Cone-beam computed tomographic evaluation of remaining dentin thickness in bifurcated roots of maxillary first premolars after rotary instrumentation and post space preparation: An in vitro study

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Abstract

Background: Intraradicular procedures remove radicular dentin and jeopardizing longevity of a tooth. Traditional in vitro methods used to determine the remaining dentin thickness (RDT) have limitations.

Aim: The aim is to evaluate, using cone-beam computed tomography (CBCT), RDT following rotary instrumentation and post space preparation in buccal and palatal roots of maxillary first premolars.

Materials and Methods: Twenty-three maxillary first premolars with two roots were selected. CBCT images were taken preoperatively, after instrumentation and Parapost 3 and 4 preparation (CBCT 1, 2, 3, and 4). RDT was measured 5 mm above apex, 1 mm below furcation, and 1 mm above furcation (Levels 1, 2, and 3). Data were analyzed using ANOVA and post hoc Tukey’s test ($P = 0.05$).

Results: Rotary instrumentation and post space preparation reduced RDT in all walls of buccal and palatal roots. Post space preparation with Parapost 3 and 4 reduced RDT in the palatal wall of buccal root to <1 mm and Parapost 4 reduced all walls to 1 mm of dentin.

Conclusion: Post space preparation in maxillary first premolars should be performed cautiously. It is safer to place a post in the palatal root of this tooth and limit preparation to Parapost 3.

Keywords: Cone-beam computed tomography; maxillary premolars; parapost drills; remaining dentin thickness

INTRODUCTION

A pulless tooth loses substantial amount of tooth structure as an aftereffect of caries, previous restorations, trauma, access cavity preparation, cleaning, and shaping of root canal system. In such cases, analysis of whether or not a post is needed relies on how much natural tooth substance remains to retain a core build up. Studies relate that loss of tooth structure >50% would determine the use of root posts to retain a core and to distribute stresses.

Tamse et al. observed that longitudinal root fractures are more common in teeth or roots whose mesiodistal dimension is narrow, such as maxillary premolars. A palatal invagination on the bifurcation aspect of the buccal root is found in 80%–100% of the maxillary first premolars, an important clinical landmark to be considered during
post space preparation. Research has concluded that a post must not exceed 1 mm in diameter at its tip, leaving a minimum of 1-mm dentin around the post, as thicker root dentin walls increase the fracture resistance of root-filled teeth considerably. Thus, remaining dentin thickness (RDT) after post space preparation is relevant because it makes the root less liable to fracture under horizontal impact.

Clinicians should bear in mind the root morphology along with the significance of RDT to exercise caution during rotary instrumentation and post space preparation. Various methods have been used in vitro to determine RDT such as sectioning, radiographic imaging, and muffle technique. However, sectioning and muffle technique demand destructive sectioning of the specimens and physical reassembly of sections.

In this regard, cone-beam computed tomography (CBCT) has come up as a boon since it can measure dentin thickness of root canal walls, because of its noninvasive nature, three-dimensional (3D) view, accuracy, and reliability, thus serving as a crucial diagnostic tool to gauge the RDT, particularly in teeth with compromised root morphology. There is limited literature on the use of CBCT for measuring RDT following post space preparation.

Thus, the aim of this study was to evaluate, using CBCT, the RDT following rotary instrumentation and post space preparation using Parapost drills, in buccal and palatal roots of maxillary first premolars.

MATERIALS AND METHODS

Twenty-three maxillary first premolars extracted for orthodontic purpose, with closed apices and having bifurcation at the junction of cervical and middle third or the middle third of the roots, were included in this study. Teeth with caries, restoration, resorption, incompletely formed apices, fused roots, calcified canals, and endodontically treated were excluded from this study. Samples were cleaned of any visible blood and gross debris and were immersed in 10% formalin (Nice Chemicals Ltd., Kochi, Kerala, India) for 7 days. Then, they were soaked in 3% sodium hypochlorite (VIP, Vensons India, Bengaluru, Karnataka, India) for 30 min and immersed in distilled water throughout the study. Teeth were embedded in wax blocks up to the cementoenamel junction, which in turn were mounted on a putty template. Preoperative CBCT images (CS 9300, Carestream Dental, NY, USA) of all the teeth were taken (70 kV, 5.0 mA, and 90 µm voxel size), which acted as the control group images (CBCT 1) [Figure 1].

Access cavity was prepared in each tooth with a round diamond bur No. 2 (Dentsply Maillefer, Ballaigues, Switzerland) in a high-speed handpiece. A size 10 K-file was inserted into the canals to verify the patency. Coronal preflaring was done using Gates Glidden drill No. 2 and No. 3. Working length was determined by insertion of a size 10 K-file into the buccal and palatal canals until the file tip was just visible at the apical foramen and then 0.5 mm was subtracted from the measured length. Chemomechanical preparation was completed in both canals up to size 25/0.06 using the Mtwo rotary system (VDW, Munich, Germany). Sufficient lubrication was done with Endo-prep RC (Anabond Stedman Pharma Research, Tamil Nadu) while instrumenting the canals. Each set of Mtwo rotary files was used for two teeth. Canals were copiously irrigated with at least 10 ml of 3% sodium hypochlorite with a 26-gauge needle in between files and with an additional 3 ml after the completion of chemomechanical preparation. The canals were finally irrigated with 1 ml of 17% ethylenediaminetetraacetic acid followed by irrigation with distilled water. The teeth were remounted on the template and the second set of CBCT images was taken (CBCT 2).

Post space preparation was initiated in both the root canals 5 mm short of working length using Parapost parallel-sided drill (Coltene/Whaledent®, Langenau, Germany) No. 3 (0.9 mm) and No. 4 (1.0 mm), each followed by sets of CBCT images (CBCT 3 and CBCT 4, respectively) [Figure 2].

All the CBCT images were examined and RDT was measured in horizontal sections at three levels of root canals using Carestream 3D imaging software.

- Level 1: 5 mm above the apex
- Level 2: 1 mm below the furcation level
- Level 3: 1 mm above the furcation level

Levels 1 and 2 provided four directions of measurements for each root (buccal, palatal, mesial, and distal), which extended from the root canal lumen to the outer surface. Level 3 provided three consistent directions of measurements for each root: outward (buccal or palatal), mesial, and distal.

Statistical analysis

For statistical analysis, data were entered into Microsoft Excel and later analyzed using SPSS version 20 (IBM Corp, Armonk, NY, USA). Descriptive analysis was done to calculate the mean and standard deviation for continuous data. One-way ANOVA and post hoc Tukey’s tests were performed to analyze the intergroup and intragroup comparisons, respectively.

RESULTS

At Level 1, all walls had RDT >1 mm following rotary instrumentation (CBCT 2). After post space preparation with Parapost 3 (CBCT 3), RDT of palatal wall of the buccal
root decreased from 1.1 mm to 0.9 mm, which further reduced to 0.8 mm after post space preparation with Parapost 4 (CBCT 4) [Tables 1 and 2].

At Level 2, all the walls had RDT more than 1 mm after rotary instrumentation (CBCT 2). After post space preparation with Parapost 3 (CBCT 3), RDT of palatal wall of the buccal root decreased from 1.1 mm to 1.0 mm, which further reduced to 0.9 mm after post space preparation with Parapost 4 (CBCT 4) [Tables 1 and 2].

At Level 3, there was a significant reduction in RDT in all walls after rotary instrumentation as well as post space preparation with Parapost 3 and Parapost 4, but the RDT did not reduce to <1 mm [Tables 1 and 2].

**DISCUSSION**

This study aimed to evaluate RDT following rotary instrumentation and post space preparation, in buccal and palatal roots of maxillary first premolars using CBCT.

Premolars are subjected to oblique forces and have less tooth substance and smaller pulp chambers to retain a core buildup after endodontic treatment than do molars, and posts are required more often in premolars. In most of the two-rooted premolars, the furcation area is located in the middle third, therefore, this study was conducted on two-rooted maxillary first premolars with bifurcation at the junction of cervical and middle-third or in the middle third.

The results of the study showed that the mean RDT values of all walls of both canals reduced after mechanical preparation but did not reach the critical thickness of 1 mm. Mtwo rotary system was chosen for mechanical preparation as it causes lesser thinning of root dentin as compared to other systems such as ProTaper Universal and ProTaper.
Table 2: Mean values of remaining dentin thickness for walls of the palatal root at three different levels (mm)

| Level   | Palatal root walls | CBCT 1 | CBCT 2 | CBCT 3 | CBCT 4 |
|---------|--------------------|--------|--------|--------|--------|
| Level 1 | Buccal             | 1.3±0.16 | 1.2±0.17 | 1.1±0.17 | 1.0±0.14 |
|         | Palatal            | 1.2±0.13 | 1.1±0.14 | 1.0±0.13 | 0.9±0.11 |
|         | Mesial             | 1.3±0.12 | 1.2±0.13 | 1.1±0.10 | 1.0±0.10 |
|         | Distal             | 1.3±0.14 | 1.2±0.13 | 1.1±0.10 | 1.0±0.07 |
| Level 2 | Buccal             | 1.5±0.16 | 1.3±0.14 | 1.2±0.10 | 1.1±0.09 |
|         | Palatal            | 1.4±0.12 | 1.2±0.12 | 1.1±0.13 | 1.0±0.12 |
|         | Mesial             | 1.4±0.15 | 1.2±0.14 | 1.1±0.12 | 1.0±0.12 |
|         | Distal             | 1.4±0.20 | 1.3±0.16 | 1.2±0.14 | 1.0±0.14 |
| Level 3 | Palatal            | 1.5±0.12 | 1.4±0.13 | 1.3±0.12 | 1.2±0.11 |
|         | Mesial             | 1.5±0.16 | 1.4±0.14 | 1.2±0.12 | 1.1±0.12 |
|         | Distal             | 1.6±0.19 | 1.4±0.17 | 1.3±0.14 | 1.1±0.12 |

* RDT values <1 mm, † RDT values of 1 mm. SD: Standard deviation, CBCT: Cone beam computed tomography, RDT: Remaining dentin thickness, † RDT values of 1 mm

Next,[9] RDT values of the palatal wall of buccal root after post space preparation (0.9 mm after Parapost 3 and 0.8 mm after Parapost 4) [Table 1] correspond to RDT values of 0.82–0.9 mm reported by Pilo et al.[16] and 0.75–0.86 mm by Ghoddusi et al.[7] The slight difference in mean values could be attributed to the more coronal or apical location of the slice in these studies. Such a detrimental dentin thickness made the root vulnerable to perforations and to both outward and inward crack propagation. The post space preparation primarily jeopardized the inner wall of buccal root. This is in agreement with the findings of Katz et al.[10]

The significant reduction in RDT of the palatal wall of buccal root can be attributed to the anatomical morphology of the maxillary first premolar. The furcation groove in the palatal wall of buccal root of maxillary first premolars was reported by Gher and Vernino[11] (78%) and Tamse et al.[12] (97%). The concavity starts at the bifurcation site, reaching a maximum value of 0.40 mm at a mean distance of 1.18 mm from the bifurcation. In the area of the deepest invagination, the average dentin width is only 0.81 mm before any endodontic and prosthetic intervention. The concavity then gradually becomes shallower disappearing toward the apex.[10] The root canal facing the furcal wall bears a concavity opposite the furcation groove, giving the canal a kidney-shaped appearance in cross section. The mean distance from the invagination to canal wall (0.81 ± 0.24 mm) and the shape of canal contradict a circular-shaped post space preparation at that level.[12]

Reducing dentin width too vigorously, particularly in this danger zone, can be a predisposing factor for perforation or vertical root fracture.[13] Hence, it would be relevant to evaluate RDT of root canal walls in this region. This validates the measurements being done at 1 mm below (Level 2) and 1 mm above (Level 3) the furcation in the present study. Level 1 (5 mm from the root apex) was selected since it is usually recommended to leave 5 mm of gutta-percha in place.[14] The RDT gradually decreased as measurements were taken nearer to apex, which is consistent with those ascertained within previous studies.[4,10,15]

The parallel Parapost X system drills have sure benefits such as, depth calibration for precise channel depth measurement (7, 9, and 11 mm from apical end), color coding for quick and reliable identification, non-end-cutting tip for low perforation risk, and precise matching to every post for optimum cement film thickness. Standlee et al.[16,17] claimed that tapered posts exhibit a wedging impact and may lead to vertical fractures. In vitro study by Cooney et al.[18] has shown that stresses are divided more uniformly with parallel posts compared to the tapered ones.

Traditional methods such as sectioning and muffle technique demand destructive sectioning of specimens and physical reassembly of sections.[19] In this regard, Hartmann et al.[20] has recommended CBCT to be a reliable method that requires no destructive sectioning of specimens. It has been widely advocated for pre- and postinstrumentation evaluation of dentin thickness of root canal walls.[9] Horizontal sections were examined as they allowed for the measurement of RDT of all four walls of the root canals.

Root size and canal morphology ought to be given consideration when selecting a post and preparing the post space. Considering the deep palatal invagination on buccal root of maxillary first premolars, palatal root should be chosen for postplacement, when needed. Tamse et al.[12] observed that mean distance of the deepest invagination of the palatal groove in the buccal root from the apex was 5.38 ± 1.51 mm. Therefore, in cases, where buccal root cannot be avoided as an anchor for a post, it is desirable to leave 7 mm of gutta-percha to prevent strip perforation in this critical area.

Regarding the size to which the root canal should be enlarged to receive a post, Parapost 4 reduced the dentin thickness of all walls of both roots to 1 mm or <1 mm at Levels 1 and 2 [Tables 1 and 2]. Hence, it is safer to limit the post space preparation to Parapost 3 in maxillary first premolar roots.

There are limitations inherent in an in vitro study design. As these teeth were not subjected to functional forces of the oral cavity, the impact of intraradicular procedures on their survival rate cannot be estimated. The use of CBCT in clinical scenario may not always be feasible owing to the radiation exposure it causes to the patient. This study was conducted under ideal conditions. The fact that root canals were not obturated in the study made it easier to centralize the post space preparation. To further reinforce the results of the present study, other teeth with morphological variations can also be evaluated. Various post space preparation techniques and post systems can be compared to recommend the most suitable combination for individual teeth. Thus, this study opens vistas for future research.
CONCLUSION

Within the limitations of the current study, it was concluded that mechanical preparation and post space preparation reduced dentin thickness of the root canal walls of maxillary first premolars. Palatal root should be given preference over buccal root for post placement, and the preparation should be limited to Parapost 3 in these teeth. Special care should be exercised for teeth with developmental invaginations and depressions, especially in the cervical and middle third of the root.

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Conflicts of interest
There are no conflicts of interest.

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