be no more than 250 words and is in bold format. 2-3 keywords may follow the abstract.

IV. Introduction:
This section should entice readers by describing the need for bridging the gap of a particular knowledge.
A few relevant review of literature and historical background of the problem covers this section.

V. Materials and Methods:
Materials and methods should all be described in paragraph form. No bullets are accepted.

VI. Results:

Relevant Figures and Tables that would clearly reflect on possible conclusions are in this section.
Each figures and table should have brief descriptions. Figure/Image formats if using Photoshop should be:



VII. Discussion:

This section discusses the current study's result with previous studies and how it can affect the purpose of the study. More importantly, conclusions are drawn in this section.

VIII. Acknowledgments

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Reference style follows the following format:

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  Example: Primus CM, Gutmann JL, Yapp R, Tay FR. Physical properties of new generation tricalcium silicate dental materials. Bioceram Dev Appl 2014;4:76, 2014; http://dx.doi.org/10.4172/2090-5025.

B. Original Case Reports:

I. Title (same as in Section A)
II. Introduction
III. Case History
IV. Materials and Methods
V. Discussion
VI. Conclusion
VII. Acknowledgments
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IV. Submission Procedure

Submissions are to be emailed to esp.journal2010@gmail.com. Acceptance of article will be notified to the main author through email. Unless the author has complied and has satisfied all members of *The ESP Journal* editorial board before the cut-off date for the upcoming issue, the article will be considered "pending" and will not be published on the said upcoming issue.

Correlation between Furcation Groove Depth and Palatal Dentin Thickness of Maxillary First Premolars Utilizing Cone-Beam Computed Tomography

Young Min Jung, DMD, MScD, Michelle S. Santos, DDM, MScD, and Grace Ellen S. Dey, DMD, MScD

Abstract

Introduction: An adequate knowledge of the root anatomical variations is essential in achieving a successful endodontic treatment. The furcation groove found on the buccal root of bifurcated maxillary first premolars is an anatomical structure displaying varying dentin thickness along its course which has implications during endodontic treatment. The purpose of this study was to evaluate the relationship between the furcation groove depth and palatal dentin thickness in the coronal and middle thirds of the buccal root of maxillary first premolars. **Methods:** A total of 31 Cone-Beam Computed Tomography images of bifurcated maxillary first premolars were examined. The furcation groove depth and palatal dentin thickness in the coronal and middle thirds were measured. **Results:** Spearman's Rho revealed a weak, negative correlation between the furcation groove depth (FGD) and palatal dentin thickness (PDT) in both coronal and middle thirds of the buccal root of maxillary first premolars (MFPs). **Conclusion:** There is no difference in the correlations between the coronal and middle thirds of the buccal root of bifurcated maxillary first premolars.

Introduction

Maxillary first premolars (MFPs) have complex anatomical features which include bifurcated roots, multiple canals, narrow furcation entrance width and mesial concavities. Therefore, endodontic treatment and prosthetic post procedure in this tooth is a challenge. Morphometric studies indicate that the presence of the groove on the palatal aspect led to varying wall thickness in this area of the buccal root (Tamse et al., 2000; Lammertyn et al., 2009; Li et al., 2013). A lack of knowledge about the possible relationship between this groove and wall thickness in the palatal aspect of the buccal root might lead to excessive thinning of the dentin wall during root canal procedures and may lead to iatrogenic errors such as strip perforation or vertical root fracture (Gutmann, 1992; Tomer et al., 2017).

The MFPs usually present with two roots that may either be separated or partially fused (Dababneh and Rodan, 2013). A distinct anatomical characteristic of buccal root of the bifurcated MFPs is the presence of a furcation groove (Tamse et al., 2000).

Furcation groove (FG) is also described as 'buccal furcation groove', 'developmental depression' or 'furcal concavity'. This groove is located on the palatal aspect of the buccal root, beginning on the coronal two-thirds, and gradually disappearing as it progresses towards the apex (Gher and Vernino, 1980).

Although the morphological features have been presented from other studies, there was not enough literature providing the relationship between the depth of this groove and thickness of the dentin wall in palatal aspect of the buccal root of bifurcated MFPs. Furthermore, anatomical studies on the presence of this groove on the buccal root demonstrated an average of less than 1 mm of dentin wall on the palatal in majority of cases. (Tamse et al., 2000; Katz et al., 2006; Lammertyn et al., 2009; Li et al., 2013; Al-Shahrani et al., 2013). A dentin thickness of ≤ 1.3 mm could increase the probability of vertical root fractures (Pilo et al., 2008, Silva et al., 2020).

Testori et al. in 1993, stated that the premolar is most prone to have vertical root fracture after endodontic treatment. Additionally, the vertical root fracture was mostly limited to the buccal root of bifurcated MFPs and the fracture patterns were found including cracking from the furcation groove to the canal surface (Chai and Tames, 2018).

In a study done by Lammertyn et al. in 2009 whereby they examined 20 extracted teeth aged 13 to 55 years old from an Argentinian population, results showed that there was a negative correlation between the furcation groove depth (FGD) and palatal dentin thickness (PDT) in the coronal third of the buccal root of MFPs. To further explore the previous research,

Li et al. in 2013 performed a micro-computed tomography study using 36 extracted teeth aged 35 to 65 years old from a Chinese population. The study determined that the bucco-palatal wall thickness of buccal root was asymmetric. There was a significant difference in PDT between the buccal and the palatal aspects in the coronal and middle thirds of the buccal root of bifurcated MFPs. Likewise, findings also revealed that there was a significant negative correlation between the root canal shape and furcation groove depth. The deeper the furcation groove, the more irregular the canal shape appeared and consequently, the more difficult it becomes during canal instrumentation and obturation.

In addition, Brook et al. (2008) stated that there is a relationship between the tooth size and ethnicity. Different genetic and environmental influences play a role in tooth size variability across populations. Furthermore, Liu et al. (2016) reported there is a relationship between the crown and root ratios in terms of length, surface area and volume of the premolars. Aside from that, the dentin goes through morphological and histological changes in which size of the root canal decreases with aging (Carvalho and Lussi, 2017; Liu et al., 2019).

Endodontic treatment is a multi-phase treatment procedure. During biomechanical preparation, enlarging the coronal third is essential to allow better access to the apical third for debris removal, canal enlargement, irrigation, medication and obturation (Katz et al., 2006). When instrumenting the canal, various cutting blade and tip designs and tapers of the files influence the removal of dentin structure (Abraham, 2018). For the obturation and post space preparation, the extent of lateral forces exerted on the root during cold lateral condensation (Chai and Tames, 2018), together with the amount of dentin removed during post space preparation was found to be greatest in the palatal aspect of the buccal root of bifurcated MFPs in both coronal (31.3%) and middle thirds (15.3%) (Katz et al., 2006; Pilo et al., 2008; Ghoddusi et al., 2013; Silva et al., 2020), which could eventually lead to vertical root fracture (Katz et al., 2006; Chai and Tames, 2018).

Investigations from previous studies indicate that the presence of the furcation groove may lessen the palatal dentin thickness and increase the complications during treatment of bifurcated MFPs (Lammertyn et al., 2009; Li et al., 2013). Nevertheless, correlation between the furcation groove depth and palatal dentin thickness in middle thirds has not been reported.

The aim of this study was to determine the relationship between FGD and PDT in the coronal and middle thirds of the buccal root of bifurcated MFPs using CBCT imaging.

Materials and Methods

The CBCT records of patients were obtained from Insights diagnostic (2/F St. Patrick's Square, 566 Shaw Boulevard, Barangay Highway Hills, Mandaluyong City, Metro Manila, Philippines).

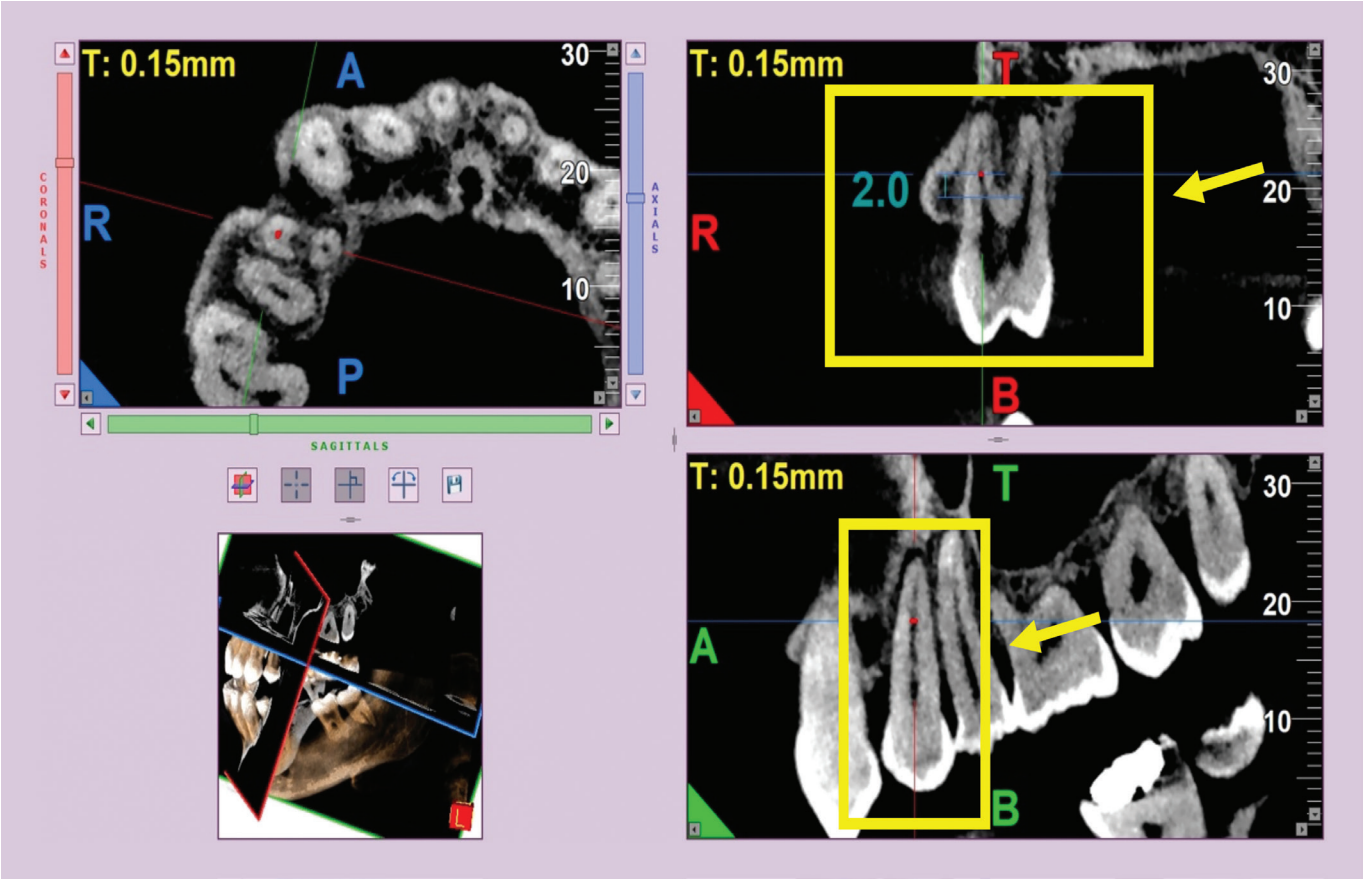

Figure 1: Isolation of the buccal root of bifurcated maxillary first premolar. Horizontal lines drawn to mark the coronal third of the buccal root and placement of marker for the root canal

The method of data collection was done by scanning CBCT images of one hundred seventy (170) patients. Thirty-one (31) fully developed left or right bifurcated MFPs samples were selected based on the inclusion and exclusion criteria.

CBCT Scans Acquisition

The CBCT images were taken using Myray Hyperion X9 (Cefla Dental Group, Imola, Bologna, Italy) machine set at 90kV and 10mA with an exposure time of 9 seconds, 75 µm of voxel size and field of view 11 x 8 cm, with thickness slice of 0.15 mm. The image acquisition process was performed by a radiologist from the manufacturer.

Calibration of the Examiners

For data validation, Inter-examiner calibration was performed. The measurements of ten (10) samples were selected randomly. All images were assessed separately twice by two examiners with 1-week interval between assessments. The measurements were then recorded and validated by an intraclass correlation coefficient test to confirm data reliability.

Manipulation of CBCT Scan Image

The iRYS Viewer Software version 5.6 was used to analyze the CBCT image in Multi-Planar Reformatting (MPR) mode.

1. Isolation of the buccal root of bifurcated maxillary first premolar (Fig. 1)
2. Measurement of the coronal third of the FGD and PDT (Fig. 2)
   a. Horizontal lines were drawn 2mm from the furcation in the coronal plane to mark the coronal third
   b. Measure the furcation groove depth and palatal dentin thickness
3. Measurement of the middle third of the FGD and PDT (Fig. 3)
   a. Horizontal lines were drawn 2mm from the anatomic apex to mark the apical third
   b. Another horizontal line, equidistant from the coronal and apical third, was drawn to mark the middle third
   c. Measure the furcation groove depth and palatal dentin thickness

Data Analysis

Statistical analysis was performed using SPSS (Version 22.0; IBM Corp, Armonk, NY). Intraclass correlation coefficient was tested to determine the reliability of the examiner. Shapiro-Wilk's test was used for normality of the data. Spearman's Rho was used to measure the strength of relationship between two variables.

Results

A total of 170 patients with CBCT image data were scanned, thirty-one (31) left or right bifurcated maxillary first premolars (MFPs) met the inclusion criteria and were examined by CBCT imaging. The individual furcation groove depth (FGD) and palatal dentin thickness (PDT) in the coronal and middle thirds of the buccal root of bifurcated MFPs were measured.

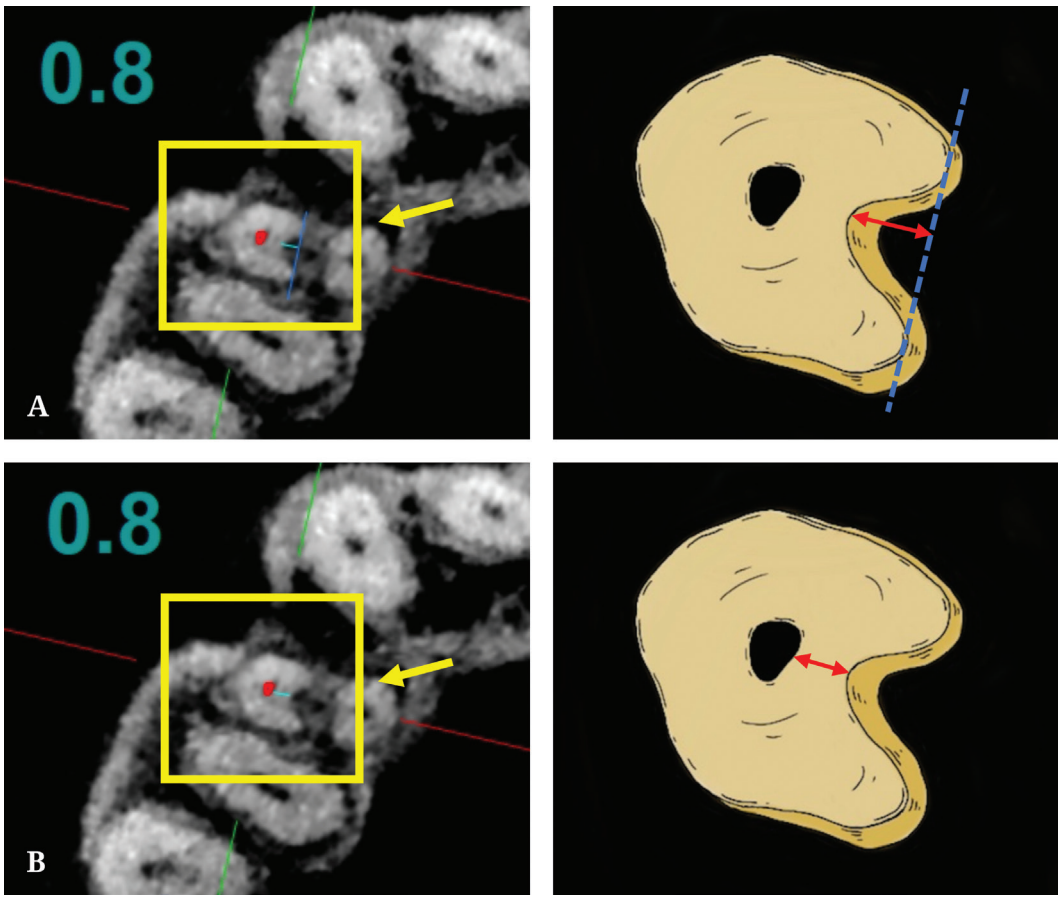

Figure 2: (A) Measurement of the coronal third of the FGD (Left) and schematic drawing of axial plane (Right). (B) Measurement of the coronal third of the PDT (Left) and schematic drawing of axial plane (Right).

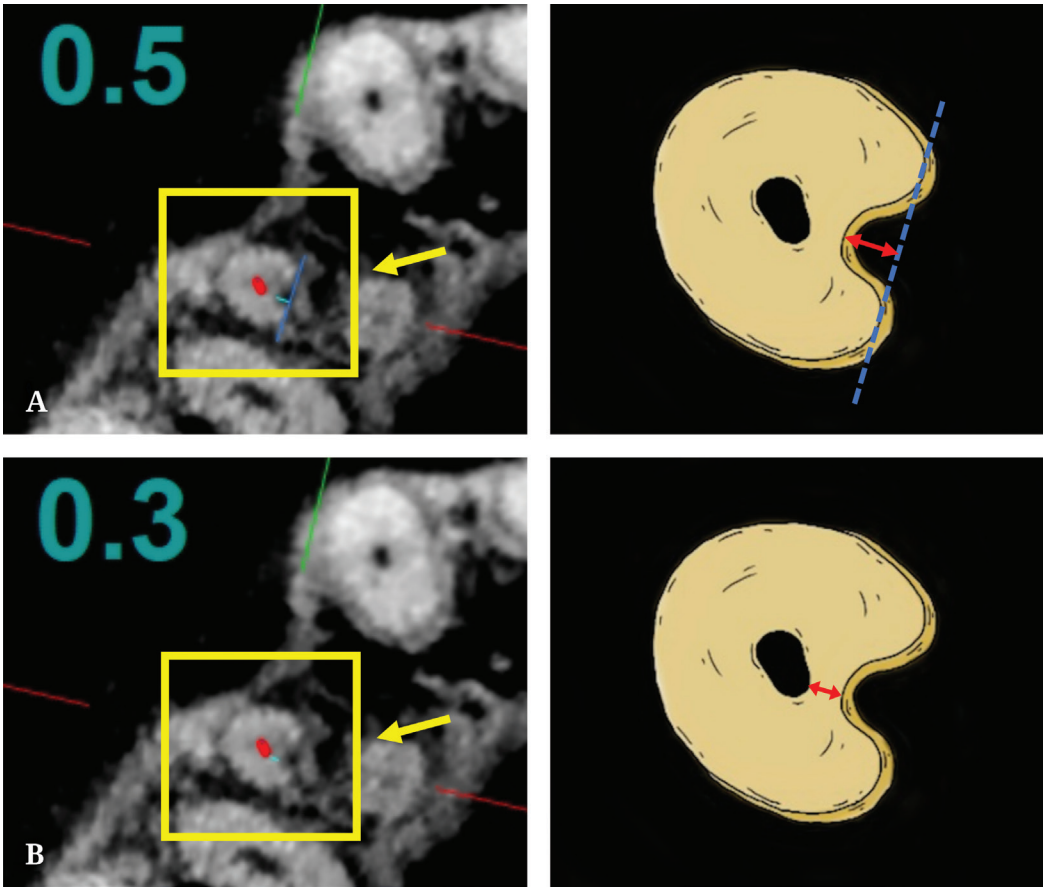

Figure 3: (A) Measurement of the Middle third of the FGD (Left) and schematic drawing of axial plane (Right). (B) Measurement of the Middle third of the PDT (Left) and schematic drawing of axial plane (Right).

All CBCT images were assessed separately by two examiners. The measurements were then recorded and validated by Intraclass correlation coefficient.

The descriptive statistics were generated consisting of the mean and standard deviation values for each measurement. The mean value of the furcation groove depth in the coronal third was 0.62 ± 0.21. The mean value of the palatal dentin thickness in the coronal third was 0.65 ± 0.24. The mean value of the furcation groove depth in the middle third was 0.46 ± 0.19. The mean value of the palatal dentin thickness in the middle third was 0.51 ± 0.19 (Table 1). The Spearman's Rho correlation was performed to establish the relationship between the furcation groove depth and palatal dentin thickness in the coronal and middle third of the buccal root of bifurcated MFPs. The results of the present study revealed that there is a weak, negative correlation between the FGD and PDT in both coronal (r= -.38, N = 31, P = .04 < .05) (Table 2a) and middle thirds (r= -.37, N = 31, P = .04 < .05) (Table 2b) of the buccal root of bifurcated MFPs. This indicates that there is a significant relationship between the furcation groove depth and palatal dentin thickness in both coronal and thirds of buccal root of bifurcated MFPs. The variables were inversely related, moving in opposite direction from each other.

Discussion

Bifurcated maxillary first premolars have inherent anatomical characteristics. The presence of the furcation groove may lead to uneven wall thickness in the palatal aspect of the buccal root of bifurcated MFPs. When the furcation groove gets deeper, the thinner the dentin thickness is, and the more irregular the canal shape appeared. Consequently, the more difficult the treatment of this tooth becomes (Lammertyn et al., 2009; Li et al., 2013).

This study was conducted to determine the relationship between the furcation groove depth and palatal dentin thickness in the coronal and middle thirds of the buccal root of bifurcated MFPs. Thirty-one (31) samples were examined by CBCT imaging, the measurements were subjected to statistical analysis using the Shapiro-Wilk test and Spearman's Rho correlation.

The results of present study revealed that there is a weak, negative correlation between the FGD and PDT in both coronal and middle thirds of the buccal root of bifurcated MFPs. This indicates that the inverse relationship between the furcation groove and the palatal dentin wall was observed in both coronal and middle thirds. The study also showed that there is no difference between the two correlations in the coronal and middle thirds of buccal root of bifurcated MFPs. However, a study conducted by Lammertyn et al. (2009) revealed that there was a high, negative correlation between the FGD and PDT in coronal thirds. Findings from their study reported an average FGD of 0.44 mm in the coronal and 0.34 mm in the middle thirds. In the present study, the average FGD showed 0.62 mm in the coronal, 0.46 mm in the middle thirds.

The differences in the result could be due to the difference in

Table 1:
Descriptive Statistics of the furcation groove depth and palatal dentin thickness in the coronal and middle thirds of the buccal root of maxillary first premolars

Group	N	Mean	Std. Deviation
Coronal FGD	31	.62	.21
Coronal PDT	31	.65	.24
Middle FGD	31	.46	.19
Middle PDT	31	.51	.19

Table 2a:
Spearman's Rho Correlation: Furcation groove depth and palatal dentin thickness in the coronal third of the buccal root of maxillary first premolars

		Coronal FGD	Coronal PDT
Coronal FGD	Correlation Coefficient	1.00	-.38*
	Sig. (2-tailed)	.	.04
	N	31	31
Coronal PDT	Correlation Coefficient	-.38*	1.00
	Sig. (2-tailed)	.04	.
	N	31	31

Note. Correlation is significant at the 0.05 level (2-tailed).

Table 2b:
Spearman's Rho Correlation: Furcation groove depth and palatal dentin thickness in the middle third of the buccal root of maxillary first premolars

		Middle FGD	Middle PDT
Middle FGD	Correlation Coefficient	1.00	-.37*
	Sig. (2-tailed)	.	.04
	N	31	31
Middle PDT	Correlation Coefficient	-.37*	1.00
	Sig. (2-tailed)	.04	.
	N	31	31

Note. Correlation is significant at the 0.05 level (2-tailed).

ethnicity. In the present study, CBCT images among Filipino citizens were used. However, the study done by Lammertyn et al. (2009), made use of extracted teeth from an Argentinian population. Brook et al. (2008) found out that there is a relationship between tooth size and ethnicity. Their study reported that Western-Eurasian populations tend to have the smallest tooth size and American Indian populations tend to have the largest tooth size. Additionally, Southern Chinese populations tend to have larger mesio-distal crown dimensions. The study concluded that both genetic and environmental factors influence tooth size. Furthermore, Liu et al. (2016) found out that a significant relationship exists among the crown to root ratios in length, surface area and volume of the premolars.

The average PDT measurements from the present study showed 0.65 mm in coronal, 0.51 mm in middle thirds. These findings are similar to Li et al. (2013) wherein their study reported the average PDT measurements of 0.73 mm in the coronal, and 0.66 mm in the middle thirds. However, in a study done by Lammertyn et al. (2009), the average PDT measurements showed 1.17 mm in the coronal, and 0.97 mm in the middle thirds.

The variability in the results can be due to the age of the patient's teeth when the samples were taken. In the present study, samples gathered were from aged 13 to 55 years old. Li et al. (2013) examined teeth from individuals aged 17 to 25 years old. However, Lammertyn et al. (2009) examined teeth from adults

aged 35 to 65 years old. The dentin goes through morphological and histological changes as the patient gets older. Therefore, the root canal diameter of the maxillary first premolars is larger in age 20s compared to 40s, showing decreasing diameter size with aging (Carvalho, T. S. and Lussi, A., 2017; Liu et al., 2019).

Based on the findings of this study, the presence of the furcation groove on the buccal root of maxillary first premolars rendered the palatal dentin thickness thinner. Therefore, when treating a bifurcated MFP, clinicians can use this information in exercising caution by positioning the file more on the buccal aspect of the buccal root to conserve dentin structure on the palatal aspect of bifurcated MFPs during biomechanical preparation.

The various cutting blade, tip design and taper of the files selected during root canal treatment also influence the amount of dentin structure removed (Abraham, 2018). Hence, the practitioners should avoid using greater taper size file as well.

Additionally, the increased loss of dentin with post space preparation has led to a shift in performing minimally invasive techniques that uses restorations that are bonded directly to teeth. Fiber-reinforced resin material, which uses advanced adhesive technology and reinforced composite has been used as posts and full cuspal coverage restorations on posterior teeth (Rocca et al., 2013).

Conclusion

The study determined that there is a weak-negative significant relationship between the furcation groove depth and palatal dentin thickness in both coronal and middle thirds of the buccal root of bifurcated maxillary first premolars, which means, the variables measured behave in opposite direction from each other. The study also determined that there is no difference in the correlation between the coronal and middle thirds of the buccal root of bifurcated maxillary first premolars.

Conflicts of Interest

The authors disclosed that there is no conflict of interest.

Acknowledgements

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References

1. Abraham AJ. CBCT evaluation of deepest portion of furcal groove in maxillary first premolars before and after instrumentation with stainless steel hand files and two niti rotary file systems. The Tamilnadu Dr. M.G.R. Medical University Chennai 2018.
2. Ahmad IA, Alenezi MA. Root and root canal morphology of maxillary first premolars: a literature review and clinical considerations. American Association of Endodontists 2016; 42(6): 861-872; http://dx.doi.org/10.1016/j.joen.2016.02.017.
3. Al-Shahrani SM, Al-Sudani D, Almalik M, Gambarini G, AlRumaihi FA, Microcomputed tomographic analysis of the furcation grooves of maxillary first premolars. Ann Stomatol (Roma) 2013; 4(1): 142-148; https://doi.org/10.11138/ads.0142.
4. Baumgaertel S, Palomo JM, Palomo L, Hans MG. Reliability and accuracy of cone-beam computed tomography dental measurements. American Journal of Orthodontics and Dentofacial Orthopedics 2009; 136(1): 19-25; https://doi.org/10.1016/j.ajodo.2007.09.016.
5. Brook AH, Griffin RC, Townsend G, Levisianos Y, Russell J, Smith RN. Variability and patterning in permanent tooth size of four human ethnic groups. Archives of oral biology 2008; 54: 79-85; https://doi.org/10.1016/j.archoralbio.2008.12.003.

6. Carvalho TS, Lussi A. Age-related morphological, histological and functional changes in teeth. Journal of Oral Rehabilitation 2017; 44(4): 291-298; https://doi.org/10.1111/joor.12474.
7. Chai H, Tames A. Vertical root fracture in buccal roots of bifurcated maxillary premolars from condensation of gutta-percha. Journal of Endodontics 2018; 44(7): 1159-1163; https://doi.org/10.1016/j.joen.2018.03.017.
8. Cotton TP, Geisler TM, Holden DT, Schwartz SA, Schindler WG. Endodontic applications of cone-beam volumetric tomography. Journal of Endodontics 2007; 33(9): 1121-1132; https://doi.org/10.1016/j.joen.2007.06.011.
9. Dababneh R, Rodan R. Anatomical landmarks of maxillary bifurcated first premolars and their influence on periodontal diagnosis and treatment. Journal of the international academy of periodontology 2013; 15(1): 8-15.
10. Gher ME, Vernino AR. Root morphology – clinical significance in pathogenesis and treatment of periodontal disease. Journal of the American Dental Association 1980; 101(4): 627-633; https://doi.org/10.14219/jada.archive.1980.0372.
11. Ghoddusi J, Bagherpour A, Mahmudabadi F, Forghani M, Sarmad M. Residual dentin thickness of bifurcated maxillary premolars following two post space preparation methods. Iranian Endodontic Journal 2013; 8(3): 94-98.
12. Giudice RL, Puleio FN, Alibrandi A, Cervino G, Lizio AS, Pantaleo G. Accuracy of periapical radiography and CBCT in endodontic evaluation. International Journal of Dentistry 2018; 1-7; https://doi.org/10.1155/2018/2514243.
13. Gulabivala K, Ng YL. Tooth organogenesis, morphology and physiology. Endodontics 2014; 2-32; http://doi.org/10.1016/b978-0-7020-3155-7.00001-1.
14. Gupta S, Sinha DJ, Gowhar O, Tyagi SP, Singh NN, Gupta S. Root and canal morphology of maxillary first premolar teeth in north Indian population using clearing technique: an in vitro study. Journal of Conservative Dentistry 2015; 18(3): 232-236; https://doi.org/10.4103/0972-0707.157260.
15. Gutmann JL. The dentin-root complex: anatomic and biologic considerations in restoring endodontically treated teeth. Journal of Prosthetic Dentistry 1992; 67(4): 458-67; https://doi.org/10.1016/0022-3913 (92)90073-J.
16. Katz A, Wasenstein-Kohn S, Tames A, Zuckerman O. Residual dentin thickness in bifurcated maxillary premolars after root canal and dowel space preparation. American Association of Endodontists 2006; 32(3): 202-205; https://doi.org/10.1016/j.joen.2005.10.048.
17. Lammertyn PA, Rodrigo SB, Brunotto M, Crosa M. Furcation groove of maxillary first premolar, thickness, and dentin structures. Journal of Endodontics 2009; 35(6): 814-817; https://doi.org/10.1016/j.joen.2009.03.012.
18. Li J, Li L, Pan Y. Anatomic study of the buccal root with furcation groove and associated root canal shape in maxillary first premolar by using micro-computed tomography. American Association of Endodontists 2013; 32(2); http://dx.doi.org/10.1016/j.joen.2012.10.003.
19. Liu L, Li H, Zhao T, Gao Y, Guo J, Wang X, Li X. Crown-to-root ratios in terms of length, surface area and volume: A pilot study of premolars. International Journal of Morphology 2016; 34(2): 465-470.
20. Liu X, Gao M, Ruan J, Lu Q. Root canal anatomy of maxillary first premolar by microscopic computed tomography in a Chinese adolescent subpopulation. BioMed Research International 2019; https://doi.org/10.1155/2019/4327046.
21. Patel S, Dawood A, Ford TP, Whaites E. The potential applications of cone beam computed tomography in the management of endodontic problems. International Endodontic Journal 2007; 40(10): 818-830; https://doi.org/10.1111/j.1365-2591.2007.01299.x.
22. Pilo R, Shapenco E, Lewinstein I. Residual dentin thickness in bifurcated maxillary first premolars after root canal and post space preparation with parallel-sided drills. Journal of Prosthetic Dentistry 2008; 99(4): 267-273; https://doi.org/10.1016/S0022-3913 (08)60059-1.
23. Rocca GT, Rizcalla N, Krejci I. Fiber-reinforced resin coating for endocrown preparations: a technical report. Operative Dentistry 2013; 38(3): 242-248; https://doi.org/10.2341/12-139-tr.
24. Sethi P, Tiwari R, Das M, Singh MP, Agarwal M, Ravikumar AJ. Two dimensional versus Three-dimensional imaging in endodontics – an updated review. Journal of Evolution of Medical and Dental Sciences 2016; 5(84): 6287-6293; https://doi.org/10.14260/jemds/2016/1420.
25. Sherrard JF, Rossouw PE, Benson BW, Carrillo R, Buschang PH. Accuracy and reliability of tooth and root lengths measured on cone-beam computed tomography. American Journal of Orthodontics and Dentofacial Orthopedics 2010; 137(4): 100-108; https://doi.org/10.1016/j.ajodo.2009.03.040.
26. Silva LR, Lima KL, Santos AA, Leles CR, Estrela CE, Freitas Silva BS, Yamamoto-Silva FP. Dentin thickness as a risk factor for vertical root fracture in endodontically treated teeth: a case-control study. Clinical Oral Investigations 2020; https://doi.org/10.1007/s00784-020-03406-1.
27. Sopariwala N, Garg S. Buccal furcation groove in bifurcated maxillary first premolars and associated residual dentine cementum wall thickness using cone beam computed tomography: an in vitro study. Endodontic Practice Today 2016; 10(4): 231-238.
28. Tamse A, Katz A, Pilo R. Furcation groove of buccal root of maxillary first premolars – a morphometric study. Journal of Endodontics 2000; 26(6): 359-363; https://doi.org/10.1097/00004770-200006000-00012.
29. Testori T, Badino M, Castagnola M. Vertical root fractures in endodontically treated teeth: a clinical survey of 36 cases. Journal of Endodontics 1993; 19(2): 87-91; https://doi.org/10.1016/S0099-2399 (06)81202-1.
30. Tomer AK, Miglani A, Chauhan P, Nagarjuna P, Rana S, Kumari A. An in-vitro evaluation of remaining dentine thickness through CBCT using different file. Journal of Dental and Medical Sciences 2017; 16(2): 121-124; https://doi.org/10.9790/0853-160201121124.
31. Walmsley AD, Lumley PJ, Shortall AC, Pretty IA, Walsh TF, Burke FJ, Hayes-Hall R. Restorative dentistry (second edition). Churchill Livingstone 2007; 89-113; https://doi.org/10.1016/B978-0-443-10246-2.50012-5.

Dentists' Knowledge of Root Canal Treatment is Sub-optimal and Variable: A Scoping Review

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Abstract

Introduction: Social, psychological, and behavioral dimensions influence both patients and dentists in their provision of nonsurgical root canal treatment (NSRCT). Knowledge is the comprehension or awareness of an idea or intention. Cognitions are not only formed by educational experiences, but by all interactions with the world. It is possible that a less than optimal quality of community NSRCT is related to knowledge gaps. The purpose of this study was to conduct a scoping review to determine if dentists' knowledge of NSRCT may affect the provision of care for disease of pulpal origin. **Methods:** A scoping review, a newer approach to evidence synthesis, useful when a systematic review would not be effective, was conducted. Defined searching produced 715 titles; 39 papers were included from countries that spanned the Human Development Index; data was compiled into an evidence table and summarized. Data on dentists' knowledge focused on themes of fundamental importance to patient welfare. A wide variety of NSRCT areas were addressed and 30 distinct topics identified. **Results:** All papers showed substantial gaps in dentists' NSRCT knowledge; dentists' responses to clinically oriented questions varied widely. Deficiencies existed in both rarely used and frequently used knowledge, in areas long unchanged and in the new. Like other humans, dentists are and cannot be all-knowing. Lack of knowledge appears to be a foundational problem, but the underlying causes are unknown. **Conclusion:** Despite many efforts, knowledge related to NSRCT is both variable and poor, and the provision of knowledge without attention to dentists' social cognitions is unlikely to be successful.

MeSH Terms and keywords: root canal, knowledge, endodontics, review

Significance

The value of this present study is in the application of its insights towards advancing the dental profession and quality of root canal treatment that we deliver to our patients. As members of a healthcare profession, it is incumbent upon us to surveil our community, promote best practices, accept knowledge, reflect, and solicit regular external feedback on our care.

Introduction

Longitudinal studies of non-surgical root canal treatment (NSRCT), generally performed in institutional settings, point to extremely high rates of healing or success (1-3). In contrast, cross-sectional studies of populations all around the World have found high prevalence of cases with periapical radiolucencies and have broadly decried the quality of community NSRCT (4, 5). Nonetheless, NSRCT is widely accepted and utilized by dentists, resulting in a very high prevalence amongst patient populations worldwide. There is a large gap between what routinely occurs in institutions, including dental student clinics, and what routinely happens in community practice (5). This pattern is found in societies at all levels of development, wealthy or not, so it is probably not caused by resource issues (5).

Social, psychological, and behavioral dimensions of disease of pulpal origin and NSRCT influence both patients and dentists (1, 6). Knowledge, beliefs, attitudes, preferences, behaviors, and decision-making processes not only shape patients' responses (7), but also dentists' responses to disease and treatment. Bjorndal has suggested that dentists view NSRCT not so much as treating an infectious disease, but as a procedure to relieve symptoms, hence NSRCT likely accepted by dentists regardless of their knowledge level or the technical quality achieved (6).

Knowledge is the comprehension or awareness of an idea or intention. For example, we may be told that untreated caries causes pulpal pathology. After knowing this, one can accept it as true, reject it as false, or be indifferent. Beliefs refer to subjective

probability judgment linking some understanding of oneself and one's environment. Beliefs are thought of as the actuality or acceptability of something. Beliefs are influenced by many social factors including gender, race, education, ethnicity, religion, and culture (8). Attitude is one's tendency, feeling, or evaluation to respond to something in a favorable or unfavorable manner. Attitudes may be general, towards groups, or specific to a particular target (9). Decision-making is the cognitive process resulting in the selection of a specific action or behavior among several alternatives. This can be influenced by knowledge, attitude, belief, and cultural factors (8). Behavior is an action or reaction toward a stimulus or an internal or external motivation. Behavior results from knowledge, attitudes, beliefs, feelings, and learned experiences (9). Knowledge, beliefs, attitudes, and decision-making are cognitions, embedded in the mental process by which we know the world. Behaviors are shaped by these cognitions. Cognitions are not just formed by educational experiences, but by all interactions with the world; for example, social media is known to have had substantial impact on recent election results and acceptance of vaccines by healthcare workers during the COVID-19 pandemic.

Much is known about the profound influences of medical doctor's cognitions on the provision and delivery of medical

Authors	Year	Reference	Country	General Area Addressed
Adeyemo et al.	2011	27	Nigeria	Antibiotics (IEP)
Akbar	2015	28	Saudi Arabia	Restoration
Albahiti	2020	29	Saudi Arabia	Decontamination
Al-Nahlawi et al.	2019	30	Syria	NSRCT Procedure
Benoist et al.	2014	31	Senegal	Dentin Sensitivity
Bidar et al.	2015	32	Iran	Emergencies
Bigras et al.	2008	33	USA	Decision Making
Bjorndal & Reit	2005	34	Denmark	Technology Adoption
Bjorndal et al.	2007	6	Denmark	Outcome
Coutinho et al.	2009	35	Brazil	Antibiotics (IEP)
Crespo-Gallardo et al.	2018	36	Spain	Deep Caries
Demant et al.	2012	37	Denmark	NSRCT Procedure
Eckerbon & Magnusson	2001	38	Sweden	Restoration
Foley	2007	39	UK	Primary Molar Treatment
Frujeri & Costa	2009	40	Brazil	Trauma
Hommez et al.	2003	41	Belgium	NSRCT Procedure
Ibhawoh & Enabulele	2015	42	Nigeria	Pregnancy
Janani & Sandhya	2019	43	India	CBCT
Jaunay et al.	2000	44	South Africa	Antibiotics
Jayadev et al.	2014	45	India	Antibiotics & Analgesics
Karthikeson & Vignesh	2019	46	India	Primary Tooth Treatment
Kostopoulou & Dugal	2005	47	UK	Trauma
Lopez-Jornet et al.	2014	48	Spain	Pregnancy
Madarati et al.	2018	49	UK	Instrument Separation
Malmberg et al.	2020	50	Sweden & Norway	Outcomes
Manfrin et al.	2007	51	Brazil	Trauma
Morgano et al.	1994	52	USA	Restoration
Oderinu	2017	53	Nigeria	Dentin Sensitivity
Palmer et al.	2001	54	UK	Antibiotics
Qazi & Nasir	2009	55	Pakistan	Trauma
Re et al.	2014	56	Italy	Trauma
Shashirekha et al.	2014	57	India	Rubber Dam
Skaare et al.	2015	58	Norway	Trauma
Tortopidis et al.	2010	59	Greece	Restoration
Vega et al.	2012	60	USA	Hand Hygiene
Walimbe et al.	2015	61	India	Devitalizing Agents
Yeng & Parashos	2008	62	Australia	Trauma
Zadik	2008	63	USA	Antibiotics (IEP)
Zhao	2010	64	China	Trauma

(Key: IEP = Infective Endocarditis Prophylaxis, CBCT = Cone Beam Computed Tomography)

Figure 1: Evidence table for knowledge related to NSRCT

care (10-14). Dentists' cognitions have received less attention, but interest is building (15-20). Data relating cognitions to the provision of care for disease of pulpal origin, NSRCT, has not yet received comprehensive evaluation. Dentists' lack of NSRCT knowledge may be a foundational problem. We must ask what information on dentists' NSRCT knowledge has been presented in the literature?

Systematic reviews are considered to be the highest form of clinical evidence but can be ill-suited to address broad questions. Moreover, studies concerning dentists' knowledge rarely use "knowledge" in titles or keywords, so a focused systematic search might not effectively survey the literature. In contrast, a scoping review, a newer approach to evidence synthesis, can be used to search for concepts by mapping the language and data surrounding the concept of interest to iteratively assess the scope or coverage of the literature, to give an indication of the volume of the available literature, to refine the methods of data extraction, organization, and analysis, to map the available evidence and provide an overview of the topic (21-26).

Hence, a scoping review was used to provide an overview of the available research evidence and address the above question. A scoping review can be helpful in designing subsequent systematic reviews.

The purpose of this study was to conduct a scoping review to determine if dentists' knowledge of NSRCT may affect the provision of care for disease of pulpal origin.

Materials and Methods

A scoping review was developed following established practice (21-26). The review question was: What knowledge do dentists manifest in providing NSRCT for disease of pulpal origin, including trauma, management of deep caries and dentin sensitivity, and subsequent restoration? Inclusion criteria required data addressing the above question in articles published in English from January 1960 to October 26, 2020. Exclusion criteria consisted of literature that failed to meet the above inclusion criteria, and on data relating to health care practitioners other than dentists. An electronic search was performed in PubMed for "knowledge, root canal." Due to the recognition that titles alone were poor indicators of papers containing data on dentists' knowledge of NSRCT, all papers identified by electronic search received an initial abstract review, which was followed by full text review when appropriate. Abstracts were reviewed independently by two reviewers; in the event of disagreement, papers defaulted to full text review. Manual searching, citation mining, and expert recommendation were performed as previously described (4). Resultant data was categorized and summarized.

Results

The initial electronic search produced 715 titles; abstract review gave 45 papers and full text review gave 25 papers. Hand searching produced a further 14 papers for a total of 39 papers (6, 27-64). Qualitative data was extracted and compiled.

Included papers were published between 1994 and 2020, all but one since 2000, and more than half since 2010, indicating that this topic is an emergent area of interest (Fig. 1). All 39 papers were based on questionnaires, surveys, or interviews. Only 6 of the papers were published in journals whose primary focus in endodontics, 3 being published in the International Endodontic Journal, and none being published in the Journal of Endodontics. However, 5 papers were published in Dental Traumatology. The 39 included papers were dispersed across 28 different journals.

Specific Topics Studied	# of Articles
Modern Technology	12
Restoration	11
Rubber Dam	10
Intra Canal Medicament	9
Modern Instruments	9
Trauma	8
Irrigation	7
Deep Carries	6
Antibiotics	5
Radiography	5
Diagnosis	4
Local Anesthesia	4
Primary Teeth	4
Number of Visits	3
Outcomes	3
Recall	3
Analgesia	2
Dentin Sensitivity	2
Pregnancy	2
Pulp Cap	2
Racial Bias	2
Retreatment	2
CBCT	1
Chelating Agents	1
Devitalizing Agents	1
Emergency Management	1
Instrument Separation	1
Knowledge Source	1
Microbe Sampling	1
Treatment Planning	1

Figure 2: Specific topics studied within these included papers

Heterogeneity arose from many areas, the approaches of the investigators, reporting methods, the gold standards used, the dentist populations studied, and the 20 countries where the studies were performed being spread across the spectrum of the Human Development Index (HDI).

A wide variety of topics of fundamental importance to patient welfare relating to NSRCT were studied. In this scoping review paper, data was organized by general area of the paper (Fig. 1) and by specific NSRCT topic (Fig. 2). Many of the NSRCT-related topics included in the papers were not explicitly included in the papers' titles. Data was not amenable to meta-analysis due to heterogeneity of methods used by different investigators.

Because the included papers were generally not designed to focus on a common definition of knowledge or on commonly defined areas, some overlap and subjectivity in interpretation and assignment was inevitable.

The 39 included papers assessed knowledge of NSRCT within 30 different specific topics (Fig. 2). The topics most frequently studied were knowledge of modern technologies [12], restoration of NSRCT teeth [11], rubber dam [10], intracanal medicaments [9], modern instruments [9], trauma [8], irrigation [7], deep caries [6], antibiotics [5], radiography [5], diagnosis [4], local anesthesia [4], and primary teeth [4].

All included papers discerned substantial gaps in dentists' knowledge of NSRCT, gaps between dentists' knowledge and established standards. While many papers found gaps in knowledge related to modern technologies or instruments, others found gaps in foundational areas where there has been little change for a century, such as rubber dam usage and irrigation (41, 55). Knowledge of diagnosis and consequent prognosis, foundational topics of critical importance, were little studied (6, 33, 37, 50). Bjorndal et al. noted that dentists self-assessed themselves as having excellent or satisfactory knowledge in most areas of NSRCT; however, their assessment of prognostic factors often differed from established gold standards (6). Malmberg et al. identified the importance of regular feedback on dentists' awareness of their shortcomings (50). Skaare et al. explained that self-estimation of one's own competence does not reflect one's level of knowledge (58).

Knowledge of infrequently encountered situations, such as trauma management, might be expected to be less than optimal. Nonetheless, knowledge and provision of trauma management has enormous life impact on affected patients. Hence, great efforts have been made to educate dentists in trauma management. Although practicing dentists had generally received advice on avulsion management, knowledge was incomplete or poor (40, 47, 51, 55, 56, 58, 62, 64). In contrast, knowledge of fractured instrument management, another relatively infrequent event, was comparatively good (49). Knowledge of something as frequently performed as handwashing was extremely poor (60).

Knowledge of antibiotic use was high for some topics but poor in others; overuse was signified, but underuse was also denoted (44, 45, 54). Knowledge of antibiotic regimens for infectious endocarditis prophylaxis were poor, despite being heavily promulgated (27, 32, 63). Likewise, knowledge of NSRCT relating to pregnant women was poor (42, 48).

Knowledge relating to restoration of endodontically treated teeth was extremely mixed (28, 52). On one hand the importance of the remaining tooth structure was generally recognized, on the other the long-outdated myth that posts reinforce teeth survives (28, 38, 52, 59).

Many of the included studies were performed in countries with very high or high human development indices, suggesting that resources are not a key factor in the creation of gaps in knowledge.

Many papers concluded that improved dental school training, specialty education, and continuing education were needed; however, data supporting such conclusions was lacking. The causes of knowledge gaps were not studied. Continuing education was a key source of knowledge (40, 57, 63, 64). One study found that a single lecture on trauma management could be effective in increasing knowledge for at least a couple of months (40).

No directly explicit data on whether dentists accepted, rejected, or were indifferent to knowledge was found in this scoping review. However, some implicit examples of rejection or indifference to knowledge were described as dissonance.

Discussion

Ultimately, the value of this present study will be in the application of its insights towards advancing the dental profession and quality of care that we deliver to our patients. As explained above, the medical profession is more advanced in studying care providers' cognitions and psychosocial barriers than the dental profession. The relevance of this study is evident from what we dentists experience on a daily basis through social media and various discussion forums, namely the lack of consensus from dental practitioners on addressing a clinical situation (46). It is common for well-established practitioners to tell young clinicians to "Forget what you learned in school, because this is how I do it." If we are to advocate for evidence-based dentistry, we must understand the reasons for the manifestation of cognitive dissonance. Lack of knowledge appears to be a foundational problem, but what are the underlying causes? An issue with the evidence perhaps? Or is it a problem with interpretation of evidence? Is this human nature? How can we mitigate against the factors that produce deleterious cognitions? As members of a healthcare profession, it is incumbent upon us to surveil our community and promote best practices.

This scoping review revealed that dentists, like the rest of humanity, are not all-knowing. Not only must dentists master knowledge and technical skill, but they must also be taught to become aware of and understand the limitations of their own acquired knowledge as well as of their beliefs, attitudes, motivational factors, coping mechanisms, and behaviors, so that appropriate care can be provided. Gaps exist between teaching or accepted best practices and dentists' knowledge of NSRCT (6).

Adoption of evidence-based practice demands much more than the generation of knowledge alone. Knowledge is disseminated through dental school curriculum, standard textbooks, specialty training programs, and through continuing education or in-service training. This dissemination is not haphazard; it's governed by external accreditation agencies, government regulation, reciprocal agreements, and peer-review. However, standard curricular content, or key areas tested in licensing examinations, cannot be equated with the knowledge demonstrated by practicing dentists. What people are taught can be quite different from what they know. Dentists' behaviors are unquestionably shaped by belief and attitude, as well as by knowledge.

Cognitions are influenced by interactions with colleagues, co-workers, patients, and others. Memes including outmoded

or inappropriate behaviors are introduced, maintained, and reinforced in this way. Therefore, it was not surprising that knowledge showed substantial variance. Unanimous conformity was extremely rare for any question of knowledge; generally, dentists were split amongst several alternatives.

The social environment (including psychosocial skills and behavioral control), in combination with the physical environment (including technical skills and knowledge), determine and limit health provision. While recognizing that treatment of pulpal disease carries a preeminent psychosocial stigma, similar applications of cognitions and behaviors likely exist throughout all disciplines of dental practice.

This scoping review was inherently constrained to the extant literature. Source papers generally focused on specific aspects of dental practice, rather than upon cognitions. Questionnaires were commonly used in the source papers; these were self-administered, mailed, and by interview. Patient scenarios were often used to study dentists' knowledge, decisions, and behaviors. The included data can be broadly generalized because same themes were often reported in studies performed, in different countries, on different places on the HDI, with different aims and methodologies.

Careful examination of the included papers suggested approaches that could lead to an effective systematic review through great sensitivity to proximity awareness in search strategy. The use of methodological terms such as "survey" or "questionnaire;" related psychosocial parameters such as "attitude," "belief," and "behavior;" as well as areas of NSRCT related knowledge that are commonly investigated may be very helpful in designing effective systematic search strategies.

Despite the difficulties identified in the results section of this scoping review, it is recommended that the information derived from this scoping review be used to design systematic reviews relating key cognitions, dentists' knowledge, attitude, and behavior, relating to NSRCT. It is clear that despite many efforts, knowledge related to NSRCT is both variable and poor, and the provision of knowledge without attention to dentists' cognitions is unlikely to be successful.

Conclusion

Dentists' knowledge of non-surgical root canal treatment generally exhibited substantial gaps and considerable variability.

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References

1. Torabinejad M, Anderson P, Bader J, Brown LJ, Chen LH, Goodacre CJ, Kattadiyil MT, Kutsenko D, Lozada J, Patel R, Petersen F, Puterman I, White SN. Outcomes of root canal treatment and restoration, implant-supported single crowns, fixed partial dentures, and extraction without replacement: a systematic review. J Prosthet Dent 2007; 98:285-311; doi: 10.1016/S0022-3913(07)60102-4.
2. Iqbal MK, Kim S. For teeth requiring endodontic treatment, what are the differences in outcomes of restored endodontically treated teeth compared to implant-supported restorations? Int J Oral Maxillofac Implants. 2007;22 Suppl:96-116. Erratum in: Int J Oral Maxillofac Implants 2008; 23:56.
3. Ng YL, Mann V, Gulabivala K. Tooth survival following non-surgical root canal treatment: a systematic review of the literature. Int Endod J 2010; 43:171-89; doi: 10.1111/j.1365-2591.2009.01671.x.
4. Pak JG, Fayazi S, White SN. Prevalence of periapical radiolucency and root canal treatment: a systematic review of cross-sectional studies. J Endod 2012; 38:1170-6; doi: 10.1016/j.joen.2012.05.023.
5. Kirkevang LL, Ørstavik D, Hörsted-Bindslev P, Wenzel A. Periapical status and quality of root fillings and coronal restorations in a Danish population. Int Endod J 2000; 33:509-15; doi: 10.1046/j.1365-2591.2000.00381.x.
6. Bjørndal L, Laustsen MH, Reit C. Danish practitioners' assessment of factors influencing the outcome of endodontic treatment. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007; 103:570-5; doi: 10.1016/j.tripleo.2006.09.014.
7. Vaughn LM, Jacquez F, Baker RC. Cultural Health Attributions, Beliefs, and Practices: Effects on Healthcare and Medical Education. The Open Medical Education Journal 2009; 2:64-74. doi: 10.2174/1876519X00902010064
8. Fishbein M, Ajzen I. Belief, attitude, intention, and behavior: An Introduction to Theory and Research. Boston: Addison-Wesley; 1975. pp131-156 and 216-222.
9. Schuman H, Johnson MP. Attitudes and Behavior. Annual Review of Sociology 1976; 2:161-207; https://doi.org/10.1146/annurev.so.02.080176.001113
10. Armitage KJ, Schneiderman LJ, Bass RA. Response of physicians to medical complaints in men and women. JAMA 1979; 241:2186-7.
11. Eisenberg JM. Sociologic influences on decision-making by clinicians. Ann Intern Med 1979; 90:957-64; doi: 10.7326/0003-4819-90-6-957.
12. Bernstein B, Kane R. Physicians' attitudes toward female patients. Med Care 1981; 19:600-8. doi: 10.1097/00005650-198106000-00004.
13. Jay M, Kalet A, Ark T, McMacken M, Messito MJ, Richter R, Schlair S, Sherman S, Zabar S, Gillespie C. Physicians' attitudes about obesity and their associations with competency and specialty: a cross-sectional study. BMC Health Serv Res 2009; 9:106; doi: 10.1186/1472-6963-9-106.
14. Christensen AJ, Howren MB, Hillis SL, Kaboli P, Carter BL, Cvengros JA, Wallston KA, Rosenthal GE. Patient and physician beliefs about control over health: association of symmetrical beliefs with medication regimen adherence. J Gen Intern Med 2010; 25:397-402; doi: 10.1007/s11606-010-1249-5.
15. Koele P, Hoogstraten J. Determinants of dentists' decisions to initiate dental implant treatment: a judgment analysis. J Prosthet Dent 1999; 81:476-80; doi: 10.1016/s0022-3913(99)80017-1.
16. Moore R, Brødsgaard I. Dentists' perceived stress and its relation to perceptions about anxious patients. Community Dent Oral Epidemiol 2001;29(1):73-80.
17. Doshi D, Reddy BS, Kulkarni S, Karunakar P, Anup N. Dentists' knowledge, attitudes, and practices toward patients with epilepsy in Hyderabad city, India. Epilepsy Behav 2012; 23:447-50; doi: 10.1016/j.yebeh.2012.01.022.
18. Nagarajappa R, Tak M, Sharda AJ, Asawa K, Jalihal S, Kakatkar G. Dentists' attitude to provision of care for people with learning disabilities in Udaipur, India. Scand J Caring Sci 2013; 27:57-62; doi: 10.1111/j.1471-6712.2012.01000.x.
19. Demant S, Markvart M, Bjørndal L. Quality-Shaping Factors and Endodontic Treatment amongst General Dental Practitioners with a Focus on Denmark. Int J Dent. 2012; 2012:526137. doi: 10.1155/2012/526137.
20. Othman AA, Yusof Z, Saub R. Malaysian government dentists' experience, willingness, and barriers in providing domiciliary care for elderly people. Gerodontology 2014; 31:136-44; doi: 10.1111/ger.12023.
21. Arksey H, O'Malley L (2005). "Scoping studies: Towards a methodological framework" (PDF). International Journal of Social Research Methodology 2005; 8:19–32; doi:10.1080/1364557032000119616.
22. PRISMA. PRISMA for Scoping Reviews. www.prisma-statement.org/Extensions/ScopingReviews. Accessed 30 October 2021.
23. Smith V, Devane D, Nichol A, Roche D. Care bundles for improving outcomes in patients with COVID-19 or related conditions in intensive care – a rapid scoping review. Cochrane Database of Systematic Reviews 2020, Issue 12. Art. No.: CD013819. doi: 10.1002/14651858.CD013819. Accessed 30 October 2021.
24. Peters MD, Godfrey CM, Khalil H, McInerney P, Parker D, Soares CB. Guidance for conducting systematic scoping reviews. Int J Evid Based Healthc 2015; 13:141-6; doi: 10.1097/XEB.0000000000000050.
25. Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. Implement Sci 2010; 0; 5:69. doi: 10.1186/1748-5908-5-69.
26. Colquhoun HL, Levac D, O'Brien KK, Straus S, Tricco AC, Perrier L, Kastner M, Moher D. Scoping reviews: time for clarity in definition, methods, and reporting. J Clin Epidemiol 2014; 67:1291-4; doi: 10.1016/j.jclinepi.2014.03.013.
27. Adeyemo WL, Oderinu OH, Olojede AC, Ayodele AO, Fashina AA. Nigerian dentists' knowledge of the current guidelines for preventing infective endocarditis. Community Dent Health 2011; 28:178-81.

28. Akbar I. Knowledge, attitudes, and practice of restoring endodontically treated teeth by dentists in north of Saudi Arabia. Int J Health Sci (Qassim) 2015; 9:41-9; doi: 10.12816/0024682.
29. Albahiti MH. Knowledge and practices of decontamination during root canal treatment by dentists in Jeddah. Saudi Dent J 2020; 32:213-8; doi: 10.1016/j.sdentj.2019.08.010.
30. Al-Nahlawi T, Doumani M, Alalo HA, Habib A. Dentists' Knowledge, Attitude and Practice of Root Canal Treatment Procedure: Survey-based Research. J Contemp Dent Pract 2019;20(3):347-54.
31. Benoist FL, Ndiaye FG, Faye B, Bane K, Ngom PI, Ndong PM. Knowledge of and management attitude regarding dentin hypersensitivity among dentists from a West African country. J Contemp Dent Pract 2014; 15:86-91; doi: 10.5005/jp-journals-10024-1493.
32. Bidar M, Gharechahi M, Soleimani T, Eslami N. A Survey over the Dentists' and Endodntists' Approaches towards the Management of Endodontic Emergencies in Mashhad, Iran. Iran Endod J 2015; 10:256-62; doi: 10.7508/iej.2015.04.010.
33. Bigras BR, Johnson BR, BeGole EA, Wenckus CS. Differences in clinical decision making: a comparison between specialists and general dentists. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008 Jul;106(1):139-44; doi: 10.1016/j.tripleo.2008.01.037. PMID: 18585628.
34. Bjørndal L, Reit C. The adoption of new endodontic technology amongst Danish general dental practitioners. Int Endod J 2005; 38:52-8; doi: 10.1111/j.1365-2591.2004.00904.x.
35. Coutinho AC, Castro GF, Maia LC. Knowledge and practices of dentists in preventing infective endocarditis in children. Spec Care Dentist 2009; 29:175-8; doi: 10.1111/j.1754-4505.2009.00087.x.
36. Crespo-Gallardo I, Martín-González J, Jiménez-Sánchez MC, Cabanillas-Balsera D, Sánchez-Domínguez B, Segura-Egea JJ. Dentist's knowledge, attitudes and determining factors of the conservative approach in teeth with reversible pulpitis and deep caries lesions J Clin Exp Dent 2018;10(12): e1205-e1215. doi: 10.4317/jced.55395.
37. Demant S, Markvart M, Bjørndal L. Quality-Shaping Factors and Endodontic Treatment amongst General Dental Practitioners with a Focus on Denmark. Int J Dent 2012;2 012:526137; doi: 10.1155/2012/526137. Epub 2012 Mar 26.
38. Eckerbom M, Magnusson T. Restoring endodontically treated teeth: a survey of current opinions among board-certified prosthodontists and general dental practitioners in Sweden. Int J Prosthodont 2001; 14:245-9.
39. Foley J. A comparison of knowledge of local analgesia, pulp therapy and restoration of primary molar teeth amongst dental students, dentists and dental therapists within a dental hospital setting. Eur Arch Paediatr Dent 2007; 8:113-7; doi: 10.1007/BF03262579.
40. Frujeri Mde L, Costa ED Jr. Effect of a single dental health education on the management of permanent avulsed teeth by different groups of professionals. Dent Traumatol 2009; 25:262-71; doi: 10.1111/j.1600-9657.2008.00760.x.
41. Hommez GM, Braem M, De Moor RJ. Root canal treatment performed by Flemish dentists. Part 1. Cleaning and shaping. Int Endod J 2003; 36:166-73; doi: 10.1046/j.1365-2591.2003.00633.x.
42. Ibhawoh L, Enabulele J. Endodontic treatment of the pregnant patient: Knowledge, attitude, and practices of dental residents Niger Med J 2015; 56: 311–6.doi: 10.4103/0300-1652.170386: 10.4103/0300-1652.170386
43. Janani K, Sandhya R. A survey on skills for cone beam computed tomography interpretation among endodontists for endodontic treatment procedure. Indian J Dent Res. 2019 Nov-Dec;30(6):834-838. doi: 10.4103/ijdr.IJDR_289_18.
44. Jaunay T, Sambrook P, Goss A. Antibiotic prescribing practices by South Australian general dental practitioners. Aust Dent J 2000; 45:179-86; doi: 10.1111/j.1834-7819.2000.tb00554.x.
45. Jayadev M, Karunakar P, Vishwanath B, Chinmayi SS, Siddhartha P, Chaitanya B. Knowledge and Pattern of Antibiotic and Non-Narcotic Analgesic Prescription for Pulpal and Periapical Pathologies - A Survey among Dentists. J Clin Diagn Res 2014; 8:ZC10-4. doi: 10.7860/JCDR/2014/9645.4536.
46. Karthikeson P.S, Vignesh R Knowledge and attitude of general dentists and dentists of other specialties toward endodontic treatment of primary teeth. Drug Invention Today 2019;11(6):1372-7.
47. Kostopoulou MN, Duggal MS. A study into dentists' knowledge of the treatment of traumatic injuries to young permanent incisors. Int J Paediatr Dent 2005; 15:10-9; doi: 10.1111/j.1365-263X.2005.00588.x. PMID: 15663440.
48. López-Jornet P, Camacho-Alonso F, Sanchez-Siles M, Molina-Miñano F. Oral and dental health in pregnant women: attitudes among dentists in southeastern Spain. N Y State Dent J 2014; 80:38-41.
49. Madarati AA, Watts DC, Qualtrough AJ. Opinions and attitudes of endodontists and general dental practitioners in the UK towards the intra-canal fracture of endodontic instruments. Part 2. Int Endod J 2008; 41:1079-87; doi: 10.1111/j.1365-2591.2008.01473.x.
50. Malmberg L, Sturestam A, Fagring A, Björkner AE. Endodontic follow-up practices, sources of knowledge, and self-assessed treatment outcome among general dental practitioners in Sweden and Norway. Acta Odontol Scand 2020; 78:547-52; doi: 10.1080/00016357.2020.1763455.
51. Manfrin TM, Boaventura RS, Poi WR, Panzarini SR, Sonoda CK, Massa Sundefeld ML. Analysis of procedures used in tooth avulsion by 100 dental surgeons. Dent Traumatol 2007; 23:203-10. doi: 10.1111/j.1600-9657.2005.00432.x.
52. Morgano SM, Hashem AF, Fotoohi K, Rose L. A nationwide survey of contemporary philosophies and techniques of restoring endodontically treated teeth. J Prosthet Dent 1994; 72:259-67; doi: 10.1016/0022-3913(94)90339-5.
53. Oderinu OH, Sede MA, Oginni AO, Adegbulugbe IC, Uti OG, Olusile AO, Udoye CI, Savage KO. Knowledge, diagnosis, and management of dentine hypersensitivity: a national survey of dentists in Nigeria. Int Dent J; 2017; 67:287-293. doi: 10.1111/idj.12302.

54. Palmer NO, Martin MV, Pealing R, Ireland RS, Roy K, Smith A, Bagg J. Antibiotic prescribing knowledge of National Health Service general dental practitioners in England and Scotland. J Antimicrob Chemother 2001; 47:233-7; doi: 10.1093/jac/47.2.233.
55. Qazi SR, Nasir KS. First-aid knowledge about tooth avulsion among dentists, doctors, and lay people. Dent Traumatol 2009; 25:295-9. doi: 10.1111/j.1600-9657.2009.00782.x.
56. Re, D; Augusti, D; Paglia, G; Augusti, G; Cotti, E. Treatment of traumatic dental injuries: evaluation of knowledge among Italian dentists. Eur J Paediatr Dent 2014; 15:23-8.
57. Shashirekha G, Jena A, Maity AB, Panda PK. Prevalence of Rubber Dam Usage during Endodontic Procedure: A Questionnaire Survey. J Clin Diagn Res 2014; 8: ZC01-3; doi: 10.7860/JCDR/2014/9011.4425.
58. Skaare AB, Pawlowski AA, Maseng Aas AL, Espelid I. Dentists' self-estimation of their competence to treat avulsion and root fracture injuries. Dent Traumatol 2015; 31:368-73; doi: 10.1111/edt.12186.
59. Tortopidis D, Papa P, Menexes G, Koidis P. Attitudes of dentists regarding the restoration of root canal treated teeth: a survey in Greece. Int Dent J 2010; 60:336-42.
60. Vega OG, Janus C, Laskin DM. Hand-washing knowledge and practices among dentists and dental specialists. Quintessence Int 2012; 43:429-34.
61. Walimbe H, Kontham U, Bijle MN, Wani V, Nankar M, Muchandi S. Knowledge, Attitude and Practice of Devitalizing Agents: A Survey of General Dental Practitioners. J Int Oral Health 2015; 7:86-8.
62. Yeng T, Parashos P. An investigation into dentists' management methods of dental trauma to maxillary permanent incisors in Victoria, Australia. Dent Traumatol 2008; 24:443-8; doi: 10.1111/j.1600-9657.2008.00609.x.
63. Zadik Y, Findler M, Livne S, Levin L, Elad S; American Heart Association. Dentists' knowledge and implementation of the 2007 American Heart Association guidelines for prevention of infective endocarditis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106(6): e16-9; doi: 10.1016/j.tripleo.2008.08.009.
64. Zhao Y, Gong Y. Knowledge of emergency management of avulsed teeth: a survey of dentists in Beijing, China. Dent Traumatol 2010; 26:281-4; doi: 10.1111/j.1600-9657.2010.00877.x.

Treatment Alternatives in Endodontic Revision

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Abstract

Root canal treatment can fail for a multitude of reasons. The primary causative factor for failure is the continued persistence of bacterial pathogen beyond the threshold that the host's immune response can contain. Pathogenic bacteria can persist in those areas that remain untouched during the initial chemo-mechanical disinfection. For maxillary central incisors, these areas would include the lateral canals and apical ramifications found along the apical third of the root. Treatment is initially directed at non-surgical revision to control the infection within the root canal system. If the pathologic process persists, surgical revision can be the next best option. This article presents a case of a failed root canal treatment that was managed using both non-surgical and surgical approaches. Clinical and radiographic follow-up examinations up to 24 months displayed favorable outcome with evidence of healing and resolution of the periapical pathosis. This case report highlights the importance of instituting the appropriate therapeutic modality based on the patient's response to treatment.

Introduction

Non-surgical root canal treatment demonstrates a favorable outcome of 86% to 98% making it a reliable and predictable treatment modality in endodontics (1, 2). Success in endodontic therapy depends on adequate chemo-mechanical preparation of the root canal system to bring the microbial load to a level that would allow for tissue repair to take place (3). Placement of an inert filling material to seal off the canal is important as it prevents or minimizes the chances of reinfection (4). However, failure may occur when treatment fails to adhere to standard protocols in clinical endodontics (5). Failure may refer to reappearance of symptoms or persistence of periapical radiolucency (6).

Negative treatment outcome can be attributed to several reasons which include the following: inappropriate mechanical debridement; poor obturation quality; over and under extension of the root canal filling; improper coronal seal; untreated canals; iatrogenic procedural errors; and complications of instrumentation (7). Presence of pathogenic microorganisms is directly related to the continued existence of an already established lesion or may lead to the development of apical periodontitis (8). It has been agreed upon by various research that apical periodontitis is the most important factor that may affect the treatment outcome of non-surgical retreatment (9-13). In addition to performing root canal disinfection to the highest standard, knowledge of the complexities of the root canal system should be the foundation of any treatment procedure. Maxillary central incisors have its own intricacies including lateral canals and apical ramifications with an incidence ranging from 24 to 60% (14, 15). Large and patent lateral canals may serve as a portal of entrance and exit for bacteria and tissue degradation products between the root canal space and periodontal tissue (1, 2, 16, 17).

This paper presents a previously treated case of a maxillary central incisor managed by a combination of non-surgical and surgical root canal treatment because of a non-healing lesion despite efforts at non-surgical treatment revision.

Case Report

A 53-year-old female was referred to the clinic for endodontic retreatment of tooth 21. No spontaneous pain was reported and a moderate response to both percussion and palpation were present. CBCT imaging from Rayscan (Raymedical, Gyeonggi-do, Korea) revealed the extent of bone destruction and a root canal filled tooth 21 associated with a large radiolucent lesion (Fig. 1) measuring 11.7 mm x 11.1 mm x 12.1 mm at its widest dimension (Fig. 2). Upon closer inspection, the chamber was not completely unroofed which resulted to apical transportation and areas of the canal that remained uninstrumented as they appeared radiolucent on the image (Fig. 3).

Nonsurgical approach with and without surgical revision were discussed with the patient. Surgery will only be performed if no improvement is observed with the nonsurgical option.

Endodontic retreatment was performed in multiple visits

spanning a period of 5 months. The procedure was done under magnification (2.5x Telescope DKT-3, Dr. Kim, Gyeonggi-do, Korea). Gutta percha was removed using hedstrom files and a solvent of orange oil (Produits Dentaires SA, PD™ Eugenate Desobturator). Access preparation was modified and working length established and verified with a Root ZX II electronic apex locator (J. Morita, Japan). Biomechanical preparation of the canal was executed with the use of .02 stainless steel files (Mani, Japan), Protaper FHU (Dentsply Sirona,) and 15% EDTA cream (RC Prep®, Premier, USA). During this phase, mucopurulent exudate could be seen coming out from the tooth. The canal was copiously irrigated with 2ml of 2.5% NaOCl during each file change. Recapitulation with the patency file #20 K-file was done to keep the apical foramen patent and to disrupt apical biofilms mechanically (18) and chemically distributing the irrigant solution to the very apical region of the canal (19). Two ml of 17% EDTA solution (Pulpdent Corp., USA) was left in the canal for 1 minute accompanied by 2 minutes of manual activation with master gutta-percha point to remove the smear layer. After which, the canal was dried with paper points and dressed with Vitapex (Neo Dental International Inc., Japan) extending past the apex and closed with a temporary filling of Caviton (GC Corp, Japan). The use of intracanal dressing in between appointment is to allow time for the antimicrobial substance, i.e., Calcium Hydroxide paste, to diffuse and reach bacteria located in the remote areas of the root canal system (20). The temporary crown

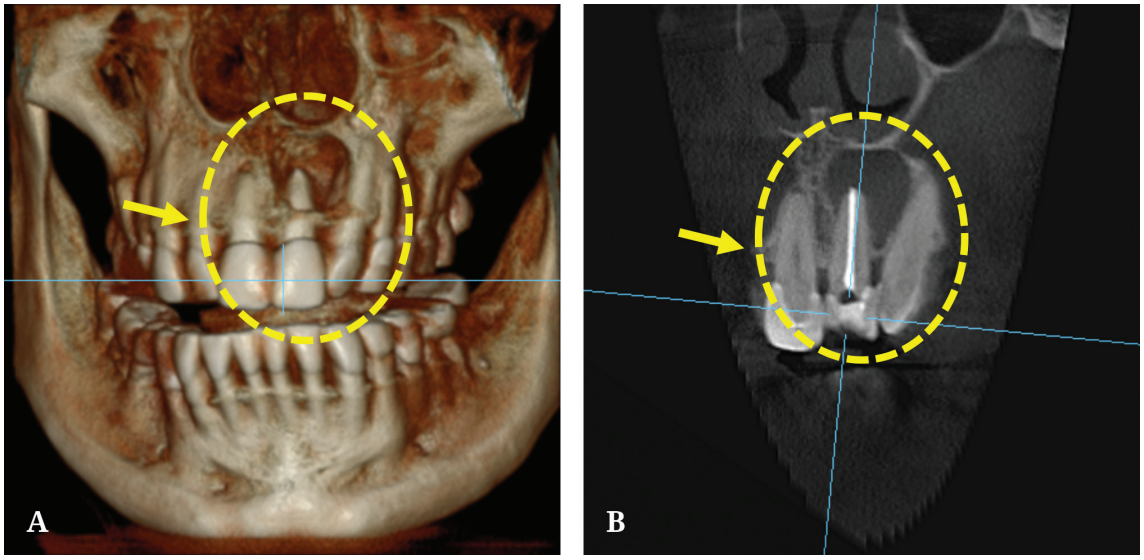

Figure 1: (A) CBCT image revealing the extent of bone destruction (B) Root canal filled 21 associated with a large radiolucent lesion

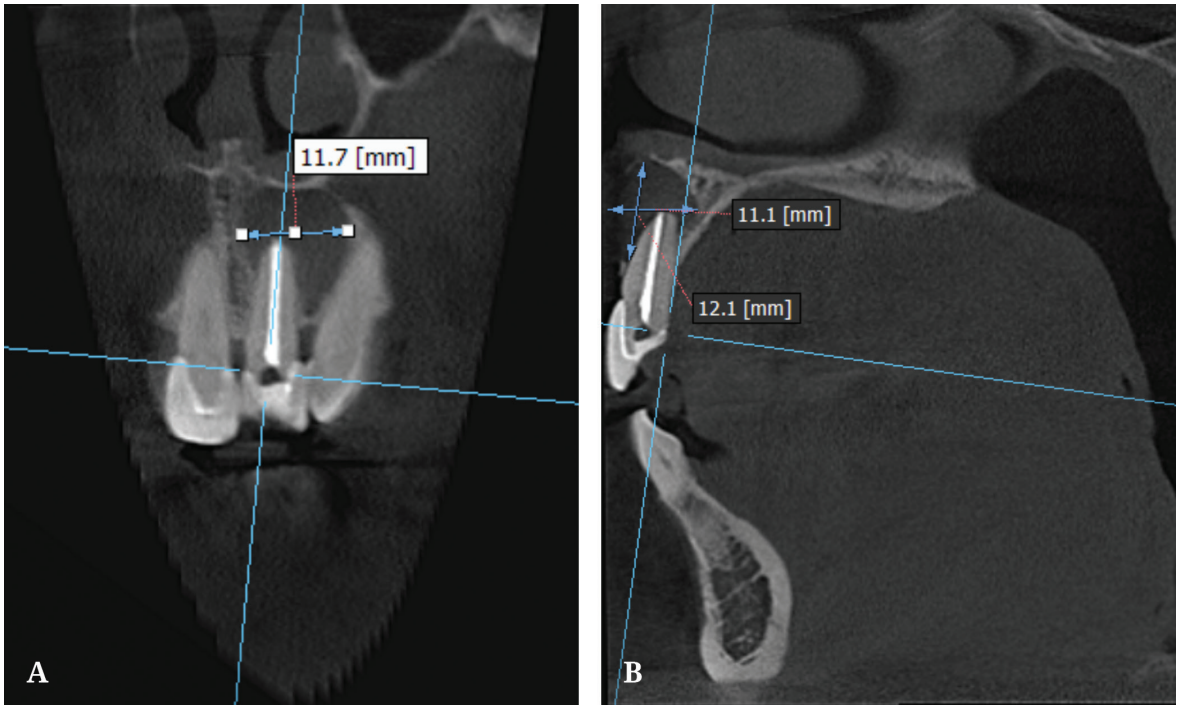

Figure 2: (A) Measurement of radiolucent lesion showing 11.7 mm in mesio-distal dimension in coronal view (B) Measurement of radiolucent lesion showing 11.1 mm bucco-lingual and 12.1 mm apico-coronal dimension in sagittal view

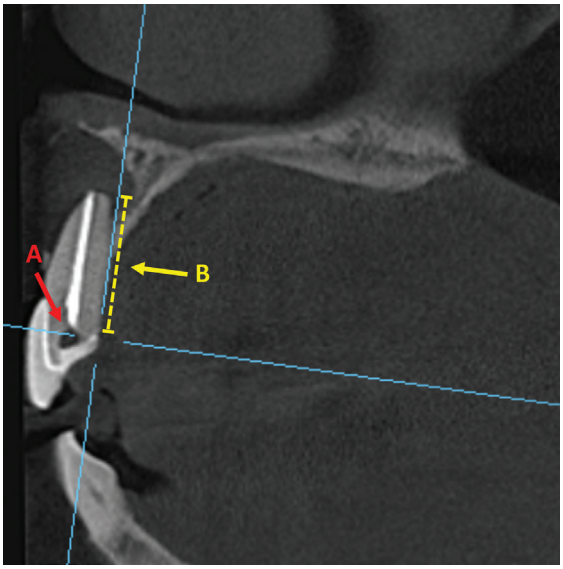

Figure 3: (A) CBCT image showing the chamber was incompletely unroofed (B) CBCT image showing apical transportation with uninstrumented canal walls appearing as radiolucent

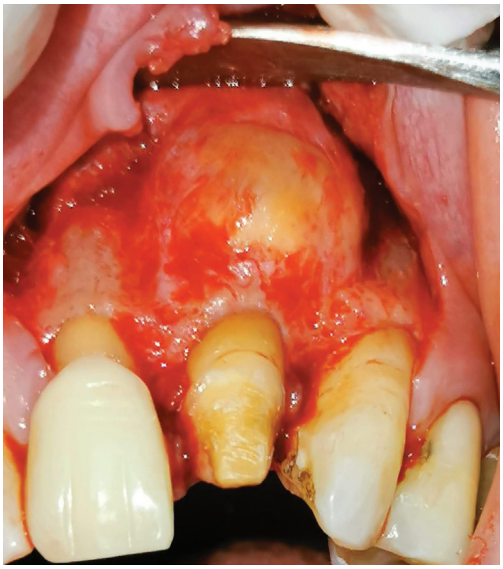

Figure 4: Clinical photograph showing reflection of full thickness mucoperiostal flap with absence of labial cortical plate

was cemented after with Freegenol Temporary Pack (GC Corp., Japan). Patient was instructed to do warm saline rinse 3-5x daily as permitted by her schedule. Recall interval was set at 4 weeks, 4 weeks and 3 months. During each recall appointment, canal was cleaned, and intra-canal dressing was changed each visit. It was noticeable with each visit that the mucopurulent exudate from the canal did not resolve over a span of almost 5 months. It was then decided, as initially discussed and planned with the patient, that simultaneous root canal treatment and endodontic surgery will be performed on the next visit due to the non-responsive lesion.

On the patient's third recall visit, biomechanical preparation was performed with 2.5% NaOCl and 17% EDTA solutions used as an irrigant with a final rinse of NSS. Upon drying with paper points, it was observed that paper point was still wet about 1mm at the tip. This apical end was plugged with Vitapex (Neo Dental International Inc., Japan) dressing prior to obturation to make sure that the canal remains dry. Obturation was performed by means of cold lateral condensation using .02 taper gutta percha (Diadent, Korea) and AH Plus® (Dentsply DETREY GmbH, Germany) root canal sealer. Glass Ionomer Cement GIC Fuji VII pink (GC Corp., Japan) was used as intraorifice barrier and access was temporarily sealed with Caviton (GC Corp., Japan). The patient was then instructed to rinse with 0.12% Chlorhexidine solution for 60 seconds prior to surgery. Once profound anesthesia was achieved, full thickness mucoperiosteal flap was raised which revealed the absence of labial cortical plate at the area (Fig. 4). Osteotomy was done to fully expose the pathologic tissue. Enucleation of the cystic lesion followed (Fig. 5). Root-end resection of the apical 3 mm of the root at a 90-degree angle followed with the use of surgical high-speed hand piece with

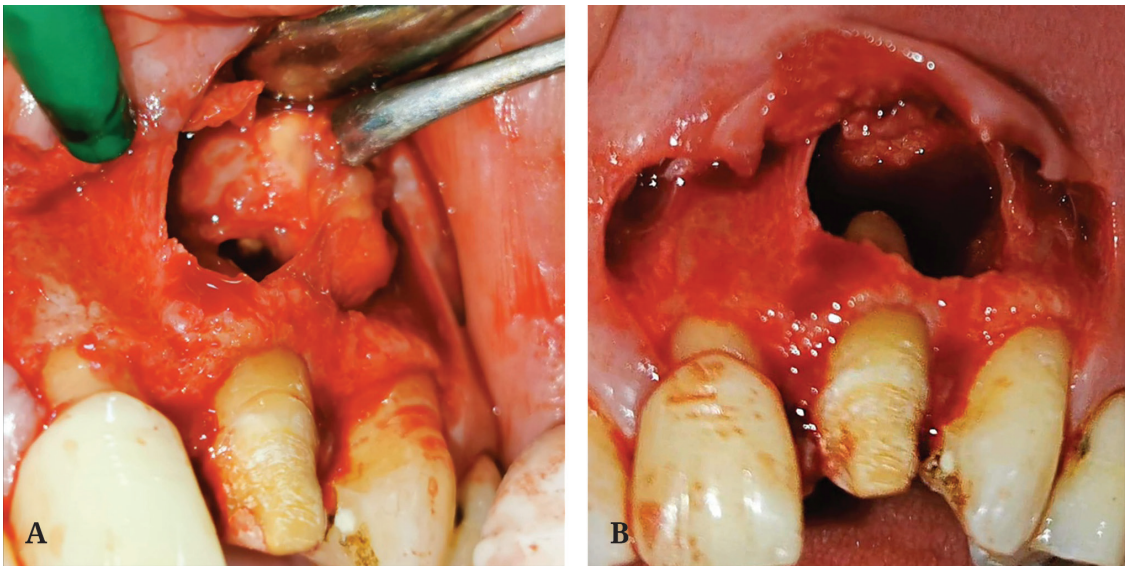

Figure 5: (A) Clinical photograph showing enucleation of the cystic lesion (B) Bone cavity after evacuation of the cystic lesion

fissure bur. Curettage of granulomatous tissue inside the bony crypt and alongside the root of the affected tooth was performed followed by copious irrigation with NSS. Root-end preparation with a small round bur and root-end filling with white mineral trioxide aggregate (ProRoot® MTA, Dentsply Tulsa, USA) concluded the surgery (Fig. 6). Site was closed with interrupted suture using Vicryl 4-O (Ethicon, USA) (Fig. 7).

Patient was recalled periodically to monitor healing at the area of the bony crypt. Radiographic images at immediate post-operative, 1-year and 2-year recall showed marked improvement in bone density at the area previously occupied by the lesion (Fig. 8A-8D). Tooth remains symptom-free. Coronal restoration also displayed good marginal seal.

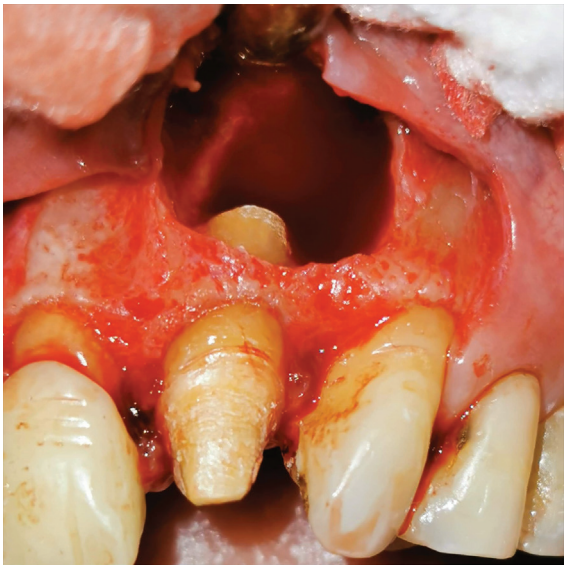

Figure 6: A clinical photograph showing the root amputation with retrograde filling on tooth 21

Figure 7: A photograph taken after the closure of surgical site

Discussion

For root canal treated teeth with associated apical periodontitis, the condition of how well the initial root canal treatment was performed influences both the necessity and degree with which the tooth may require retreatment in the future (21).

Failure may happen even on seemingly well-treated teeth and studies have documented those areas that have not been reached by chemo-mechanical preparation are possible sources (22). Areas that may remain untouched by our treatment procedures include lateral and apical ramifications (23).

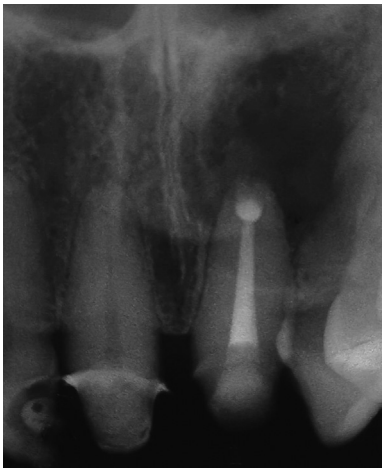

Figure 8A: An Immediate post-operative radiograph of tooth 21

Figure 8B: PA radiograph taken after a 1-year recall

Figure 8C: PA radiograph taken after a 2-year recall

Figure 8D: Clinical examination after a 2-year recall

Lateral canals and apical ramifications are branches of the main root canal and develop due to localized fragmentation of the epithelial root sheath, thereby creating a small gap, or when a blood vessel traversing the dental sac through the dental papilla persist (23, 24) Ramifications can be observed along the entire root length but in 73.5% cases, they are found on the apical third of the root (14) These tributaries provide a passageway where bacteria and their by-products from the necrotic root canal might gain access to the periodontal ligament and cause disease, and for bacteria from the periodontal pocket to reach the pulp (24).

In majority of cases with apical periodontitis, microbial infection encompasses the entire root canal system, including dentinal tubules, recesses, isthmuses, lateral canals, furcal canals, and apical ramifications (25-27). For maxillary central incisors, 39.1% of the accessory canals were found in the apical 3 mm of the root (22). It is said that bacterial biofilms are observed in the root canal system of teeth with apical periodontitis and that the older the pathologic process, as evidenced by the lesion size, the more complex is the microbial community (28). In this case report, the volume of the lesion reveals the chronicity of the infectious process. Despite performing adequate chemo-mechanical disinfection, the tooth was not responding to the intervention. It was at this point that the decision was made with the patient that non-surgical retreatment in conjunction with surgery will be performed on the next visit. According to Molzen, non-surgical retreatment, in conjunction with surgery may result to better outcome than either procedure alone because all possible sources of infection are treated (29).

It is suggested that when performing root-end resection, at least 3 mm of the root end must be removed because 98% of apical ramification and 93% of the lateral canals exist in 3mm of the root-end (30). This portion of the root is laden with tissue debris and microorganisms and should be removed during apical surgery (31). For maxillary central incisors, the incidence of accessory canals found at the apical 3mm was said to be at 46% (32). MTA as a retrograde filling material for endodontic surgery was used for this case due to its biocompatibility, ease of use as it is hydrophilic and its ability to stimulate healing and osteogenesis (17).

Conclusion

It is imperative that for teeth with long-standing pulp necrosis or previously treated cases with large periapical lesion, the clinician must discuss with the patient the challenges of disinfecting the root canal system as the microbial communities become more established and complex. Non-surgical revision is greatly beneficial for intra-radicular infections to eradicate the bacteria within the root canal system (9). Surgery is advocated for cases whereby infection continues to persist in the intricate areas in the periapical region (33). Non-surgical revision prior to surgery should be the sequence of treatment if the case warrants it to eliminate first the bacteria from within the root canal system.

The use of 3D imaging as part of the diagnostic data and magnification such as loupes during treatment are all important components of revision as it aids clinicians in performing the procedure that would translate to a positive outcome.

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References

1. Friedman S, Abitbol S, Lawrence HP. Treatment outcome in endodontics: The Toronto Study. Phase 1: Initial treatment. J Endod 2003; 29: 787-793.
2. Setzer FC, Boyer KR, Jeppson JR, Karabucak B, Kim S. Long-term prognosis of endodontically treated teeth: a retrospective analysis of preoperative factors in molars. J Endod 2011; 37:21-25.
3. Salas H., et al. Outcome of endodontic treatment with chlorhexidine gluconate as main irrigant: A case series. Australian Endodontic Journal 2020. doi: 10.1111/aej.12401;1-9
4. Tabassum S, Khan FR. Failure of endodontic treatment: The usual suspects. European Journal of Dentistry 2016. Vol. 10, Issue 1; 144-147.
5. Siqueira Jr. JF. Aetiology of root canal treatment failure: why well-treated teeth can fail. International Endodontic Journal 2001, 34, 1-10.
6. Ashley M, Harris I. The assessment of the endodontically treated tooth. Dent Update 2001; 28:247-52.
7. Tabassum S, Khan FR. Failure of endodontic treatment: The usual suspects. Eur J Dent 2016; 10:144-7.
8. Sundqvist G. Bacteriological studies of necrotic dental pulps. Umea, Sweden Umea University Odontological Dissertation no 7; 1976
9. Friedman S. Considerations and concepts of case selection in the management of post-treatment endodontic disease (treatment failure). Endod Topics 2002:1: 54–78.
10. Friedman S. Treatment outcome and prognosis of endodontic therapy. In: Orstavik D, Pitt-Ford TR, eds. Essential Endodontology. Oxford: Blackwell Science, 1998: 367–401.
11. Hoskinson SE, Yuan-Ling N, Hoskinson HE, Moles DR, Gulabivala K. A retrospective comparison of outcome of root canal treatment using two different protocols. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2002: 93: 705–715.
12. Chugal NM, Clive JM, Spangberg LS. A prognostic model for assessment of the outcome of endodontic treatment: effect of biologic and diagnostic variables. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2001:91: 342–352.
13. Chugal NM, Clive JM, Spangberg LS. Endodontic infection: some biologic and treatment factors associated with outcome. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003:96: 81–90.
14. Vertucci FJ. Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol 1984; 58: 589–99.
15. Adorno CG, Yoshioka T, Suda H. Incidence of accessory canals in Japanese anterior maxillary teeth following root canal filling ex vivo. Int Endod J 2010; 43:370-376.
16. Rubach WC, Mitchell DF. Periodontal disease, accessory canals, and pulp pathosis. J Periodontol 1965; 36:34-38.
17. Harrington GW. The perio-endo question: differential diagnosis. Dent Clin North Am 1979; 23: 673-690.
18. Siqueira JF Jr. Reaction of periradicular tissues to root canal treatment: benefits and drawbacks. Endod Topics 2005; 10: 123–47.
19. Vera J, Hernandez EM, Romero M, et al. Effect of maintaining apical patency on irrigant penetration into the apical two millimeters of large root canals: an in vivo study. J Endod 2012; 38:1340–3.
20. Siqueira JF Jr. Treatment of Endodontic Infections. London: Quintessence Publishing; 2011.
21. Cohn S. Treatment choices for negative outcomes with non-surgical root canal treatment: non-surgical retreatment vs. surgical retreatment vs. implants. Endodontic Topics 2005; 11, 4-24.
22. Lin LM, Pascon EA, Skribner J, Gaengler P, Langeland K. Clinical, radiographic, and histopathological study of endodontic treatment failures. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics 1991; 71, 603-11.
23. Ricucci D, Siqueira JF. Fate of the tissue in the lateral canals and apical ramifications in response to pathologic conditions and treatment failures. Journal of Endodontics 2010; Vol.36, no.1; 1-15.
24. Dammaschke T, Witt M, Ott K, Schäfer E. Scanning electron microscopic investigation of incidence, location, and size of accessory foramina in primary and permanent molars. Quintessence Int 2004; 35:699-705.
25. Nair PNR. Light and electron microscopic studies of root canal flora and periapical lesions. J Endod 1987; 13:29–39.
26. Siqueira JF Jr, R^oc¸as IN, Lopes HP. Patterns of microbial colonization in primary root canal infections. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2002; 93:174–8.
27. Sen BH, Piskin B, Demirci T. Observation of bacteria and fungi in infected root canals and dentinal tubules by SEM. Endod Dent Traumatol 1995; 11:6–9.
28. Ricucci D, Siqueira JF Jr. Biofilms and apical periodontitis: study of prevalence and association with clinical and histopathologic findings. J Endod 2010; 36:1277–88.
29. Molven O, Halse A, Grung B. Surgical management of endodontic failures: indications and treatment results. Int Endod J 1991; 41: 33–42.
30. Kim S, Kratchman S. Modern endodontic surgery concepts and practice: a review. J Endod 2006; 32: 601-623.
31. Shabahang S. State of the art and science of endodontics. Journal of the American Dental Association 2005; 136, 41–52.
32. Iqbal MK, Gartenberg J, Kratchman SI, Karabucak B, Bui B. The clinical significance and management of apical accessory canals in maxillary central incisors. J Am Dent Assoc 2005; 136: 331-335.
33. Pasha S., et al. Treatment outcome of surgical management in endodontic retreatment failure. Pakistan Oral and Dental Journal 2013. Vol 33, no.3, 554-557.

Clinical Management of Dens Evaginatus

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Abstract

Dens evaginatus is a developmental anomaly typified by the existence of a protuberance on the tooth structure. If the protuberance undergoes attrition or fractures, pulpal exposure, infection and necrosis ensues necessitating endodontic therapy. The authors present a case of dens evaginatus in a mandibular second premolar, in which the evagination underwent attrition resulting in pulpal exposure, subsequent necrosis and chronic apical abscess formation. Since the tooth had undergone apical maturation, management was by endodontic treatment with intracanal medicament dressing of the canal prior to obturation.

Introduction

According to the American Association of Endodontists, glossary of endodontic terms, Dens evaginatus is defined as an anomalous outgrowth of tooth structure resulting from the folding of the inner enamel epithelium into the stellate reticulum with the projection of structure exhibiting enamel, dentin and pulp tissue [1]. It is a relatively rare dental anomaly which in permanent dentition primarily affects the premolars, but it can also occur on incisors, canines and molars. When it occurs in premolars they are referred to 'Leong's Premolars' [2, 3]. A review of literature reports that it could occur unilaterally of bilaterally and is more frequently seen in Asians [4]. It is more common in men than women [4] and more frequent in mandibular teeth than maxillary teeth [5]. Dens Evaginatus is clinically important because the projected portion of tooth structure, is usually fragile and on fracturing or wearing off, the pulp becomes infected, then undergoes necrosis and periapical pathosis ensues [3, 4]. When pulpal necrosis occurs before completion of root formation, special treatment strategies must be employed to save the tooth [6]. Patient with certain syndromes, including Sturge-Weber syndrome and Rubinstein-Taybi syndrome are at high risk of having Dens evaginatus. Furthermore, panoramic radiographs are indicated for exclusion of the association of dens evaginatus with other dental abnormalities, such as impacted teeth, supernumerary teeth and odontomes [3].

Case Report

This is a case report of a 19 year-old male patient referred to the University of the East Endodontics-Periodontics Postgraduate Clinic for futher assessment and treatment.

About 2 years prior to consultation, the patient began experiencing sensitivity on the lower left region. The sensitivity was short-lived and occasional. With time, the sensitivity intensified, became more frequent and lasted longer than before. A year prior to consultation, he began experiencing mild pain that was aggravated by taking cold drinks. After about 6 months, he noticed that the mild pain subsided until there was no pain even when he took very cold drinks.

The patient did not have any problem until one morning, 2 weeks prior to consultation, the patient woke up with a swelling on the lower left jaw and associated mild pain. The swelling resolved in a weeks' time without taking any medications. He visited the Orthodontics postgraduate clinic in the university for treatment and upon examination, he was referred to the Endodontics postgraduate clinic for management of tooth 35.

Figure 1: Pre-operative photograph showing fistula on the labial aspect of tooth 35

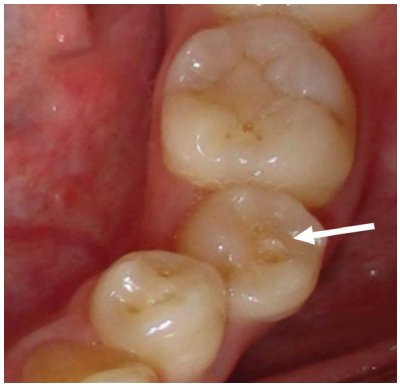

Figure 2: Note: arrow shows the worn out protuberance on the occlusal surface of tooth 35

The medical history was non-contributory. On clinical examination, a fistula was observed on the buccal aspect of tooth 35 (Fig.1). It also revealed a cusp-like projection on the occlusal surface that had undergone attrition (Fig. 2). Percussion, heat, cold and mobility tests were negative. However, he reported slight tenderness on palpation. Gutta percha tracing pointed to tooth 35 with a radiolucency evident on the mesial and periapical region of the said tooth. Tooth 35 also appeared to be mesially inclined (Fig. 3).

Figure 3: Gutta percha tracing on tooth 35

After considering the clinical and radiographic findings, the diagnosis made was Necrotic pulp and Chronic Apical Abscess [AAE 2013].

For the treatment, after rubber dam isolation, access cavity preparation then patency was done using pre-curved no. 6, 8, 10, stainless steel files [M Access™ Dentsply Sirona]. Working length was determined using Root ZX mini apex locator (J Morita, Japan) and an initial apical file radiograph taken to confirm the length. The glide path was prepared using ProGlider [Dentsply Sirona] and the canal shaped using WaveOne® Gold [Dentsply Sirona]. Canal was dressed using Vitapex® [Neo Dental International, Inc-USA] intracanal medicament (Fig. 4) and a temporary restoration placed using Fermin [Detax GmbH-Germany].

Fourteen days later, the Vitapex® [Neo Dental International, Inc-USA] intracanal medicament was removed, Master Apical File

Figure 4: Radiograph showing intracanal dressing

radiograph taken followed by Master Cone radiograph.

Obturation was done using lateral compaction method, with AH Plus [Dentsply Sirona] root canal sealer.

Fuji VII GIC [GC Dental-Japan] coronal orifice seal was placed before placing a direct composite onlay restoration using DiaFil [DiaDent International-Korea] (Fig. 5).

Figure 5: Final restoration radiograph

The patient was seen a month after the obturation, and is symptom-free. The tooth was reviewed at 3 months and 6 months (Fig. 6, 7).

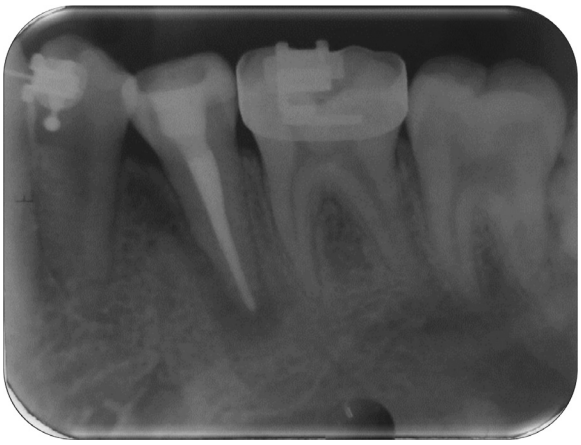

Figure 6: Three-month recall radiograph

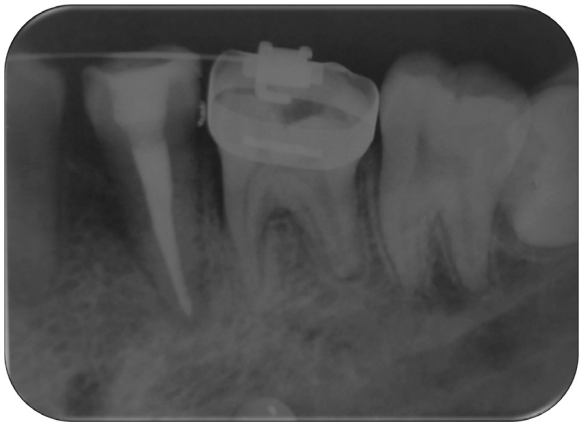

Figure 7: Six-month recall radiograph

Discussion

Dens evaginatus is a developmental anomaly of considerable clinical significance. The protuberance or elevation composed of enamel covering over a dentin core with a fine extension of pulp tissue may go unnoticed. However, if not detected early, the projection may fracture or undergo attrition leaving little or no external evidence of the malformation. Furthermore, keeping the area intact around the projection is difficult, and dental caries often develops [7].

The chances of pulp exposure during early phases of root development are high, if preventive management is not started as early as possible. If the pulp undergoes necrosis following exposure, then normal root formation and apical maturation ceases to happen [8].

In the current case, pulp necrosis occurred after apical maturation. The treatment of choice therefore was endodontic treatment. When pulp necrosis occurs in teeth with immature roots, treatment is either by apexification or regenerative endodontics [9, 10]. Selective reduction of the occluding teeth has been recommended for vital teeth with dens evaginatus to prevent attrition and subsequent pulpal exposure [4]. In circumstances where fracture of the projection occurs, it can be sealed with a resin material. When pulpal exposure occurs during the early phase of root development, depending on the extent of the exposure, pulp capping or mineral trioxide aggregate (MTA) pulpotomy is recommended to allow continual root development and apical maturation [4, 11]. Other preventive measures include giving oral hygiene instructions, full-mouth scaling and polishing, regular dental check-ups and application of topical fluoride. During the regular check-ups, extra attention should focused on the fissures. Furthermore, occlusal, pulp and periapical assessments should be done [3]. Reinforcing the protuberance with flowable composite in teeth with normal pulp has been shown to be useful. When there is adequate pulp recession, the tubercle can be removed and the tooth restored with composite [4]. Communication between the oral cavity and the root canal system via the tubercle may lead to more virulent microorganisms harboring and colonizing the root canal system. Diseases associated with such microorganisms may be resistant to treatment and thus special therapeutic strategies may be needed to eliminate the infection. Studies have established that antimicrobial intracanal medication results in predictable disinfection of the root canal system [12, 13, 14]. In the presented case, Vitapex® [Neo Dental International, Inc-USA] [Calcium hydroxide paste with Iodoform] was used to dress the canal for 14 days prior to obturation (Fig. 4). Calcium hydroxide has an alkaline pH that neutralizes bacterial endotoxins. Hydroxyl ions produced by the chemical dissociation of calcium hydroxide damages the bacterial DNA, cytoplasmic membrane and proteins generating an antibacterial effect [15]. Free iodine released from Iodoform causes oxidation of bacterial enzymes and precipitation of proteins thus inhibiting bacterial growth [16]. One study reported a high success rate in the healing of periapical lesions after dressing the canals with calcium hydroxide paste containing Iodoform [17]. In the current case, the healing of the fistula was observed after 14 days of dressing the canal with Vitapex® [Neo Dental International, Inc, USA]. Moreover, at the 6-month review, patient was asymptomatic and the recall radiograph showed continued healing of the periapical area (Fig. 7).

Conclusion

The clinician should be aware of anomalies such as dens evaginatus and their consequences so that proper preventive measures and treatment can be undertaken. Early detection enables the clinician to institute preventive therapies thus preventing further complications and allowing normal physiologic growth of the root and apical maturation. In cases that result in pulp necrosis after apical maturation and endodontic therapy is indicated, judicious use of intracanal medicament results in a better prognosis.

Conflicts of Interest

The authors declare no conflict of interests regarding the publication of this report.

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References

1. American association of endodontists, glossary of endodontic terms, ninth edition.
2. Vasudev S, Goel B. Endodontic Management of Dens Evaginatus of Maxillary Central Incisors: A Rare Case Report. Journal of Endodontics 2005; 31(1): 67–70.
3. Manuja N, Chaudhary S, Nagpal R, Rallan M. Bilateral dens evaginatus (talon cusp) in permanent maxillary lateral incisors: a rare developmental dental anomaly with great clinical significance. BMJ Case Reports 2013; https://doi.org/10.1136/bcr-2013-009184.
4. Levitan ME, Himel VT. Dens evaginatus: literature review, pathophysiology, and comprehensive treatment regimen. Journal of Endodontics 2006; 32 (1): 1–9.
5. Echeverri EA, Wang MM, Chavaria C, Taylor DL. Multiple dens evaginatus: diagnosis, management, and complications: case report. Pediatric Dentistry 1994; 16 (4): 314–7.
6. Cho S, Ki Y, Wing-Yee CV. Management of dens evaginatus: A case report. Hong Kong Dent J 2006; 3: 45–7.
7. Segura-Egea JJ, Jimenez-Rubio A, Rios-Santos JV, Velasco-Ortega E. Dens evaginatus of anterior teeth (talon cusp): Report of five cases. Quintessence Int 2003; 34: 272–7.
8. Stecker S, DiAngelis AJ. Dens evaginatus. A diagnostic and treatment challenge. The Journal of the American Dental Association 2002; 133 (2): 190–193.
9. American Academy of Pediatric Dentistry Council on Clinical Affairs Committee, Pulp Therapy Subcommittee: Guideline on pulp therapy for primary and young permanent teeth. Pediatr Dent 2005; 27(7): 130.
10. Kim JY, Xin X, Moioli EK. Regeneration of dental pulp-like tissue by chemotaxis-induced cell homing. Tissue Eng Part A 2010; 16: 3023-3031.
11. Koh ET, Ford TR, Kariyawasam SP, Chen NN, Torabinejad M. Prophylactic treatment of dens evaginatus using mineral trioxide aggregate. Journal of Endodontics 2001; 27 (8): 540–2.
12. Siqueira JF, Rocas IN, Microbiology and treatment of endodontic infections," in Cohen's Pathways of the Pulp, Hargreaves KM, Cohen S 2011; Eds: 559–600.
13. Windley W III, Teixeira F, Levin L, Sigurdsson A, Trope M. Disinfection of immature teeth with a triple antibiotic paste. Journal of Endodontics 2005; 31(6): 439–443.
14. Baumgartner CJ, Siqueira JF, Sedgley CM, Kishen A. Microbiology of endodontic disease, in Ingle's Endodontics 6, Ingle JI, Bakland LK, Baumgartner JC 2008; Eds: 221–308, BC Decker Inc, Hamilton, Canada.
15. Mohammadi Z, Dummer PMH. Properties and applications of calcium hydroxide in endodontics and dental traumatology. International Endodontic Journal 2011; 44 (8): 697–730.
16. Estrela C, Estrela CRDA, Hollanda ACB, Decurcio DDA, Pécora JD. Influence of iodoform on antimicrobial potential of calcium hydroxide. Journal of Applied Oral Science 2006; 14(1): 33–37.
17. Al Khasawnah Q, Hassan F, Malhan D, Engelhardt M, Daghma DES, Obidat D, Lips KS, El Khassawna T, Heiss C. Nonsurgical Clinical Management of Periapical Lesions Using Calcium Hydroxide-Iodoform-Silicon-Oil Paste. BioMed Research International 2018; 2018: 1–8.

Treating Severely Calcified Root Canal Systems: A Case History

Terrell F. Pannkuk, DDS, MScD

Pulp space calcification is a common root canal treatment challenge. Pulp stimulation due to previous pulp capping and disruption of the pulp circulation after tooth trauma seems to lead to changes of pulp cells. Two mechanisms have been suggested: 1. cytokine release in response to these inflammatory events activating resident stem cells, and 2. phenotypic conversion or dysplastic changing of pulp fibroblasts into odontoblast progenitors leading to tertiary dentin formation (1). Clinicians constantly challenged by the complexities and sequelae of pulp space calcification prefer to refer to tertiary dentin as "irritational" or diseased dentin rather than researchers who prefer the term "reparative" dentin. This is often a matter of perspective. One group (2) reviewed the literature and found that 75% of teeth with pulp canal obliteration (PCO) are symptom-free suggesting that no treatment is required other than radiographic monitoring. The clinical dilemma is that allowing a pulp canal to proceed to obliteration makes future treatment unnecessarily complicated when an endodontic emergency occurs. Traumatized anterior teeth are very frequently discolored and root canal treatment with internal bleaching is often desired.

The following case history will demonstrate successful navigation and treatment of severely calcified canals in two maxillary central incisors.

This patient presented with a history of trauma to the anterior maxilla. Both Maxillary Left and Right Central Incisors were clinically discolored (Fig. 1A) and appeared to be severely calcified on the preoperative radiographs. Both teeth tested equivocally to cold thermal stimulation (ice pencil) and the electric pulp test (Analytic Technology) resulted in no response to the maximum level (80). Mobility, percussion, biting, chewing and palpation tests were unremarkable with normal periodontal findings. Both teeth were diagnosed as having necrotic pulps with a questionable periapical status. Endodontic treatment was recommended with optional internal bleaching at the discretion of the patient. A detailed description of the treatment of the left central incisor will be explained due to it being the most calcified tooth requiring deep penetration to establish patency.

A well-angulated periapical and bitewing radiographs provides useful information for a pretreatment access strategy. Occasionally, a root anomaly or unusual root angulation requires a change in standard technique. A CBCT scan can provide even more precise three dimensional information about the geometry of the root canal system space. In this case the tooth had straight alignment with a centered canal (Fig. 1B).

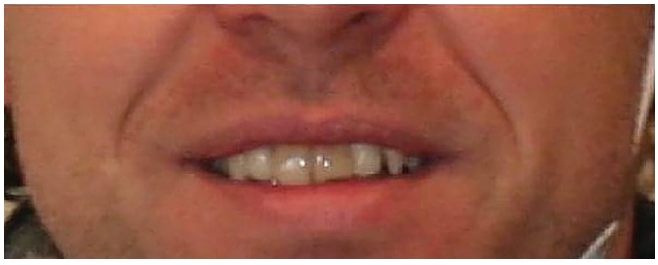


Figure 1A

Figure 1B

Initial access penetration was performed with a #330 carbide bur, made just above the lingual cingulum. A common error is to misdirect the penetration angle labial to the canal space. If a slight error is made toward the lingual, good visibility is maintained as the preparation is smoothed revealing the "pulpal floor map" which contrasts the darker tertiary dentin (obliterated canal space) to the lighter, peripheral (secondary and primary) dentin.

Smoothing with a #2 round carbide bur reveals the dark tertiary dentine (the calcified canal) (Fig. 2). Clearing with 17% EDTA maintains the perspective of the calcified dentine which should be penetrated at the most apical and lingual position to remain on a centered line with the long axis of the root. Deeper penetration with a small Munce bur is alternated with a #2 round bur while constantly clearing with 17% EDTA. I refer to this as the "Staging and Penetration Technique" which I also developed for drilling out posts. The idea is to create an initial flat smooth floor that highlights the pulpal floor map with good visibility so that penetration with a smaller diameter bur can be made precisely down the long axis of the root only into the tertiary dentin. The "staging and penetration" process is repeated keeping the penetrations shallow with subsequent controlled flat staging. Progress will be steadily made until a "white dot" is seen after constant clearing with 17% EDTA. Occasional clearing with alcohol (either 95% isopropyl or absolute ethanol) allows complete drying and "frosting" of the white dot for better visibility.

When a catch or "stick" is felt with an endodontic explorer, a small K-file may be placed. The value of a novel new pulp dehydrant (trichloroacetic acid-based) is shown (Fig. 3). The pulp dehydrant shrinks the pulp remnants creating space for a file to pass. It also dissolves debris like accumulated blocking hydroxyapatite crystals. Once cleared, the file passes easily down the canal space as calcification occurs coronal-apically so the more apical root tends to be less obstructed. Any perceived apical obstructions are usually canal curvature or branches that can be navigated by more coronal flaring and copious irrigation. Progress is made down the natural canal space with patience (Fig. 4). The process is repeated with sequenced use of pre-curved K-files (recapitulations) and rotary file shaping. The canal is

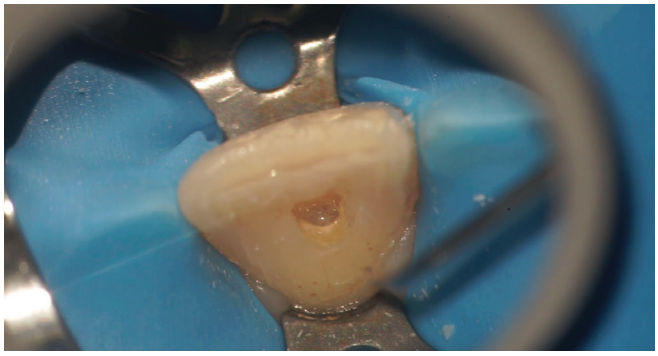
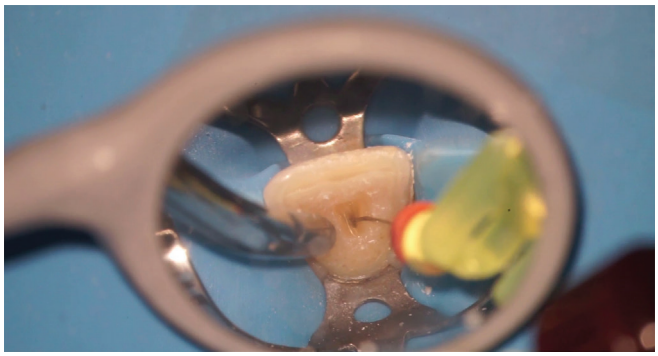


Figure 2



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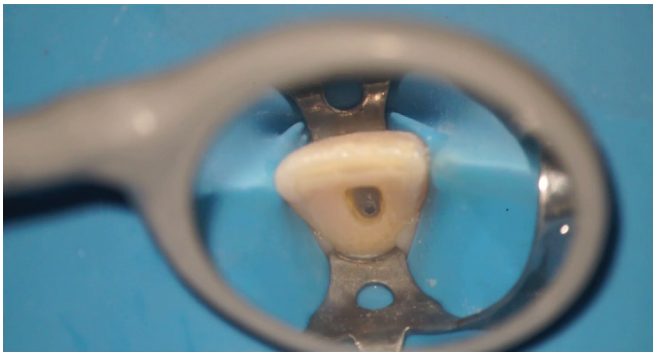

Figure 4

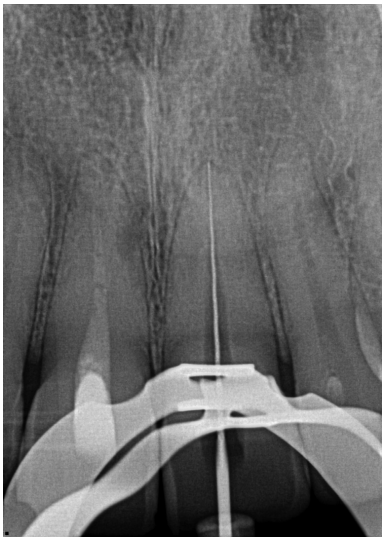

Figure 5

Figure 6

Figure 7

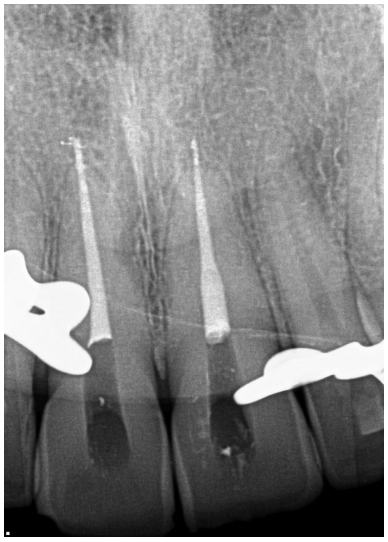

Figure 8

Figure 9

constantly flushed with sodium hypochlorite to minimize debris accumulation. Eventually the entire canal space is cleaned and shaped with patency established (Fig. 5).

The pulps were diagnosed as being necrotic so intracanal calcium hydroxide was placed (Fig. 6). The access cavity preparations were filled with Cavit and no pulp chamber spacer to insure coronal seal. Three weeks later, the root canal systems were filled with gutta percha and Kerr sealer (regular set) via the vertical compaction of warmed gutta percha technique (3) (Figs. 7, 8, and 9).

In summary, it is rare for root canal systems to be completely obliterated and calcification tends to be in the coronal portion only. A patient thoughtful strategy of cleaning and shaping can result in predictable endodontic treatment with an extremely rare need for surgery. Make sure the patient is scheduled for adequate treatment time to avoid a feeling of stress and rushing. Understanding root anatomy is important and as clinical experience is developed challenges like calcification will become routinely treated without frustration and a great sense of accomplishment knowing the best possible treatment was provided the patient.

About the Author

Dr. Terry Pannkuk is a native of California, graduated from University of California School of Dentistry in Los Angeles (UCLA) with a degree in Biology. He received his Doctor of Dental Surgery degree in Georgetown Dental School and went to Boston University for a degree of Master of Science in Dentistry in Endodontics. He held several positions in the different organizations in the field of Endodontics - Diplomate of the American Board of Endodontics, a former editor and publisher of "The Endodontic Report", former president of the Boston University Endodontic Alumni Association, a current reviewer for the Journal of Endodontics (official journal of the American Association of Endodontists), former president of the Academy of Microscope Enhanced Dentistry (AMED), former president of the Schilder Institute for the Advancement of Endodontics, and international lecturer-author of topics relating to clinical endodontics.

His current passion is the development of virtual dental education conferences networking dental students, educators, researchers, and clinical practitioners from around the world. He occasionally plays golf and goes fishing. He lives with his wife of 40 years (Diane), has two gainfully employed sons who live in Seattle, and practices in Santa Barbara, California.

References

1. Hargreaves KM, Goodis HE, Tay FR. Seltzer and Bender's Dental Pulp, 2nd ed. Hanover Park, IL, Quintessence; 2012, p. 317
2. McCabe PS, Dummer PMH. Pulp canal obliteration: an endodontic diagnosis and treatment challenge. Int Endo J. 2012; 45:177-197
3. Schilder H. Filling root canals in three dimensions. Dent Clin of North Am; 1967:723-44