Influence of Rotary and Reciprocating Glide Path Techniques on the Incidence of Dentinal Crack Formation– an in vitro study

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ABSTRACT

Introduction: Creating a reproducible glide path was shown to be the first step for safer use of nickel titanium rotary instruments. Various mechanical glide path management systems have been introduced so as to secure a reproducible glide path. The aim of this present study was to compare the incidence of dentinal crack formation by using rotary and reciprocating glide path systems.
Material and Methods: Sixty extracted mandibular molars with 10°- 40° mesial root curvature were selected. In group I (n=20): control group no instrumentation was done, group II (n=20): glide path was achieved using stainless steel ISO 8, 10, 15 K-files in reciprocating handpiece, group III (n=20): glide path was achieved using ProGlider. Then shaping was done with ProTaper Next rotary system. The roots were sectioned perpendicular to long axis at 1mm, 2mm, 3mm 4mm, 6mm, 8mm from apex. The sections were observed under stereomicroscope. The presence or absence of cracks was recorded. The data was statistically analyzed using chi-square test ($P<0.05$).
Results: No cracks were observed in control group. Instrumentation with ProGlider followed with ProTaper Next caused few cracks (23.3%) compared to stainless steel hand K-files in reciprocating handpiece followed by instrumentation with ProTaper Next (27.6%) with no significant difference between them ($P>0.05$).
Conclusion: Glide path with Proglider and reciprocating stainless steel K-files created cracks with no significant difference between them. So glide path management with stainless steel K-files inserted in reciprocating handpiece can be an alternative to achieve endodontic glide path in curved canals.

Keywords: Dentinal cracks, glide path, ProGlider, ProTaper Next, reciprocating hand piece.

INTRODUCTION

Schilder in 1974, has outlined the revolutionary concepts of biological objectives for optimally shaping and debriding root canal systems.[1] So technical protocols have been evolved to achieve the objectives outlined by Schilder[1] and to reduce the occurrence of procedural errors. An important step for the safety of this cleaning and shaping procedure, is the achievement of endodontic glide path. A glide path is defined as a smooth, though possibly narrow, tunnel or passage from the coronal orifice of the canal to the radiographic terminus or electronically determined portal of exit.[2] If this smooth passage is reproducible by files used successively in the canal indicates the maintenance of a glide path.[3] By the achievement of glide path before the use of nickel-titanium rotary instruments of greater taper (NTRIGT), the canal diameter becomes at-least equal to file tip used for shaping[4] so that the apical end of file acts as a pilot reducing the torsional stress, binding, structural fatigue and failure rate thereby improving efficacy and safety of cleaning and shaping procedures especially in curved canals.[5,6]

Several authors have recommended using stainless steel (SS) K-files by hand for preparing the glide path.[7-10] Creation of glide path manually with SS K-files though time consuming has some advantages of understanding original canal anatomy thereby eliminating anatomic problems and interferences.[5,6] In contrast creating glide path with nickel-titanium (NiTi) rotary instruments is faster with better maintenance of the original canal anatomy, less modification of canal curvature, fewer canal aberrations and lower prevalence/severity of postoperative pain, compared with manual glide path performed with SS K-files.[11,12] Of different path-finding rotary systems available for creating of glide path, recently introduced was the ProGlider (PG) by Dentsply Maillefer. It is single file rotary instrument manufactured from heated M-Wire NiTi alloy to enhance flexibility and cyclic fatigue resistance as claimed by the manufacturer[13] and has variable progressive taper (from 0.02 to 0.08).

But creating glide path with NiTi rotary instruments showed reduced resistance to buckling during exploration of curved canals as they might not be able to advance in the apical direction beyond constrictions and anatomic impediments.[14] So an alternative to overcome this could be the use of SS K-file in a reciprocating hand piece for glide path management. The stiffness of SS hand K-files aids in path-finding by negotiating blockages and calcifications[8,15] and movements of reciprocating handpiece can be considered the mechanical expression of the balanced force motion.[16] According to the manufacturer, this watch-winding motion keeps the file loose inside the canal, reduces torsional stress and cyclic fatigue and can be safe for the endodontic glide path preparation.[17] It is of interest to evaluate to what extent SS instruments can benefit from a reciprocating motion while creating an endodontic glide path.

Numerous studies have investigated the dentinal damage associated with different NiTi rotary instruments.[18-21] But there is no research dealing with the effect of glide path on creating dentinal damage during root canal preparation with rotary NiTi instruments. Therefore, the aim of this study was to investigate the dentinal crack formation after using ProTaper Next (PTN)

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How to cite this article: M. Chandrasekhar, S. Naga Lakshmi Reddy, Gopi Krishna Moosani, N. Upendranatha Reddy, K. Nikhita, M. Praveen Kumar. Influence of Rotary and reciprocating glide path techniques on the incidence of dentinal crack formation– an in vitro study. International Journal of Contemporary Medical Research 2016;3(7):2075-2078.

system with the newly introduced rotary single file system PG used in continuous rotation and SS K-files used in a reciprocating handpiece for glide path preparation.

MATERIAL AND METHODS

In this in vitro study sixty extracted human mandibular molars were selected. The teeth were extracted for reasons not related to the study and were stored in purified distilled water until use. Radiographic evaluation was performed to exclude presence of resorption defects and root canal obliteration. Teeth with mesial root canal curvature of 10° - 40° according to the method introduced by Schneider[22] were selected. Teeth were examined under a stereomicroscope (Lynx, Lawrence and Mayo) at 12× magnification to confirm the absence of cracks/ fractures. Access cavity was prepared and then the distal root with respective part of the crown was sections at the furcation level using a low speed saw (Isomet; Buehler Ltd, Lake Bluff, IL) under water-cooling. To ensure standardization, the mesial half of the teeth were sectioned 16 mm from the apex. Then size 10 K-file (Dentsply Maillefer) was progressed through the root canal until it was visible at the apex, and the working length of the canal was determined to be 1 mm short from this point. The roots were covered with a fine layer of silicon impression material simulating the periodontal ligament (PDL) and were then embedded in acrylic blocks. And randomly divided into three groups (n=20).

Experimental groups

In groups I (n=20) the teeth were left unprepared (control group).

In group II (n=20), a glide path was prepared with SS K files mounted to reciprocating M4 handpiece (SybronEndo,Orange, Calif., USA) (4:1 reduction, 30° CW/30° CCW), mounted on the electric motor TCM III (SybronEndo, Orange, Calif., USA) with a speed of 900 rpm. An ISO size 8 K-file was used first to negotiate the canal to working length by hand before being attached to a reciprocating hand piece. After negotiation to working length M4 hand piece connected to TCM III electric motor was attached to plastic handle of hand K-file which was already in the canal which was then moved vertically up and down, with an amplitude of 1mm to 3mm until the file was loose in canal for approximately 15 to 30 seconds in each root canal.[23] Sequentially larger size ISO 10, 15 K-files were inserted in similar manner. Glide path preparation was completed as 15 K-file meets no resistant and moves easily in the canal. Then root canals were shaped with PTN (Dentsply Maillefer, Ballaigues, Switzerland) in the sequence of X1 and X2 at a rotational speed of 300 rpm and 2 Ncm torque according to the manufacturer's instructions.

In group III (n=20), a glide path was prepared with PG instrument. Then root canals were instrumented with ProTaper Next files (Dentsply Maillefer, Ballaigues, Switzerland) in the sequence of X1 and X2 at a rotational speed of 300 rpm and 2Ncm torque according to the manufacturer's instructions.

All the instruments were used up to the working length. The rotary file systems were used with an electrical motor (X-Smart, Dentsply Maillefer) and a 16:1 reduction handpiece. Each instrument was used in 3 canals. The root canals were irrigated with 2 mL of 1% sodium hypochlorite solution (Vishal Dento Care Pvt. Ltd.) after each instrument change. After preparation, the specimens were rinsed with 5 mL of distilled water. The roots were horizontally sectioned at 1, 2, 3, 4, 6, and 8 mm from the apex using a low-speed saw under water-cooling. To avoid any artifacts by dehydration, the teeth were kept moist in distilled water during all the experimental procedures. All slices were observed under a stereomicroscope at 24× magnification and pictures were taken. All root canal preparations were performed by one operator and the assessment of each cross section was performed by another examiner who was blinded in respect to all experimental groups. In each group, a total of 120 slices were examined for cracks. To define crack formation, two categories were made as 'no crack' and 'crack'. 'No crack' was defined as root dentine without cracks either at internal or external surface of the root. 'Crack' was defined as all lines observed on the slice that either extended from the root canal lumen to the dentin or from the outer root surface into the dentin (Figure-1).[24]

STATISTICAL ANALYSIS

The data was analyzed using the Chi-square and Fisher's exact tests and the level of significance was set at 0.05. Statistical analyses were performed using SPSS 18.0 software (SPSS, Inc., Chicago, IL, USA).

RESULTS

The number of roots with cracks observed for all groups at different sections and percentage of cracks are shown in Table-1 and Figure-2. In group I (control group) no cracks were observed. When considering the crack formation in total sections, it was found to be 23.3% in group III, while 26.7% in group II. However, there were no significant differences between the two experimental groups ($P > 0.05$). Regarding the different section levels (1, 2, 3, 4, 6, and 8 mm), no significant difference was found between the experimental groups at any level.

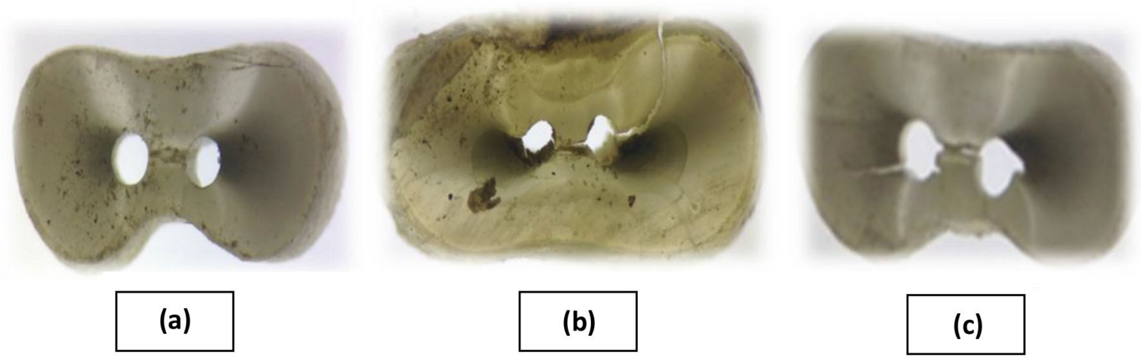

Figure-1: Representative stereomicroscopic images of the root cross-sections. (a) 'no crack'; (b) and (c) 'crack' formation

DISCUSSION

In the present study, PG in continuous motion and SS K-files in reciprocation motion were used to create glide path. Of this PG is a new single NiTi rotary file system manufactured from heated M-Wire NiTi alloy to enhance flexibility and cyclic fatigue resistance.[13] It has square cross section with variable progressive taper (from 0.02 to 0.08) by which preliminary pre-flaring of middle and coronal portion of canal occur during glide path management. The PG instrument has tip size 16 with a taper of 0.02 at the tip of the file. Whereas SS K-files has rectangular cross section with 0.02 constant taper and in the present study it was used to size of ISO 15 in M4 handpiece with reciprocating motion oscillating 30º in both clockwise (CW) and counterclockwise (CCW) directions which plays significant role in determining resistance to cyclic fatigue. A previous study revealed that SS K-files used in reciprocation motion showed greater resistance to cyclic fatigue compared to 0.02 tapered NiTi rotary glide path instruments used in continuous rotation and were safe for endodontic glide path preparation.[17]

After achievement of glide path, shaping was done with PTN rotary file system. Results of the present study indicated that dentinal cracks occurred in both groups independent of glide path systems used. The incidence of dentinal cracks observed was 23.3% in group III and 26.7% in groups II with no significant between them ($P = 0.551$). Less incidence of cracks noticed when glide path was performed with PG might be due to its M-Wire technology which enhanced flexibility and cyclic fatigue resistance[13] and its variable progressive taper (from 0.02 to 0.08) by which preliminary pre-flaring of middle and coronal portion of canal occur during glide path management so that it reduced stress on the further used NTRIGT. SS K file is made of SS alloy and it is well known that this SS alloy has inherent rigidity.[14,25] But in the present study SS K files of size ISO 15 were used for creation of glide path, to this size the rigidity might be negligible disadvantage. SS files are harder and permits more efficient cutting action[26] and improved torsional resistance[14,25] which are the important properties for glide path instruments to negotiate and pre-enlarge mainly small, narrow and curved canals. In the present study reciprocating SS K-files showed no significant difference with that of PG in dentinal crack formation, it might be due to the reciprocating motion which allows the file to be more centered in the canal[27] and also reduces the flexural and torsional stresses acting on the dentin by its repeated 30º CW and 30º CCW rotation which allows continuous release of the file when it is engaged in the inner surface of root canal during cutting and shaping thereby reduces stress despite of its low mechanical properties. West and Roane describe the "watchwinding" motion as a back and forth oscillation of a file (30 to 60 degrees) CW and CCW as the instrument is pushed downward into the canal. It is a definite inward progression of the instrument in a filing motion. An "envelope of motion" occurs when a precurved file is advanced into the canal short of maximum resistance, then the file is removed while it is simultaneously rotated in a clockwise direction.[2,28] The "envelope of motion" created by the rotation of the curved file as it is withdrawn from the canal scribes the side walls of the canal at random contact points, gradually widening and evolving the root canal shape to allow larger files to follow. PTN was used to shape the canals after glide path achievement. PTN files exhibit an off-centered rectangular cross-sectional design for superior strength and generates an exceptional asymmetric rotary motion i.e snake like swaggering motion, which decreases the screw effect, dangerous taper lock, and torque on any given file by minimizing the contact between the file and the dentin.[30] Innovative M-Wire Ni-Ti technology provides greater flexibility and greater resistance to cyclic fatigue for the system.[29] It can be speculated that as a result of this exceptional asymmetric rotary motion there will be reduction in the contact area between the file and canal system so lower defects may occur as lower frictional forces to canal walls.

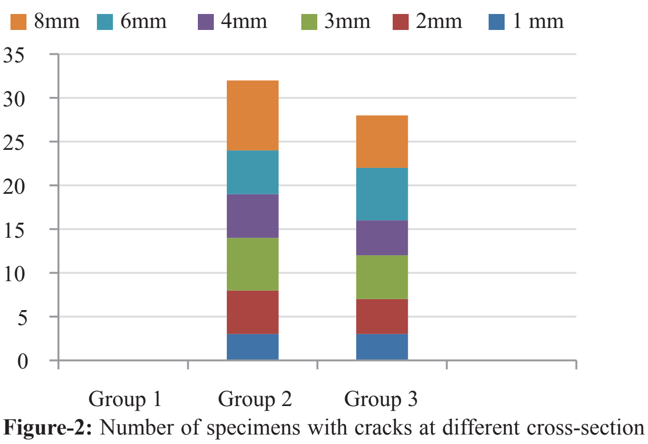

Figure-2: Number of specimens with cracks at different cross-section levels

Capar *et al*. reported cracks in 28%, Karataş *et al*. reported cracks in 33.3%, whereas Cicek *et al*. reported in 64.44% of roots instrumented with the PTN system.[30-32] The conflicting results of present study compared to previous studies might be due to, in the present study curved mesial roots of mandibular molars were selected as sampling to assess the dentinal damage and instrumentation was done in both mesiobuccal and mesiolingual canals thereby having more chance of defect rate due to repeated instrumentation compared to previous studies where single rooted teeth were selected as samples. Moreover, Capar *et al*. performed a glide path via a size 15 K type file before instrumentation with ProTaper Next files in mandibular premolar teeth, whereas Karataş *et al*. And Cicek *et al*. did

	n	1mm†	2mm†	3mm‡	4mm†	6mm‡	8mm‡	Total number of cracks‡
Group -1	20	0	0	0	0	0	0	0
Group-2	20	3	5	6	5	5	8	32 (26.7%)
Group-3	20	3	4	5	4	6	6	28 (23.3%)
p-value		>0.99; NS	>0.99; NS	0.723; NS	>0.99; NS	0.723; NS	0.507; NS	0.551; NS

† Fishers exact test; ‡ Chi-Square test; Numbers in the parentheses are the percentages of the specimens with cracks out of 120 total samples in each group.

Table-1: Number of specimens with cracks at different cross-section levels and their percentages within each group not mention any glide path preparation before instrumentation in mandibular central incisors and mandibular molars, respectively.[30-32]

CONCLUSION

Within the limitations of this in vitro study, glide path with PG showed less incidence of cracks formation compared with reciprocating SS K-files but with no significant difference between them. Present results demonstrated that with specific reciprocating motion small size SS instruments can be an alternative method to create glide path in curved canals.

REFERENCES

1. Schilder H. Cleaning and shaping the root canal. Dent Clin North Am. 1974;18:269-96.
2. West J. Endodontic update 2006. J Esthet Restor Dent. 2006;18:280-300.
3. Peters OA, Paque F. Current developments in rotary root canal instrument technology and clinical use: a review. Quintessence Int. 2010;41:479-88.
4. Berutti E, Negro AR, Lendini M, Pasqualini D. Influence of manual preflaring and torque on the failure rate of ProTaper instruments. J Endod. 2004;30:228–30.
5. Patino P, Biedma B, Liebana C, Cantatore G, Bahillo J. The influence of a manual glide path on the separation rate of NiTi rotary instruments. J Endod. 2005;31:114–6.
6. Hulsmann M, Peters OA, Dummer PMH. Mechanical preparation of root canals: shaping goals, techniques and means. Endod Topics. 2005;10:30–76.
7. Walsch H. The hybrid concept of nickel-titanium rotary instrumentation. Dent Clin North Am. 2004;48:183-202.
8. Mounce RE. Endodontic K-files: Invaluable endangered species or ready for the Smithsonian? Dent Today. 2005;24:102-104.
9. Ruddle CJ. The ProTaper technique. Endod Topics. 2005;10:187-90.
10. Van der Vyver PJ. Creating a glide path for rotary NiTi instruments: Part one. Endod Practice. 2011:40-3
11. Berutti E, Cantatore G, Castellucci A, Chiandussi G, Pera F, Migliaretti G, Pasqualini D. Use of nickel-titanium rotary PathFile to create the glide path: comparison with manual preflaring in simulated root canals. J Endod. 2009;35:408–12.
12. Pasqualini D, Mollo L, Scotti N, Cantatore G, Castellucci A, Migliaretti G, Berutti E. Postoperative pain after manual and mechanical glide path: a randomized clinical trial. J Endod. 2012;38:32–6.
13. Elnaghy AM, Elsaka SE. Evaluation of the mechanical behaviour of PathFile and ProGlider pathfinding nickel-titanium rotary instruments. Int Endod J. 2015;48:894-901.
14. Lopes HP, Elias CN, Siqueira JF, Soares RG, Souza LC, Oliveira JCM, et al. Mechanical behavior of pathfinding endodontic instruments. J Endod. 2013;38:1417–21.
15. Young GR, Parashos P, Messer HH. The principles of techniques for cleaning root canals. Aust Dental Journal. 2007;52 Suppl1: S52-S63.
16. Wildey WL, Senia ES. A new root canal instrument and instrumentation technique: a preliminary report. Oral Surg Oral Med Oral Pathol Oral Radiol. 1989;67:198–207.
17. Gianluca Gambarini, Gianluca Plotino, GianPaolo Sannino, Nicola Maria Grande, Alessio Giansiracusa, Lucila Piasecki, Ulisses Xavier da Silva Neto, Dina Al-Sudani, Luca Testarelli. Cyclic fatigue of instruments for endodontic glide path. Odontology. 2015;103:56-60.
18. Bier CA, Shemesh H, Tanomaru-Filho M, Wesselink PR, Wu MK. The ability of different nickel-titanium rotary instruments to induce dentinal damage during canal preparation. J Endod. 2009;35:236-238.
19. Yoldas O, Yilmaz S, Atakan G, Kuden C, Kasan Z. Dentinal microcrack formation during root canal preparations by different NiTi rotary instruments and the self-adjusting file. J Endod. 2012;38:232-235.
20. Hin ES, Wu MK, Wesselink PR, Shemesh H. Effects of self-adjusting file, Mtwo, and ProTaper on the root canal wall. J Endod. 2013;39:262-264.
21. Liu R, Kaiwar A, Shemesh H, Wesselink PR, Hou B, Wu MK. Incidence of apical root cracks and apical dentinal detachments after canal preparation with hand and rotary files at different instrumentation lengths. J Endod. 2013;39:129-132.
22. Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral Surg Oral Med Oral Pathol. 1971;32:271–5.
23. Brian Kinsey, Richard Mounce. Safe and efficient use of the M4 safety handpiece in endodontics. roots. 2_2008.
24. Shemesh H, Bier CA, Wu MK, Tanomaru-Filho M, Wesselink PR. The effects of canal preparation and filling on the incidence of dentinal defects. Int Endod J. 2009;42:208-213.
25. Tepel J, Schafer E, Hoppe W. Properties of endodontic hand instruments used in rotary motion. Part 3. Resistance to bending and fracture. J Endod. 1997;23:141–5.
26. Tepel J, Schafer E, Hoppe W. Properties of endodontic hand instruments used in rotary motion. Part 1. Cutting efficiency. J Endod. 1995;21:418–21.
27. You S-Y, Kim H-C, Bae K-S, Baek S-H, Kum K-Y, Lee W. Shaping ability of reciprocating motion in curved root canals: a comparative study with micro-computed tomography. J Endod. 2011;37:1296–300.
28. West JD, Roane JB. Cleaning and Shaping the Root Canal System. In: Cohen S, Burns RC, editors. Pathways of the Pulp. 7th ed. Mosby Inc., St. Louis, Missouri; 1998.
29. Elnaghy AM, Elsaka SE. Evaluation of root canal transportation, centering ratio, and remaining dentin thickness associated with ProTaper Next instruments with and without glide path. J Endod. 2014;40:2053-2056.
30. Capar ID, Arslan H, Akcay M, Uysal B. Effects of ProTaper Universal, ProTaper Next, and HyFlex instruments on crack formation in dentin. J Endod. 2014;40:1482-1484.
31. Karataş E, Gunduz HA, Kirici DO, Arslan H, Topcu MC, Yeter KY. Dentinal crack formation during root canal preparations by the twisted file adaptive, ProTaper Next, ProTaper Universal, and WaveOne Instruments. J Endod. 2015;41:261-264.
32. Cicek E, Kocak MM, Saglam BC, Kocak S. Evaluation of microcrack formation in root canals after instrumentation with different NiTi rotary file systems: a scanning electron microscopy study. Scanning. 2015;37:49-53.

Source of Support: Nil; **Conflict of Interest:** None

Submitted: 19-05-2016; **Published online**: 30-06-2016