Comparative evaluation of canal transportation, centering ability, and dentin removal between ProTaper Gold, One Curve, and Profit S3: An in vitro study

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Abstract

Aim: The aim of the study was to compare the canal transportation, centering ability, and dentin removal of Profit S3 (PS3), One Curve (OC), and ProTaper Gold (PTG) systems using cone-beam computed tomography (CBCT).

Materials and Methods: Thirty extracted human single-rooted premolars were used in the present study. Preinstrumentation scanning of all the teeth in arch form was taken using CBCT. To increase standardization, crowns were removed and only teeth measuring 16 mm were included in the study. The samples were randomly divided into three groups, with ten samples in each group; Group I was instrumented with PS3, Group II was instrumented with OC, and Group III – PTG. Postinstrumentation scans were performed, and the two scans were compared to determine canal transportation, centering ability, and dentin removal at 3, 6, and 9 mm, from the apex.

Statistical Analysis: One-way-ANOVA and the independent t-test were done for the pairwise comparison. The significance level was set at \( P = 0.05 \); statistical analysis was performed with SPSS statistics version 20.0 (SPSS Inc., Chicago, IL, USA).

Results: The mean canal centering ratio and canal apical transportation for PS3, OC and PTG show no statistical difference (\( P > 0.05 \)). The mean value of dentin removal showed a statistically significant difference between the three groups (\( P < 0.05 \)). PS3 and OC rotary file showed less removal of dentin compared to PTG (\( P < 0.00 \)).

Conclusion: It was evident that PS3, OC, and PTG had no statistically significant difference when analyzed based on canal transportation and canal centering ratio. However, there was a significant difference among the three groups comparing the removal of dentin. PS3 and OC rotary file showed less removal of dentin compared to PTG.

Keywords: Canal transportation; centering ability; dentin removal; ProFit S3; ProTaper Gold

INTRODUCTION

Successful endodontic treatment is achieved by cleaning and shaping during which the canal anatomy should be maintained as much as possible and thereby paving the way for adequate obturation material. During the instrumentation process, the canal anatomy should be maintained to retain the originality of the canal morphology, thereby preventing excess removal of tooth structure. Root canals are never uniform; there are always variations and curvatures that should be anticipated and precautions for the same should be carried out. Curvatures in canals...
render the instrumentation process difficult, this results in the preparation of the canal which could be deviated from the original anatomy of the tooth. It is said that all rotary instruments tend to alter the canal morphology, especially in curved canals.[1]

Any change or deviation of the canal leads to ledge formation, zipping, strip perforation, or canal transportation. Some surfaces of the canal remain untouched by the instruments, leading to accumulation or harboring of microorganisms.[1] Canal transportation is a common mishap in curved canals. This results in incomplete cleaning and shaping of the apical region of the canal, thereby leading to the harboring of microorganisms and debris. Accumulation of dentin shavings or debris combined with microorganisms leads to failure of the root canal treatment. Factors associated with the increased risk of canal transportation could be due to inadequate access cavity preparation, type of instrument used, tip design of the instrument, insufficient irrigation leading to debris accumulation, degree of canal curvature, untraceable curvature that is not evident on a radiograph, and operator skills.[2] The cross-section design attributes to the canal centering ability of the file. In 1988 Walia et al. brought about the revolutionary modification in endodontic instrumentation systems that are replacing stainless steel with nickel–titanium (Ni-Ti) alloy.[3] The introduction of Ni-Ti instruments allows for accelerated canal preparation with reduced procedural errors.[4] It has been reported that the manufacturing process and the design of the instrument influence the clinical performance of the rotary file system.[5-8]

ProTaper Gold instruments (PTG; Dentsply, Tulsa Dental Specialties, Tulsa, OK, USA) were developed with advanced metallurgy through heat treatment technology, with convex triangular cross-section and progressive taper. It has a 2-stage specific transformation behavior and high Af temperatures.[9] It has a transformation temperature that is above body temperature and leading to martensitic or R-phase under clinical conditions.[9,10] PTG has the properties of shape memory, superelasticity along with increased cyclic fatigue resistance that is useful in curved canals.[10]

One Curve (OC) (MicroMega) is a single file rotary system introduced in 2017.[11] The OC instruments are manufactured from C-wire by the use of proprietary heat treatment which displays controlled memory and the ability to prebend instruments to amplify the shaping of root canals.[12] It has a variable cross-section along the blade for better centering ability and cutting efficacy.[12] The manufacturer declares that the file offers 33% faster root canal preparation compared to other reciprocating single file systems. OC has 2.4 times increased cyclic fatigue compared to OS, its predecessor.[13]

Profit S3 (PS3) (Kedo Dental, India) is based on Blue Technology and a new heat-treated rotary system with titanium oxide coating introduced in 2019. It has a variable taper design with a rectangular cross-section. This cross-section has two-point contact, thereby reducing the apical extrusion of debris. PS3 consists of one orifice opener and three finishing files. P0-orifice opener, PF1 (yellow), PF2 (red), and PF3 (blue) are finishing files. PS3 has good shape memory, flexibility, and increased resistance to fracture.[14] It has a variably variable taper, which varies between 4% and 8%.

Cone-beam computed tomography (CBCT), a nondestructive technology, has been advocated for pre- and post-instrumentation evaluation of canal. It can render cross-sectional (cut plane) and provide for three-dimensional reproduction of the tooth allowing for better pre- and postoperative evaluation of the root canal morphologies.[15,16] CBCT image technology used in this study to evaluate the canal transportation, canal centering ability, and to measure dentin removal. It provides a reproducible and precise assessment of the root canals.[17]

The aim of the study was to evaluate the canal transportation, canal centering ability, and remaining dentin thickness of PS3 compared with the other rotary file systems (PTG, OC) in single-rooted teeth. The null hypothesis was that there was no difference in the canal transportation, canal centering ability, and remaining dentin thickness between the tested NiTi rotary instruments in single-rooted teeth.

MATERIALS AND METHODS

Thirty extracted human mandibular premolar teeth with fully formed apices were included. The teeth exhibited no defects, their root canals were not calcified, showed no internal or external root resorption, no prosthetic crowns or dental posts, no signs of prior endodontic treatment, and no aberrant canal morphology; each tooth had a single canal and a single apical foramen, based on buccal and proximal radiographic examinations. To increase standardization, crowns were removed and only teeth measuring 16 mm were included in the study.[17] Mandibular premolars with fully formed apices having angles of curvature within 0°–10° were selected according to Schneider’s technique. Included teeth were extracted due to periodontal or orthodontic reasons and stored in normal saline at 4°C until use.[18] All the samples were standardized to 16 mm length by decoration using a diamond disc.[17] The access cavity was prepared using Endo Access bur, 21 mm size 2 (Dentsply Maillefer, Swiss made) was used and Kfile (Mani, Utsunomiya, Tochigi, Japan) of size #10 hand files were used to achieve the initial patency of the canal to full working length (WL), visible at the apical foramen, and the WL was established 1 mm short of this length.
The teeth/roots were randomly divided into three groups and embedded in modeling wax in mandibular arch form, Group I – PS3, Group II – OC, and Group III – PTG. All the teeth/roots were scanned with CBCT (Orthophos XG 3D, Dentsply Sirona) to determine the morphology of the canals before instrumentation. The centering ability, canal transportation, and amount of dentin removed were evaluated at 3, 6, and 9 mm from the root apex. After the cleaning and shaping process, postinstrumentation scans were taken. Pre- and post-instrumentation scans [Figure 1] were analyzed using CBCT, and the values were obtained on axial view.

The formula used to measure the degree of canal transportation according to Gambill et al. was used.

$$([a_1-a_2] - [b_1-b_2])$$

Where $a_1$ and $b_1$ the shortest distance from the mesial edge of the root to the mesial edge of the uninstrumented canal and the shortest distance from the distal edge of the root to the mesial edge of the uninstrumented canal. $a_2$ and $b_2$ the shortest distance from the mesial edge of the root to the mesial edge of the instrumented canal and the shortest distance from the distal edge of the root to the distal edge of the instrumented canal. The result of “0” indicates no canal transportation and other than “0” means that transportation has occurred. The following formula is used to calculate the canal centering ability.

$$(a_1-a_2)/(b_1-b_2) \text{ or } (b_1-b_2)/(a_1-a_2)$$

If the numbers are not equal, the lower figure was considered as the numerator and a result of “1” indicates perfect centering. The RDT was determined by subtracting the uninstrumented canal from the instrumented canal.

The changes in the canal centering ratio, canal transportation, and dentin removal data were analyzed using one-way ANOVA and the independent t-test was done for the pairwise comparison. The significance level was set at $P = 0.05$; statistical analysis was performed with SPSS statistics version 20.0 (SPSS Inc., Chicago, IL, USA).

**RESULTS**

The mean canal centering ratio and canal apical transportation for PS3, OC, and PTG show no statistical difference ($P > 0.05$) [Figures 2 and 3]. The mean value of dentin removal showed a statistically significant difference when compared to PTG ($P < 0.05$), when comparing OC and PS3, no significant difference was observed at all three levels [Figure 4 and Table 1]. Independent t-test among the PS3 and PTG and OC and PTG had significant differences ($P < 0.05$). PTG showed more dentin removal compared to the other two groups.

**DISCUSSION**

In 1974, Schilder suggested that “cleaning and shaping mechanics may be viewed as an extension of the principles
The mechanical preparation of root canals is to achieve the objective, i.e., maintaining the natural or original canal anatomy of the tooth that enables adequate irrigation, intracanal medicament placement, and three-dimensional obturation. Any deviation or curvature in the canal is a challenge in endodontic preparation. It is proven that instruments tend to straighten the canals and alter the original pathway of the canal. On the outside curve of the apical region of the root canal during canal preparation, the files have a tendency to straighten and restore to its original form. Yilmaz K, özyürek T, Gülşah. As the files straighten, preparation is skewed towards one wall, resulting in the alteration of the root canal pathway. In the present study, it was evident that the canal transportation among the three groups was not statistically significant (P > 0.05) implying similar deviation from the original canal pathway was observed in all the root canals. Canal transportation is an iatrogenic error or change which affects the external surface of the canal. This leads to various endodontic challenges. It causes insufficient debridement of the apical region of the canal and excessive removal on the concave surface of the canal. The ability of irrigants to sufficiently disinfect the canals are not obtained, leading to harboring of microorganisms and inadequate obturation. Thinning of canal walls leading to vertical root fracture compromises the whole endodontic treatment outcome. According to Arslan et al., 2017, this study stated that PTG when compared with ProTaper Universal and Reciproc, canal transportation was not significant among the three groups. This is consistent with the present study for the PTG system. In the current study, both PS3 and PTG have a progressive taper and both are heated treated files and show no statistical difference in canal transportation. This can be due to its high flexibility and shape memory of PS3 which does not straighten within the canal. Less canal transportation could be related to the off-centered design and rectangular cross section; this statement can be related to the ProTaper Next system which showed similar results in a study by Troiano et al.

In the analysis of centering ratio, the lower the value, it indicated the preparation was centered in the canal. There was no statistical difference among the three groups (P > 0.05). Indicating that all three file systems were well centered in the root canal at 3, 6, and 9 mm from the root apex. This can be related to the instrument manufacturing, all three systems are heat-treated file systems, making it more flexible and less straightening within the canals during instrumentation. A study by Ghoneim in 2019 stated that the OC file system had a higher mean centering ratio and more dentin removal. A study by Arslan et al., 2017, stated that there was no significant difference among PTG, ProTaper Universal, and Reciproc file systems when tested for centering ratio at 3 mm, 5 mm, and 7 mm from the apical terminus of the root. The PS3 and PTG both have a variable taper and both are heat-treated file systems, the difference is that PTG has a sequence of instruments to be used and whereas PS3 is a single file system.
There was a statistical difference ($P < 0.05$) among the three groups when analyzed for the removal of dentin. Remaining dentin thickness is important to provide enough resistance against lateral forces during the obturation process and occlusal loading forces.\cite{24,25} Apical dentin is considered as the danger zone, as the amount of dentin removed is directly proportional to the prognosis of the tooth toward occlusal forces and preventing vertical root fracture. Sathorn et al. suggested that a multitude of variables exist that increase the risk of fracture and not necessarily removal of dentin.\cite{26} Ghoneim stated in his study comparing OneShape and OC that there was no statistical difference among the two file systems but more amount of dentin removal was recorded in OC.\cite{27} According to Singh et al., in the in vitro study, PTG was reported to remove an excessive volume of dentin due to its aggressive cutting compared to two shape and wave one gold system.\cite{28} The current study was done mainly in vitro study. F. and other colleagues stated that there was no significant differences in canal centering ability and canal transportation among the three systems. We found significant difference in dentin removal among the three file systems.

**CONCLUSION**

Within the limitations of the study, it was evident that PS3, OC, and PTG had no statistically significant difference when analyzed based on canal transportation and canal centering ratio. However, there was a significant difference among the three groups comparing the removal of dentin. PTG reported removing more dentin compared to PS3 and OC systems. Further studies are required to perform in simulated canals to substantiate the results obtained.

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**Conflicts of interest**

There are no conflicts of interest.

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