Original Research

Root Canal Transportation in Canals Joining together: Assessed by Cone-Beam Computed Tomography

Neda Naghavi[1], Mina Zarei[1], Maryam Gharechahi[2], Ali Bagherpour[3], Zahra Owsati[4]

[1]Dental Material Research Center, Department of Endodontics, Faculty of Dentistry, Mashhad University of Medical Sciences (MUMS), Mashhad, Iran

[2]Dental Research Center, Department of Endodontics, Faculty of Dentistry, Mashhad University of Medical Sciences (MUMS), Mashhad, Iran.

[3]Dental Research Center, Department of Radiology, Faculty of Dentistry, Mashhad University of Medical Sciences (MUMS), Mashhad, Iran.

[4]General practitioner, private practice

Received 10 December 2017and Accepted 7 February 2018

Abstract

Introduction: Statement of the Problem: Cleaning and shaping are regarded as the most important aspects of root canal therapy and prerequisite for the success of endodontic treatment. Apical transportations can jeopardize the outcome of treatment due to the significant decrease in the sealing ability of root filling material. The purpose of this study was to evaluate transportation in type II canals with two preparation techniques. **Materials and Method**: Twenty lower first molars were selected and divided into 2 groups of 10. In the first group, the lingual canal of the mesial root was selected as the main canal and prepared up to the WL. The other canal (buccal) was prepared up to the juncture point. In the second group, both canals in the mesial root were prepared up to the working length. The amount and direction of canal transportation in each group were determined in five sections from 2 mm above the juncture point of the canals to 2 mm below the juncture point in 1-mm increments. **Results**: There were no significant differences between the two techniques in causing transportation in both buccolingual and mesiodistal directions in each increments (P>0.05). **Conclusion**: Both preparation techniques caused transportation in both mesiodistal and buccolingual directions.

Key words: Cone-beam computed tomography; Root canal therapy; Root canal transportation; Type II configuration.

Naghavi N, Zarei M, Gharechahi M, Bagherpour A, Owsati Z. Root Canal Transportation in Canals Joining together: Assessed by Cone-Beam Computed Tomography. J Dent Mater Tech 2018; 7(2): 69-74.

Introduction

Proper three-dimensional cleaning and obturation of all the root canals of a tooth is a prerequisite for the success of endodontic treatment. The pulp canal system is complex, and the root canals may branch, divide and rejoin. Weine categorized the root canal system in any root into four basic types (1). Others found a much more complex canal system (2, 3); Vertucci identified eight pulp space configurations (2). In both grouping methods (Weine and Vertucci), type II is comprised of two separate canals leaving the pulp chamber and joining short of the apex to form one canal. In one study, the prevalence of this configuration in individual teeth was as follows:

- In maxillary anterior teeth, mandibular premolars, distobuccal and palatal roots of maxillary molars: 0%
- About 0-20% in maxillary premolars,
- About 0-27% in the mesiobuccal canal of maxillary molars
- About 0 -10% in mandibular anterior teeth
- About 0-33% in mesial roots of mandibular molars
- About 0-9% in distal roots of mandibular molars (2)

According to a recommendation, this anatomy is best treated by preparing and obturating one canal to the apex and the other to the point of juncture because the point where the two canals join is a potential point to become transported (4).

Iatrogenic preparation errors such as canal transportation are clearly undesirable and can be broadly defined as any deviation from the natural canal path (5). Thus, techniques and endodontic instruments should be employed that cause fewer errors, provide greater precision, and decrease working time (6).

Various methods, such as double radiographic superimposition technique, have been used to investigate preparation errors and root canal transportation (6). Classical in vitro methods of studying the morphologic characteristics of root canal systems produce irreversible changes in the samples and can yield only a 2-dimensional image (7, 8). More accurate information can be achieved with cone-beam computed tomography (CBCT), which provides quantitative and qualitative evaluation of the root canal in 3 dimensions (9). CBCT is a non-invasive experimental method that allows the comparison of pre- and post-preparation images of root canals.

No published article is available in relation to the evaluation of the root canal transportation in type II canals in the literature. The aim of the current study was to analyze the effects of different instrumentation methods on canal transportation in type II canals using CBCT technique.

Materials and Method

A total of 20 mandibular molars were selected for this study. The inclusion criteria for the study were: type II canals in the mesial root, confirmed by conventional radiography taken in mesio-distal direction, fully formed apices, maximum canal diameter equivalent to K-file #15 (DentsplyMaillefer, Switzerland) and canal curvature less than 25°. The teeth were stored in 10% formalin until use. Prior to the study, the teeth were washed with distilled water to remove residual formalin.

For the initial CBCT scan, every 5 teeth were mounted in foam arches in close contact to each other to allow reproducible orientation in the pre- and post-preparation scans and an acrylic facing was placed on the facial side to mimic soft tissue on the radiographs (fig. 1). Prior to preparation, all the teeth were scanned by a CBCT scanner (Planmeca OY, Helsinki, Finland), with a resolution (pixel size) of 160 µm, and a field of view (FOV) of 5×8×8 cm^3. The 1-mm layer of images were taken axially by moving the toolbar from 2 mm above the juncture point of the canals to 2 mm below the juncture, and perpendicular to the long axis of the root. The pre-procedural images were recorded to be later compared with post-preparation images.

After initial scanning, the access cavities were prepared and the root canals were localized and explored with a #10 K-file (DentsplyMaillefer, Switzerland) until they were visible at the apical foramen. Working length (WL) was determined by subtracting 1 mm from a #10 K-file length visible at the apex. At this point, the total samples that were standard according to inclusion criteria, were divided randomly into 2 groups of 10 teeth each.

In the first group (G1), the lingual canal of the mesial root was selected as the main canal and prepared to the WL. The other canal (buccal) was prepared to the juncture point. In the second group (G2), both canals in the mesial root were prepared to the WL. Canal patency was achieved by k-file #10. The junction was determined by CBCT.

All the canals were instrumented by the student of dentistry on 6^{th} year with stainless steel K-files (DentsplyMaillefer, Switzerland) using the step-back technique. Apical enlargement was carried out with instrument size up to #30. Anti-curvature technique was applied in all instrumentation steps. During instrumentation, the root canals of both groups were irrigated with 2 mL of 3% sodium hypochlorite (Whitex, Chemin Chemical Co., Iran) after each file. After preparation was completed by an experienced operator, the samples were mounted in foam arches in the same sagittal position and re-scanned using the same parameters as in the initial scan, for comparison against the pre-preparation images.

The degree of canal transportation was calculated by measuring the shortest distance from the edge of a non-instrumented canal to the periphery of the root (mesial and distal, buccal and lingual) and then comparing this with the same measurements made on images of instrumented canals. According to Gambilli et al (10), the formula for canal transportation (in mm) is: ((X1-X2)-(Y1-Y2))

where X1 and X2 are the shortest distances between the mesial (and buccal) root periphery and the canal in non-instrumented and instrumented canals, respectively, and Y1 and Y2 represent the shortest distance between the distal (and lingual) root periphery and the canal in non-instrumented and instrumented canals, respectively (Fig. 2).

Pre- and post-operative calculations were compared to determine the existence of canal transportation from 2 mm above the juncture point to 2 mm short of the apex.

According to this formula, a ‘0’ value indicates no canal transportation. Any result other than ‘0’ indicated transportation of the root canal. A negative value represented transportation occurring in the distal (and lingual) direction, whereas positive values represented transportation in the mesial (and buccal) direction.

The transportation results were analyzed statistically. Data were distributed normally (Shapiro-Wilk test) and were analyzed statistically using univariate, two-way repeated-measures ANOVA. A 95% level of confidence was used for all the analyses.

Figure 1. Mounting of tooth for CBCT scan

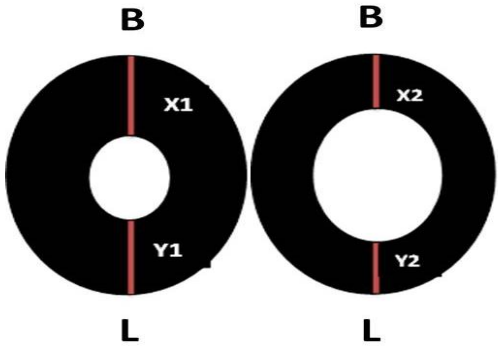

Figure 2. The degree of canal transportation was calculated by measuring the shortest distance from the edge of a non-instrumented canal to the periphery of the root (mesial and distal, buccal and lingual) and then comparing this with the same measurements made on images of instrumented canals.

Results

Regarding the direction of root canal transportation, both preparation techniques caused transportation toward both sides in both directions- buccolingual and mesiodistalwithout any significant differences (table1, 2). There was no mutual interaction between these two factors: instrumentation technique and increments in both mesio-distal (p=0.26) and bucu-lingual (p= 0.46) directions(Table 2), however; the distal displacement was more in increments coronal to the junction point and the mesial displacement was more in increments apical to the junction point, in both preparation techniques, without any significant differences. The mesiodistal displacement in junction point was less than apical and coronal points with no significant difference.

There were no significant differences between the two techniques in causing transportation in both buccolingual (p=0.12) and mesiodistal directions (p=0.99) Table 2). Significant difference was found between different increments in mesio-distal direction (p=0.01) but no significant differences in transportation between different increments (-2 mm to 2 mm) in buco-lingual direction (p=0.06) (Table 2).

Table 1. Canal transportation (mm) in bucco-lingual and mesio-distal direction for each preparation technique at each sector of the canal (n=10)

Increments	Group	Bucco-lingual	Mesio-distal
-2mm (2 mm under the junction)	G1	-.14±.35	.07±.18
	G2	-.07±.41	.12±.25
-1mm (1 mm under the junction)	G1	-.16±.27	.04±.10
	G2	-.03±.17	.15±.15
0mm (junction)	G1	-.08±.24	.01±.09
	G2	-.10±.21	.11±.23
1mm (buccal division) (1 mm above the junction)	G1	-.10±.25	-.02±.12
	G2	.07±.18	-.00±.17
1mm (lingual division) (1 mm above the junction)	G1	-.01±.21	-.00±.15
	G2	.00±.26	-.04±.27
2mm (buccal division) (2 mm above the junction)	G1	-.26±.23	-.05±.17
	G2	-.04±.25	-.17±.21
2mm (lingual division) (2 mm above the junction)	G1	.07±.24	-.09±.15
	G2	.15±.40	-.20±.23

Table 2. Effect of different parameter on transportation

Direction	Bucco-lingual	Mesio-distal
Effect of Instrumentation technique (G1 & G2)	P=0.12	P=0.99
Effect of increments	P=0.06	P=0.01
Interaction between increments and Instrumentation technique	p=0.469	P=0.26

Discussion

Root canal transportation is a common mishap during the instrumentation of root canals. Debris and residual microorganisms maybe harboring in the apical third of the root canal because of insufficient cleaning of the root canals and destruction of the root canal integrity. Insufficiently designed access cavities, use of inflexible instruments, instrumentation technique, tip design, insufficient irrigation during mechanical enlargement, degree and radius of a canal curvature, unseen canal curvatures in two-dimensional (2D) radiography, and skill of operator could be the etiology of canal transportation (11). Nazari Moghadam *et al*. (12) emphasizes that apical transportations that are > 0.3 mm can jeopardize the outcome of treatment due to the significant decrease in the sealing ability of root filling material; thus, studies that evaluate apical deviation are important tools to improve clinical practice (13). In the present study, the amount of canal transportation in all of increment was less than 0.3 mm.

Whenever a root contains two canals that join to form one, the lingual/palatal canal generally is the one with direct access to the apex. Vertucci believes that this anatomy is best treated by preparing and obturating this canal to the apex and the buccal canal to the point of juncture. If both canals are enlarged to the apex, an hourglass preparation results; the point where the two canals join is more constricted than the preparation at the apex (2). Filling such a configuration leaves voids in the apical third, favoring treatment failure, particularly if microorganisms or their byproducts remain in the canal (4). No laboratory research article is available in relation to the evaluation of the root canal transportation in type II canals in the English literature. In this study there was no significant difference between the two preparation techniques in causing transportation in buccolingual and mesiodistal directions in type II canals, however; the distal displacement was more in increments coronal to the junction point and the mesial displacement was more in increments apical to the junction point, in both preparation techniques. Anti-curvature technique used in this study may cause these differences.

We chose the mesial roots of mandibular molars in this study because the most prevalent type II canals are seen in these roots (2, 4).

In this study stainless steel K-files were used for canal preparation with the step-back technique because file separation can occur when rotary nickel-titanium files traverse the sharp curvature into the common part of the canal (4).

Recently, new methods for evaluating procedural errors after root canal preparation have improved our understanding of which preparation techniques are most efficient. The present research used CBCT that allows quantitative and qualitative evaluations of root canals, revealing their anatomical properties and variations in three dimensions, increasing the success rate of endodontic treatment and the progress of research (9, 14-16).

This study showed that in bucco-lingual direction, instrumentation technique and amount of increment dose not related to each other (p = 0.830). Also without considering the instrumentation technique, there were no significant differences in different increment depths (p=0.064). Bucco-lingual displacement only in junction increment was higher in method 2 (both canals were prepared to the WL) with no significant difference (p=0.120). Totally, in both techniques, the lingual displacements were higher than that of buccal, maybe because of consideration of the lingual canals for the main canal that in both technique were instrument up to WL. In mesio-distal direction, instrumentation technique and amount of increment dose not related to each other (p = 0.261) and the amount of displacements were decrease from apex to junction and increase from junction to coronal increments in both techniques. In the other hand, the less displacement was seen in junction point. Also the distal displacement was more in increments coronal to the junction point and the mesial displacement was more in increments apical to the junction point, in both preparation techniques that could be related to the anti-curvature method that was used for instrumentation technique in this study. Totally, there were no significant differences between the two techniques in causing transportation in both buccolingual and mesiodistal directions. Unfortunately, we were unable to find any published reports on transportation of root canals in type II canals to make comparisons.

One of the limitations of the present study was the inability of CBCT to distinguish minor changes in the apical area of the canal and we had to select teeth in which the junction of the canals was at least 4 mm away from the apex so that canal transportation at the junction could be correctly identified, which posed a problem for the selection of samples, resulting in a small sample size in each group. The present study can be considered a pilot study and it is suggested that another study be performed with rotary files and micro-CT technique in type II canals to evaluate the canal transportation, using a bigger sample size. Also we should noticed that this result obtain in canal curvature less than 25°. Maybe in cases with more curvature, the difference will found between two techniques and we suggest that these techniques should be evaluated in greater curvatures.

Conclusion

According to the methodology used, and on the basis of the results of this study, we concluded that there is no difference between two preparation techniques regarding to canal transportation in both mesiodistal and buccolingual directions.

.

References

1. Weine FS, Healey HJ, Gerstein H, Evanson L. Canal configuration in the mesiobuccal root of the maxillary first molar and its endodontic significance. Oral Surg Oral Med Oral Pathol 1969; 28: 419-425.
2. Vertucci FJ. Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol 1984; 58: 589-599.
3. Gulabivala K, Aung TH, Alavi A, Ng YL. Root and canal morphology of Burmese mandibular molars. Int Endod J 2001; 34: 359-370.
4. (4) Cohen S, Hargreaves KM. Pathways of the pulp.9th ed Mosby: Washington ; 2006. p. 158.
5. Peters OA . Current challenges and concepts in the preparation of root canal systems: a review. J Endod 2004; 30: 559-567.
6. Iqbal MK, Maggiore F, Suh B, Edwards KR, Kang J, Kim S . Comparison of apical transportation in

four Ni-Ti rotary instrumentation techniques. J Endod 2003; 29: 587-591.
7. González-Rodrguez MP, Ferrer-Luque CM. A comparison of Profile, Hero 642, and K3 instrumentation systems in teeth using digital imaging analysis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004; 97: 112-115.
8. Mikrogeorgis G, Molyvdas I, Lyroudia K, Nikolaidis N, Pitas I. A new methodology for the comparative study of the root canal instrumentation techniques based on digital radiographic image processing and analysis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006; 101: e125-131.
9. Kim I, Paik KS, Lee SP. Quantitative evaluation of the accuracy of micro-computed tomography in tooth measurement. Clin Anat 2007; 20: 27-34.
10. Gambill JM, Alder M, del Rio CE. Comparison of nickel-titanium and stainless steel hand-file instrumentation using computed tomography. J Endod 1996; 22: 369-375.
11. Yang Y, Shen Y, Ma J, Cao Y, Haapasalo M. Instrumentation Endod 2016; 42: 1258-1262.
12. NazariMoghadam K, Shahab S, Rostami G. Canal transportation and centering ability of twisted file and Reciproc: a cone-beam computed tomography assessment. Iran Endod J 2014; 9: 174–179.
13. Paleker F, van der Vyver PJ. Comparison of Canal Transportation and Centering Ability of K-files, ProGlider File, and G-Files: A Micro-Computed Tomography Study of Curved Root Canals. J Endod 2016; 42:1105-1109.
14. Cotton TP, Geisler TM, Holden DT, Schwartz SA, Schindler WG. Endodontic applications of cone-beam volumetric tomography. J Endod 2007; 33: 1121-1132.
15. Huumonen S, Kvist T, Gröndahl K, Molander A. Diagnostic value of computed tomography in re-treatment of root fillings in maxillary molars. Int Endod J 2006; 39: 827-833.
16. Low KM, Dula K, Bürgin W, von Arx T. Comparison of periapical radiography and limited cone-beam tomography in posterior maxillary teeth referred for apical surgery. J Endod 2008; 34: 557-562.

Corresponding Author
Dr. Maryam Gharechahi,
Assistant Professor, Department of Endodontics, Faculty of Dentistry,
Mashhad University of Medical Sciences
P. O. Box: 91735-984
Tell: +98 51 38829511
Email: gharechahim@mums.ac.ir