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Comparison of ProTaper Gold, Edge Taper Platinum, and V-Taper Gold Rotary Systems Regarding Transportation, Centering Ability, Remaining Dentin Thickness at the Danger Zone, and Surface Changes

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A B S T R A C T

Objectives: The purpose of this study was to compare ProTaper Gold, Edge Taper Platinum, and V-Taper Gold regarding transportation, centering ability, remaining dentin thickness at the danger zone, and surface changes.

Materials and Methods: Sixty extracted human mandibular and maxillary first molars were used in this in vitro study. Pre-instrumentation cone-beam computed tomography (CBCT) scanning of all teeth was performed; canal curvatures were calculated, and the samples were randomly allocated into three groups for root canal instrumentation with ProTaper Gold, Edge Taper Platinum, and V-Taper Gold. Post-instrumentation scans were obtained, and the two scans were compared to determine canal transportation, centering ability, and remaining dentin thickness. Surface changes were assessed with scanning electron microscopy (SEM) in the three groups. Data were analyzed using the Shapiro-Wilk test, Kruskal-Wallis test, and one-way ANOVA, as appropriate. The significance level was set at 0.05.

Results: No significant difference was found among the three groups regarding canal transportation (P>0.05), centering ability (P>0.05), or the amount of removed dentin (P>0.05). The mean remaining dentin thickness was more than the acceptable minimum in all three groups. In quality assessment of the files, no fracture, opening, or overlapping of the flutes was seen.

Conclusion: Based on the findings of the present study, the Edge Taper Platinum and V-Taper Gold rotary systems prepared the mesiobuccal canals of first molars similar to the ProTaper Gold system.

Keywords: Root Canal Preparation; Dental Instruments; Dentin; Molar; Dental Pulp Cavity

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INTRODUCTION

Root canal preparation is one of the most important steps in endodontic treatment, which includes mechanical debridement, creating a path for irrigant delivery, and canal space optimization for efficient root canal obturation [1-3]. Presence of root canal curvature may cause difficulty in root canal instrumentation, and lead to iatrogenic errors such as canal transportation, apical zipping, ledge formation, or fracture of endodontic instrument [4].

Nickel-titanium (NiTi) rotary instruments

with different designs perform endodontic treatments easier, faster, and more predictable than stainless-steel files [5]. NiTi instruments and files with non-cutting tips protect the canal centrality better than stainless-steel files. More flexible files decrease iatrogenic errors, and further improve the efficacy and safety of root canal preparation [6]. Various strategies have been developed for production of NiTi rotary files to increase their flexibility and fracture resistance. These strategies include file surface improvements through electropolishing, using new alloys that provide better mechanical properties, and using various cross-sectional designs [7-10].

ProTaper Gold (Dentsply/Maillefer, Ballaigues, Switzerland) has a convex triangular cross-section, and its convergence increases progressively. The available instruments in this collection include three shaping files and three finishing files [11-13]. Edge Taper Platinum (EdgeEndo, Albuquerque, NM, US) is a rotary system similar to ProTaper Gold in terms of size and cross-section. The manufacturer claims that Edge Taper Platinum is more flexible than ProTaper Gold, and more resistant to cyclic fatigue and torsional stress, while it is cheaper [14]. V-Taper Gold (Fanta Dental, Shanghai, China) is a NiTi rotary system designed for root canal shaping. The system includes shaping files and finishing files with a sequence comparable to that of ProTaper Gold. According to the manufacturer's description, V-Taper Gold files are produced using heat-treated NiTi technology to enhance flexibility and cutting efficiency [15].

Root canal preparation instruments significantly influence the final quality of treatment, and selecting an appropriate preparation system improves the treatment quality and maximizes success. Thus, this study aimed to compare ProTaper Gold, Edge Taper Platinum, and V-Taper Gold regarding canal transportation, canal centrality, and remaining dentin thickness at the danger zone using cone-beam computed tomography (CBCT). Surface changes in files were also evaluated using scanning electron microscopy (SEM).

MATERIALS AND METHODS

This ex vivo study was conducted on 60 extracted human mandibular and maxillary first molars (ethical approval code: IR.MUMS.DENTSTRY.REC.1398.087). The teeth had been extracted for periodontal, prosthetic, or orthodontic reasons and were collected after obtaining informed consent. The remaining tissue and calcified debris attached to the teeth were removed by scaling, and the teeth were immersed in 2.5% sodium hypochlorite solution for 24 hours. Next, the teeth were stored in saline solution until the experiment. Parallel periapical radiographs were initially obtained from the teeth to assess the canal curvature, and ensure absence of canal calcification.

The sample size was calculated based on previous comparable CBCT-based studies, with canal transportation considered as the primary outcome. With an alpha error of 0.05 and a power of 80%, the minimum required sample size was estimated to be 20 teeth per group. Therefore, 60 extracted first molars were included and randomly allocated to three groups. Only the mesiobuccal canals of the selected first molars were instrumented and evaluated in the present study.

The curvature angle was calculated based on the Schneider's method [16]. The teeth with a curvature of 10 to 24 degrees were included in the study. The teeth with a length of less than 17mm and more than 21mm were excluded from the study.

Access cavity was then prepared in the teeth, and the working length was determined using a #10 manual K-file (Mani Inc., Tochigi-Ken, Japan). The file was introduced into the canal, and 0.5mm was subtracted from its length after viewing the file tip at the apical foramen. Next, a #15 manual K-file was used to negotiate the root canal, and assess the apical foramen. The teeth with an apical diameter larger than the diameter of a #15 K-file were excluded from the study. The remaining teeth were mounted in a putty mold, and underwent CBCT (Planmeca ProMax 3D Max; Planmeca; Helsinki, Finland) with 8x8cm field of view and 160 µm voxel size, and axial, coronal, and sagittal sections were obtained. The teeth were randomly divided into three groups (n=20), and each group was prepared by

either ProTaper Gold, Edge Taper Platinum, or V-Taper Gold rotary system.

In the ProTaper Gold group, first, the Sx file was used to remove the coronal dentin barrier. In all treatment steps, root canal irrigation was performed with 5.25% sodium hypochlorite, and RC-Prep (Meta Biomed Co., Seoul, Korea) was used during instrumentation. In this step, patency was ensured using a #10 K-file. Next, S1 and S2 files were advanced to the working length. Each file was used with three pecking movements, removed from the canal, cleaned with a gauze, and this sequence was continued until the file reached the working length. In the last step, finishing files (F1, F2) were used to finish canal preparation. Each file was used for preparation of three canals.

Edge Taper Platinum and V-Taper Gold files are similar to ProTaper Gold in terms of having SX, S1, S2, F1, and F2 files. Therefore, the sequence of canal preparation with Edge Taper Platinum and V-Taper Gold systems was similar to ProTaper Gold. After preparation, the teeth were mounted again in the previous putty mold, and underwent CBCT with similar parameters.

Finally, the maintenance of canal centrality, transportation, remaining dentin thickness at the danger zone, and the amount of removed dentin were investigated using CBCT, and file appearance changes were investigated with SEM. ImageJ software version 1.52v (Java 1.8.0_112; Wayne Rasband, U.S. National Institutes of Health, Bethesda, MD, USA) was used to investigate the study variables.

The canals were assessed in three sections of apical, middle, and coronal at 3, 6, and 9mm from the apex to investigate the centering ability, and the centering ability ratio was calculated according to the following formula [17]:

$$Centering\ ability = \frac{M_1 - M_2}{D_1 - D_2}, if\ D_1 - D_2 > M_1 - M_2$$

$$Centering\ ability = \frac{D_1 - D_2}{M_1 - M_2}, if\ M_1 - M_2 > D_1 - D_2$$

Where M_1 is the shortest distance between the mesial wall of the teeth and the mesial wall of the non-instrumented canal, and M_2 is the shortest distance between the mesial wall of the teeth and the mesial wall of the instrumented canal. In this line, D_1 is the shortest distance between the distal wall of the teeth and the distal wall of the non-instrumented canal, and D_2 is the shortest distance between the distal wall of the teeth and the distal wall of the instrumented canal. The closer the achieved value to 1, the better the centering ability, and the closer the achieved value to 0, the weaker the centering ability would be.

The amount of canal transportation was investigated using the formula proposed by Gambill et al [18]. Apical transportation was determined according to the formula:

$$Transportation = (M_1 - M_2) - (D_1 - D_2)$$

at 1mm, 2mm, and 3mm distances. A value close to 0 indicates lack of transportation, and negative and positive values indicate transportation towards the distal and mesial, respectively. The absolute value of the obtained numbers was statistically analyzed to investigate the amount of transportation, and the numbers were analyzed to determine the transportation path in each group.

The dentin thickness on the first CBCT scan was measured at the furcation zone at 1mm, 2mm, 3mm, and 4mm levels to investigate the amount of dentin removed from the danger zone. The lowest dentin thickness was calculated in this zone after instrumentation. Next, their difference was calculated, and the groups were compared in this regard.

Figures 1 and 2 show prepared sections of maxillary first molar teeth at 1mm, 2mm, 3mm, and 4mm levels at the furcation area before and after canal preparation, respectively.

Similar to a study by Kour and Pradeep [19], F2 file was investigated using SEM. One new F2 file and two used F2 files were randomly selected for SEM investigation. Considering the fact that these files are made of metal, they did not need gold sputter coating for SEM investigation. First, these files were cleaned with a piece of gauze impregnated with isopropyl alcohol. Next, they were evaluated using SEM (FEG-SEM MIRA3 TESCAN, Czech Republic) at ×25 and ×200 magnifications. Finally, the cutting blade of the files was investigated for opening or overlapping of pitches, and any change was reported.

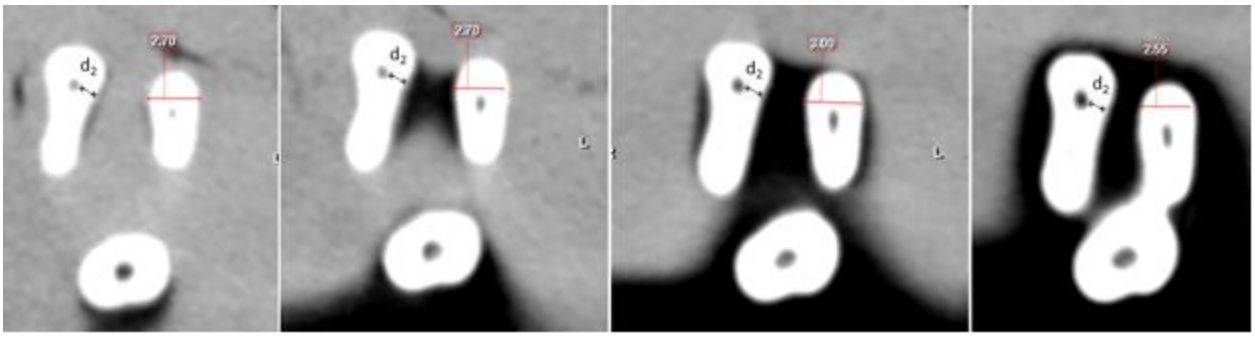

Fig 1. Axial section of the tooth root at 1mm, 2mm, 3mm, and 4mm from the furcation area (from right to left, respectively) before preparation of the mesiobuccal canal.

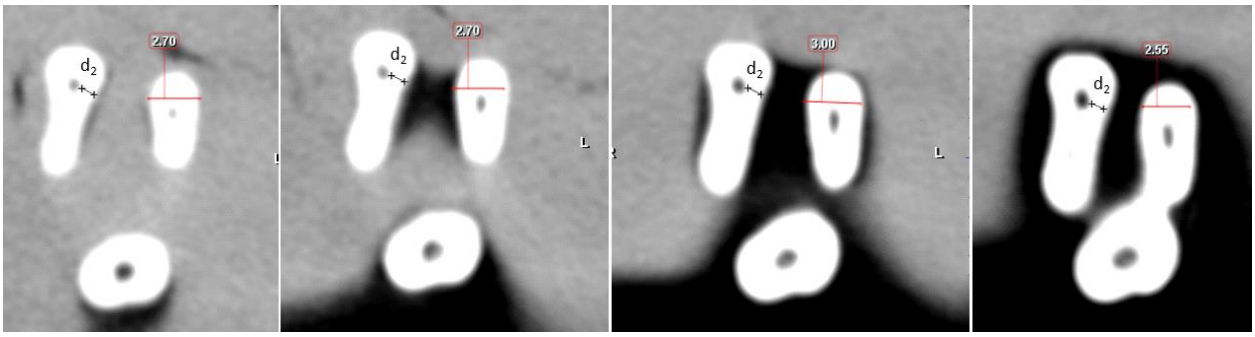

Fig 2. Axial section of the tooth root at 1mm, 2mm, 3mm, and 4mm from the furcation (from right to left, respectively) after preparation of the mesiobuccal canal.

First, the normality of data distribution was evaluated by the Shapiro-Wilk test, which showed that the data distribution was not normal for some variables and groups. Thus, the variables were compared among the three groups using the Kruskal-Wallis test or one-way ANOVA depending on data distribution.

RESULTS

Comparison of canal centrality maintenance among the groups at the apical, middle, and coronal zones:

In the apical zone, the difference among the three groups was not significant according to the Kruskal-Wallis test (P=0.989). In the middle zone, the difference among the three groups was not significant (P=0.673). In the coronal zone, the difference among the three groups was not significant either (P=0.933).

Comparison of canal transportation at 1mm, 2mm, and 3mm from the apex:

At 1mm distance from the apex, the groups did not have a significant difference according to the Kruskal-Wallis test (P=0.864). At 2mm distance from the apex, the groups did not have a significant difference in terms of canal transportation (P=0.841). At 3mm distance from the apex, the groups were not significantly different in terms of canal transportation (P=0.786).

The direction of canal transportation in all groups and at all levels was positive, indicating that the transportation was towards the mesial.

Comparison of the amount of removed dentin among the groups at different levels from the furcation:

At 1mm distance from the furcation, according to the Kruskal-Wallis test, the groups were not significantly different in terms of the amount of removed dentin (P=0.113). At 2mm distance from the furcation, the groups were not significantly different in terms of the amount of removed dentin based on one-way ANOVA (P=0.057). At 3mm distance from the furcation, the groups were not significantly different in terms of the amount of removed dentin based on the Kruskal-Wallis test (P=0.515). At 4mm distance from the furcation, there was no significant difference among the groups in terms of the amount of removed dentin (P=0.283).

Moreover, comparison of the amount of remaining dentin thickness at different distances from the furcation revealed that there was no significant difference among the groups in terms of the remaining dentin thickness (P>0.05). The lowest remaining dentin thickness belonged to the Edge Taper Platinum group (0.554±0.133mm), and the highest value belonged to the V-Taper Gold (0.623±0.161mm).

Appearance changes of the files:

Three F2 files from each group, including one unused file and two used files, were qualitatively evaluated under SEM at ×25 and ×200 magnifications. The files were examined for visible surface defects, including flute distortion, unwinding, microcracks, and deformation of the cutting edges.

As shown in Figures 3-6, unwinding, overlapping, or distortion of the flutes was not observed in any of the groups.

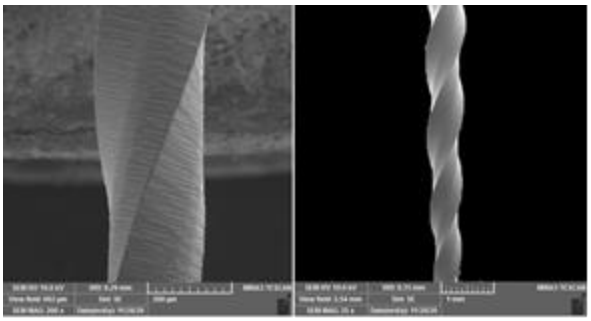

Fig 3. New F2 file from ProTaper Gold group at ×25 (right) and ×200 (left) magnifications.

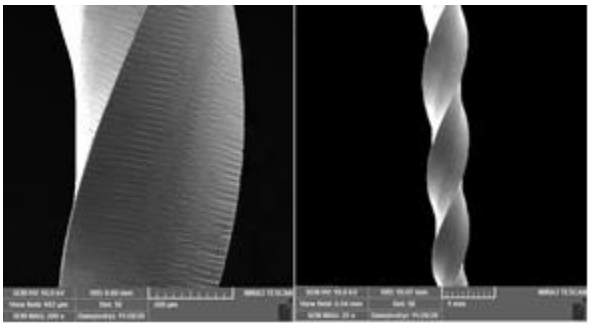

Fig 4. Used F2 file for canal preparation from ProTaper Gold group at ×25 (right) and ×200 (left) magnifications.

DISCUSSION

Different methods have been proposed to evaluate the functionality of endodontic files, root

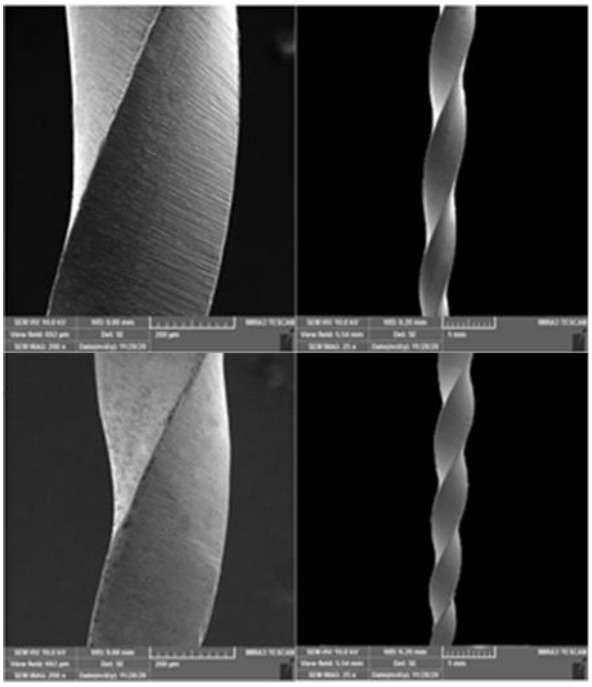

Fig 5. (Up) New F2 file from Edge Taper Platinum group at ×25 (right) and ×200 (left) magnifications; (Down) used F2 file for canal preparation from Edge Taper Platinum group at ×25 (right) and ×200 (left) magnifications.

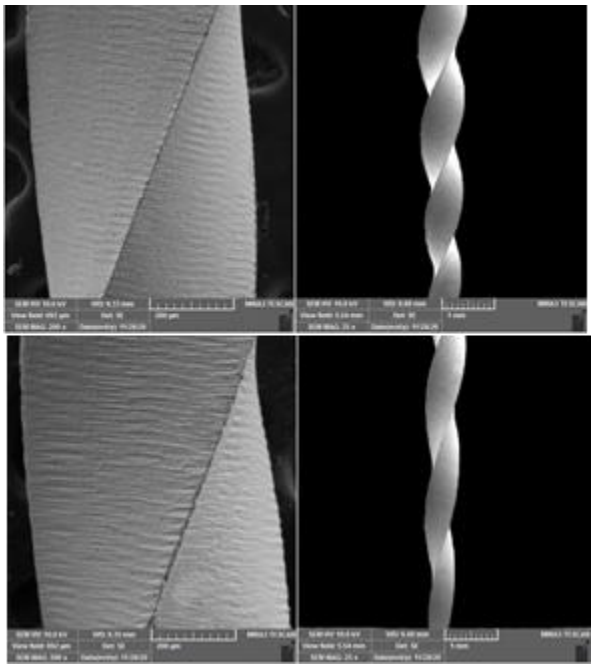

Fig 6. (Up) New F2 file from V-Taper Gold group at ×25 (right) and ×200 (left) magnifications; (Down) Used F2 file for canal preparation from V-Taper Gold group at ×25 (right) and ×200 (left) magnifications.

canal preparation techniques, and the quality of root canal preparation [20]. Some of these methods include conventional radiography and root sectioning method; each of these methods has some disadvantages. Conventional radiography provides a two-dimensional image from the specimens which cannot undergo cross-sectional evaluation [21]. Sectioning method is a common technique, but it damages the specimens [22]. Also, computed tomography has very high accuracy, but is expensive. CBCT is one of the recent innovations with low radiation dose and high resolution that provides three-dimensional images, high accuracy, and detection ability [23,24]. This method can provide CBCT scans before and after root canal preparation. The measurements can be made on the images, and any change can be detected and compared. This technique is highly accurate, and does not damage the specimens; furthermore, it provides the possibility to take various images from the root canal system [25,26]. Despite many advantages of CBCT, micro-computed tomography is still the gold standard for evaluating different techniques of canal preparation and various instruments [26]. Considering the unavailability of micro-computed tomography, CBCT was used in the current study, as in some previous studies [27,28] to investigate the variables.

This study revealed that ProTaper Gold, Edge Taper Platinum, and V-Taper Gold rotary systems did not significantly differ in terms of apical transportation at three levels from the apex. Although some transportations were observed at all levels in all systems, the magnitudes were less than 0.3mm and were within the acceptable range [28], and each of the three systems maintained the canal centrality at a reasonable rate.

Furthermore, there was no significant difference among the systems in terms of the amount of removed dentin at 1mm, 2mm, 3mm, and 4mm distances from the furcation, and the mean remaining dentin thickness in the danger zone was more than 0.3mm (the minimum acceptable value) in the three systems [29].

Since the canal curvature is usually greater in the middle and apical zones, more procedural errors are likely to occur in these zones [30]. Therefore, in this study, as in a previous study [23], apical transportation was assessed at 1mm, 2mm, and 3mm from the apex using the formula suggested by Gambill et al [18]. Some degrees of apical transportation were observed in all groups. The present results were in line with the findings of Maitin et al, [31] who showed that the canals prepared with ProTaper to F1 file had greater transportation compared to those prepared by Mtwo and RaCe rotary systems; however, there was no significant difference among these groups. Greater transportation in the ProTaper group can be attributed to the progressive taper and cutting blade design, which may reduce flexibility and increase the tendency of the file to straighten curved canals [31]. It seems to be generalizable to Edge Taper Platinum and V-Taper Gold systems due to their similar design to ProTaper.

Various parameters influence centering ability such as the type of alloy used in instruments, instruments design, its cross-sectional design, convergence, and tip. NiTi instruments have better centering ability than stainless-steel instruments, and instruments with non-cutting tips, smaller cross-sections, and less taper show greater centering ability.

In general, the low centering ability observed in some studies that used the ProTaper system for canal preparation might be due to its lower flexibility, greater tip stiffness, and progressive taper [17].

In the current study, there was no significant difference among the groups in terms of the amount of dentin removal from the root canal. Post-instrumentation assessment revealed that the minimum thickness of the root canal wall did not decrease to a great extent, which shows that none of the systems decreased the dentin thickness to a great extent. It appears that the root canal thickness before preparation is the most important factor in determining the root canal thickness after preparation [32].

According to Lim and Stock [29], the minimum dentin thickness after preparation is about 0.3mm, and this amount provides sufficient resistance against the compressive and functional forces. According to the findings of the current study, the performance of Edge

Taper Platinum and V-Taper Gold in preparation of the mesiobuccal canal of first molars was similar to that of ProTaper system.
NiTi instruments often undergo air abrasion, machining, and grinding processes during their production that can cause pits, fissures, grooves, and multiple cracks on their surfaces [33]. These areas can serve as stress accumulation sites, and create cracks during clinical usage [34]. Unexpected failure during use is a major concern in using rotary NiTi files [33]. The quality of the sharp blades and flutes of NiTi files is clinically important in fracture of the files. Therefore, evaluating these surfaces before and after instrumentation is necessary to find changes in surface topography that can cause instrument fracture [35].
In the present study, no file fracture occurred during instrumentation. Similar to the methodology described by Kour and Pradeep [19], F2 files were selected for qualitative SEM evaluation before and after use. In each group, one unused F2 file and two used F2 files were examined at ×25 and ×200 magnifications. The cutting edges and flutes were evaluated for visible defects, including unwinding, flute distortion, overlapping of flutes, microcracks, and deformation. No obvious surface deformation or structural damage was observed in any of the evaluated files. This finding may be related to the limited number of uses of each file, as each instrument was used for the preparation of only three canals.
The design and taper of NiTi rotary instruments may influence stress distribution and the risk of deformation or fracture. Instruments with a constant taper may show different torsional behavior compared with instruments with a variable taper. Previous studies have shown that the cross-sectional design, flute geometry, and taper of rotary files affect their flexibility, torsional resistance, and fatigue behavior [36-38]. ProTaper Gold, Edge Taper Platinum, and V-Taper Gold have comparable preparation sequences and similar clinical applications; therefore, their comparable performance in the present study may be partly explained by similarities in their design and instrumentation sequence. However, since SEM evaluation in the present study was qualitative and limited to selected F2 files, further studies with larger sample sizes and quantitative surface analysis are recommended. In this study, similar to some previous CBCT-based studies [17,27,39], centering ability was investigated at 3mm, 6mm, and 9mm from the apex, and some degrees of deviation from canal centrality were observed in all groups.

CONCLUSION

According to the present results, Edge Taper Platinum and V-Taper Gold systems prepared the mesiobuccal canals of first molars similarly to the ProTaper Gold system, and the initial canal anatomy was adequately preserved. Although some canal transportation and loss of centrality were observed in all three systems, these changes were within the acceptable range for rotary instrumentation.

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CONFLICT OF INTEREST STATEMENT

There is no potential conflict of interest related to this paper.

GENERATIVE AI IN SCIENTIFIC WRITING

None declared.

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