Cone Beam Computed Tomographic Assessment of Root Canal Transportation of Protaper Gold and 2Shape Rotary Systems in Severely Curved Premolars: An in Vitro Study

Mitra Sambodhi[1], Shetty Preethesh[1]*, Bhat Raksha[1], Shahid Mohammad[2], D'Cunha Kevin[1], Shetty Nihar[1]

1. Nitte (Deemed to be University), AB Shetty Memorial Institute Of Dental Sciences(ABSMIDS), Department of Conservative Dentistry and Endodontics, Mangalore.
2. A.J. Institute of Dental SciencesMangalore, Karnataka, India.

Abstract

Canal transportation is advocated as an undesirable deviation from the natural root canal path. Hence, the present study aimed to compare the canal transportation of two rotary nickel-titanium systems, Protaper Gold(PTG) and 2Shape in severely curved root canals using cone beam computed tomography.

Twenty freshly extracted single-rooted premolar teeth with curved root canals of 25–35 degrees of curvature based on Schneider's criteria were selected. Teeth were randomly divided into two experimental groups of ten each. Prior to and post preparation with PTG and 2Shape, teeth were subjected to scanning using CBCT to determine root canal deviations. Pre and post instrumentation images were obtained at three levels, 3 mm coronal, 7 mm middle, and 11 mm apical. Data obtained using the CBCT software was statistically analysed with Kruskal Wallis and Mann Whitney U Test.

No significant difference was observed in canal transportation between the 2 systems except at 3mm coronally($p<0.05$). Least apical transportation was seen in 2Shape file system in all three sections.

PTG and 2Shape rotary file systems with post machining heat treatment were successful in producing least amount of canal transportation especially in apical third preparations with no significant difference or mishaps.

Experimental article (J Int Dent Med Res 2022; 15(4): 1455-1458)

Keywords: Canal Transportation, nickel-titanium, cone beam computed tomography, curved root canals.

Received date: 14 August 2022 **Accept date:** 09 September 2022

Introduction

Apical transportation during root canal instrumentation is defined as asymmetrical dentine removal due to the tendency of the files to restore their original linear shape when working inside a curved trajectory[1]. Root canals are often seen to be curved in multiple planes and degrees, the designative of a straight root canal and a single foramen in a tooth being an exception rather than a rule[2,3]. Radiographic evaluation of the degree and frequency of canal curvatures revealed 84% of canal curvatures to be curved in at least one direction[4]. Also, 30% of the curved canals in the mesial roots of mandibular canals exhibited secondary curvatures when viewed proximally, even though only single curvatures were observed on normal clinical view[5]. The risk of canal transportation is directly proportional to the extent of curvature. Ideal instrumentation protocols necessitate equalised removal of root dentin from either of the canal walls, thereby avoiding thinning of root structure[6].

Enhanced flexibility and increased cyclic fatigue of the nickel-titanium files due to the heat treatment combined with reduced force restoration, make them ideal for the management of curved canals[6]. Protaper Gold(Dentsply, India) was introduced by Dentsply to counter the rigidity and enhance the flexibility of its predecessor Protaper Universal. PTG files undergo a grinding process post heat treatment at varied temperature ranges for different periods, based

Corresponding author:
Shetty Preethesh,
AB Shetty Memorial Institute Of Dental Sciences(ABSMIDS),
Department of Conservative Dentistry And Endodontics,
Mangaluru, Karnataka, India.
E-mail: drpreetheshshetty@nitte.edu.in

on file size and taper. Due to this heat-treatment, the rotary file system is said to lose its super elasticity producing a flexed file under tension which does not bounce back to its original shape on removal of the stress. This characteristic feature improves the biomechanical preparation of the root canal by decreasing the risk of canal transportation. The 2 shape (Micro Méga, Besançon, France) file system possesses a unique modified triple helix design with two main cutting edges for cutting efficiency with an offset blade enhancing debris removal and to reduce the stress on the instrument. This variant asymmetrical cross- section is claimed to be able to reduce the risk of instrument separation and increase the efficiency of the circumferential brushing movements for efficient selective cleaning. Nonetheless, 2Shape files have undergone a specialised post grinding heat treatment, called T-wire (Micro- Mega, 2018)[7].
Cone-beam computed tomography employs a cone-shaped X-ray beam with an area detector to capture the cylindrical volume of data in one acquisition, completely analysing the root canal system demonstrating a clear picture of canal transportations and volume of root dentin removed by endodontic instruments[8,9].The present study aimed to evaluate the canal transportation of the two-post grinding heat treated files.

Materials and methods

Teeth Selection - Human single rooted mandibular premolar teeth with fully formed apices were selected from a pool of freshly extracted teeth predominantly due to orthodontic purposes. Ethical approval was obtained from the Institutional Ethics Committee.The teeth were disinfected according to the guidelines laid down by OSHA and CDC[10]. The teeth with prior endodontic treatment, fracture lines, resorption defects, calcifications and open apices were excluded from the study. Non-caries mandibular premolars with one root and single canal with canal curvature 25º-35º were included in the study. Schneider's method was used to measure the angle of curvature.

Sample Preparation - Twenty extracted human teeth were randomly divided into two groups of ten samples each for instrumentation by the rotary file systems; Group I: PTG & Group II: 2Shape.Teeth were decoronated using a diamond disc at the level of CEJ for straight line access to the root using a diamond disc. Ten teeth each were embedded in one block customized out of modelling wax in a simulated jaw form such that the teeth had some distance between them. The wax block was then mounted on the CBCT machine to capture image in jaw mode. Each tooth was placed in the block in such a way that they could be easily removed and positioned back. Thus, after pre-operative scan the teeth were maintained in their respective positions for instrumentation with respective files and post-operative positioning of the samples was standardized.

Root canal preparation - After decoronation, glide path was established with # 10 K-files (Dentsply Maillefer). Working length was determined with #10 K-files radiographically. #15 K-file was used to further enlarge the glide path. Rotary instruments were driven with X-Smart electric motor(Dentsply Maillefer). The rotational speed and torque limit were set according to the manufacturers' recommendations. Group 1: Protaper Gold; Canal shaping with performed with the crown down technique. The vertical movement operations were executed using the S1(17/02%),S2 (20/04%), F1(20/07%) finally followed by F2(25/04%). Group 2: 2Shape file system;Canal shaping was done in downward movement in free progression till resistance, followed by two brushing strokes to free the file before proceeding apically. Only one shaping files of the sequence TS1(25/04) and TS2(25/06)were used to WL. In between each step of preparation, the instrument was cleaned followed by irrigation performed with 5ml 2.5% sodium hypochlorite and 5 ml 17% EDTA using disposable syringes with 30-G NaviTip needles (Ultradent, South Jordan, UT).

CBCT Analysis - The embedded teeth were scanned using CBCT PLANMECA ROMEXIS PROMAX 3D MID scanner with area of scan at 5*5 cm at Kv: 90, mA at 8 and mGy cm^2 at 610. Three levels of the root canals were chosen for evaluation 3mm, 7mm, & 11 mm from the apex respectively. The images were scanned for further comparison between pre instrumentation and post instrumentation data by using PLANMECA ROMEXIS 4.3 Software.

Measurement of canal transportation -The amount of transportation was evaluated by a technique developed by Gambill to measure the

degree of canal transportation which was analysed by the measure of the shortest distance from the edge of uninstrumented canal to the most peripheral part of the root followed by comparison of this with the same measurements obtained from the instrumented images. Hence, the amount of canal transportation was calculated using the following formula: CT =(a1 − a2) − (b1 − b2), where a1 was shortest distance from lateral edge of the uninstrumented canal to lateral edge of the root, b1 was shortest distance from medial edge of uninstrumented canal to medial edge of root, a2 was shortest distance from lateral edge of instrumented canal to lateral edge of root, and b2 was shortest distance from medial edge of instrumented canal to medial edge of root.

Results

Data was subjected to statistical analysis using the Kruskal Wallis Test & Mann Whitney U test. Values for mean and standard deviation for canal transportation at levels of 3, 7 and 11 mm between both groups are presented in Table 1. In PTG group, 11 mm level has the highest Median transportation of 0.34 followed by 7 mm level (0.26) and least at 3 mm level (0.1). Difference in transportation between 7 mm and 11 mm was not statistically significant whereas 3mm had significantly lowest transportation as compared to 7 mm and 11 mm. In 2 shape group there was no significant difference in transportation between the 3 levels($p>0.05$). At 3mm level, there was no significant difference in transportation between the two study groups ($p>0.05$). At 7 mm and 11 mm level, 2Shape group had significantly higher transportation as compared to TN group ($p<0.05$).[Table 2]

Discussion

In the present study, extracted natural teeth were used as they simulate the root canal preparation in clinical conditions, offering the advantage of simulation of the anatomic variations of the root canals. Mandibular premolars teeth are amongst the most frequently treated with the lowest success rates due to the presence of apical curvatures. The mandibular premolars were chosen because they often present apical curvatures making them prone to endodontic mishaps[11].

Apical preparation diameter has always been a topic of interest. However, it has been recommended to evaluate the shaping ability of various root canal instruments with identic apical preparation sizes[12,13]. Biomechanical preparation at the apex to size 25 was selected both the file systems, as increase in the apical diameter is inversely proportional to the file flexibility, thereby increasing canal transportation risk[14,15].

In the present study, canal transportation seen in PTG and 2Shape rotary file systems at 7 mm and 11 mm was not statistically significant. This can be attributed to the varied geometry, nickel titanium alloy used and heat treatment to which the files are subjected. PTG and 2Shape instruments had similar results for canal transportation between both groups at 3mm levels, depicting the preservation of peri-cervical dentin by both the file systems. Canal transportations observed had values of less than 0.3mm, which have been considered to have negatable impact on the clinical prognosis of treatment[16]. Findings of the present study are in accordance with observations of several studies that have depicted the increased efficiency of heat-treated files in biomechanical preparation with least transportation especially in apical third. PTG and 2Shape are observed to be in austenite phase when in use under clinical conditions at room temperature[17].

Conclusions

In the present study, regardless of the presence of four files in PTG system and two files in 2Shape system, no significant statistical difference was observed. This could be attributed to the heat treatments employed, the design and taper of the instruments. The advent of novel technologies in rotary file systems leads to enhancement in endodontic therapy. Nonetheless, there does exist a faint line between in vitro research findings to clinical applications. However, further analysis can be conducted in severely curved canals with bigger sample size and with clinical scenarios, to allow for use in clinical practice.

Declaration of Interest

The authors report no conflict of interest.

References

1. Sarraf P, Kiomarsi N, Taheri FH, Moghaddamzade B, Dibaji F, Kharazifard MJ. Apical Transportation of Mesiobuccal Canals of Maxillary Molars Following Root Canal Preparation with Two Rotary Systems and Hand Files: A Cone-Beam Computed Tomographic Assessment. Front Dent. 2019;16(4):272-278. doi: 10.18502/fid.v16i4.2086.
2. Phiangfah Kongkiatkool, Peraya Puapichartdumrong, Weeraya Tantanapornkul, Thosapol Piyapattamin, Kessiri Wisithphrom . Accuracy of Digital Periapical Radiography and Cone Beam Computed Tomography for Evaluation of Root Canal Configuration in Human Mandibular first Premolars . Journal of International Dental and Medical Research 2020; 13(1):80-85.
3. Vertucci, F.J. Root canal morphology and its relationship to endodontic procedures. Endodontic Topics 2005 ;10:3– 29. Doi: https://doi.org/10.1111/j.1601-1546.2005.00129.x
4. Schäfer E, Diez C, Hoppe W, Tepel J. Roentgenographic investigation of frequency and degree of canal curvatures in human permanent teeth. J Endod. 2002;28(3):211-6. doi: 10.1097/00004770-200203000-00017.
5. E.C. Tumen, I Yavuz, D.S. Tumen, N. Hamamci, G. Berber, F. Atakul, E. Uysal. The Detailed Evaluation Of Supernumerary Teeth With The Aid of Cone Beam Computed Tomography. Biotechnol. & Biotechnol. Eq. 2010; 24 (2): 1886-1892.
6. Jain A, Gupta AS, Agrawal R. Comparative analysis of canal-centering ratio, apical transportation, and remaining dentin thickness between single-file systems, i.e., OneShape and WaveOne reciprocation: An in vitro study. J Conserv Dent. 2018;21(6):637-641. doi: 10.4103/JCD.JCD_101_18.
7. Elnaghy AM, Elsaka SE. Mechanical properties of ProTaper Gold nickel-titanium rotary instruments. Int Endod J. 2016;49(11):1073-1078. doi: 10.1111/iej.12557.
8. Azhari, Fahmi O, Intan Fariska. Normal Value of Cortical and Mandibular Trabecular Bone Density using Cone Beam Computed Tomography (CBCT) . Journal of International Dental and Medical Research: 2019; 12 (1):160-164
9. Zurab Khabadze, Ferdaus Taraki, Oleg Mordanov, Saida Abdulkerimova, Yusup Bakaev, Mariam Shubitidze, Shamil Solimanov, Shamil Nazhmudinov. Analysis of Accessory Canals as Important Anatomical Structures in the Anterior Maxilla with Cone Beam Computed Tomography. Journal of International Dental and Medical Research 2020; 13 (1):162-165
10. Mehmet-Sinan Doğan, Michele Callea, Lindawati S. Kusdhany, Ahmet Aras, Diah-Ayu Maharani, Masita Mandasari, Melissa Adiatman, Izzet Yavuz. The Evaluation of Root Fracture with Cone Beam Computed Tomography (CBCT): An Epidemiological Study. J Clin Exp Dent. 2018;10(1):41-8.
11. Peters OA. Current challenges and concepts in the preparation of root canal systems: a review. J Endod. 2004;30(8):559-67. doi: 10.1097/01.don.0000129039.59003.9d.
12. Abanoub Raouf, Magdy Ali, Sherief ElZahar, Reham Hassan. Cone-Beam Computed Tomographic Analysis of Shaping Ability of XP Shaper, TRUshape, and Hyflex EDM. Journal of International Dental and Medical Research 2021;14(1):60-66.
13. Peters OA, Morgental RD, Schulze KA, Paqué F, Kopper PM, Vier-Pelisser FV. Determining cutting efficiency of nickel-titanium coronal flaring instruments used in lateral action. Int Endod J. 2014 Jun;47(6):505-13. doi: 10.1111/iej.12177.
14. Silva EJNL, Pacheco PT, Pires F, Belladonna FG, De-Deus G. Microcomputed tomographic evaluation of canal transportation and centring ability of ProTaper Next and Twisted File Adaptive systems. Int Endod J. 2017;50(7):694-699. doi: 10.1111/iej.12667.
15. Hieawy A, Haapasalo M, Zhou H, Wang ZJ, Shen Y. Phase Transformation Behavior and Resistance to Bending and Cyclic Fatigue of ProTaper Gold and ProTaper Universal Instruments. J Endod. 2015;41(7):1134-8. doi: 10.1016/j.joen.2015.02.030.
16. Pinheiro SR, Alcalde MP, Vivacqua-Gomes N, Bramante CM, Vivan RR, Duarte MAH, Vasconcelos BC. Evaluation of apical transportation and centring ability of five thermally treated NiTi rotary systems. Int Endod J. 2018;51(6):705-713. doi: 10.1111/iej.12881.
17. Nehme W, Araji S, Michetti J, Zogheib C, Naaman A, Khalil I, Pages R, Basarab A, Mallet JP, Diemer F. Assessment of root canal transportation of 2Shape and ProTaper gold in mandibular molar mesial canals: A micro-computed tomographic study. Microsc Res Tech. 2021;84(4):746-752. doi: 10.1002/jemt.23633.