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ORIGINAL ARTICLE/**ARTICOLO ORIGINALE**

Micro-CT evaluation of ProTaper Next and WaveOne Gold shaping in maxillary first molars curved canals: an *in vitro* study

Valutazione alla micro-CT della sagomatura effettuata con ProTaper Next e WaveOne Gold in primi molari superiori: uno studio in vitro

KEYWORDS
MicroCT, Glidepath, Shaping, ProTaper Next, WaveOne Gold.

PAROLE CHIAVE
MicroTC, Glidepath, Sagomatura, ProTaper Next, WaveOne Gold.

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Abstract

Introduction: *The aim of this micro-CT study was to analyze the geometrical shaping outcomes after instrumentation with rotary and reciprocating glide path and shaping systems.*
Materials and Methods: *The mesio-buccal canals of thirty extracted maxillary first permanent molars were randomized into two groups (n=15): rotary system ProGlider and ProTaper Next X1, X2 (PG-PTN) was compared with reciprocating system WaveOne Gold Glider and WaveOne Gold Primary (WOGG-WOG). Irrigation was performed with EDTA 10% and NaOCl 5%. Specimens were micro-CT scanned before instrumentation and after glide path and shaping. The measured parameters were the increase in canal volume and surface area, the centroid shift and the canal geometry variation through RDR and RA. These parameters were measured in the apical and coronal levels and at the point of maximum curvature. One-way ANOVA and post hoc Turkey-Kramer tests were used to describe the impact of the instrumentation on the selected parameters (P<0.05).*
Results: *Post glide path analysis revealed that increase in canal surface area was slightly greater in WOGG group (P=0.051). Centroid shift was not significant even if the trend seemed more favorable to PG group, except for the apical third. Centroid shift reported no significant differences.*
Conclusions: *Both rotary and reciprocating systems seemed to create a homogeneous and well-centered glide path and shaping.*

Introduzione: *Lo scopo del lavoro è stato quello di comparare, con la micro-TC, gli esiti della sagomatura dopo la strumentazione con un sistema rotante reciprocante e uno a rotazione continua.*
Materiali e metodi: *Sono stati selezionati 30 primi molari superiori permanenti. I canali MB1 e MB2 sono stati suddivisi randomicamente in due gruppi (n=15): rotazione continua ProGlider e ProTaper Next X1, X2 (PG-PTN), e movimento reciprocante WaveOne Gold Glider e WaveOne Gold Primary (WOGG-WOG). I canali sono stati irrigati con EDTA 10% a NaOCl 5%. I campioni sono stati scannerizzati alla micro-TC prima della strumentazione e dopo glidepath e shaping. Sono stati misurati i seguenti parametri nel terzo coronale, apicale e al punto di massima curvatura: incremento nel volume canalare, superficie canalare, spostamento del centroide e variazioni geometriche (tramite RA e RDR). Per analizzare l'efficacia della strumentazione sui suddetti parametri sono stati utilizzati test ANOVA one-way e post hoc Turkey-Kramer (P<0.05).*
Risultati: *L'analisi post glidepath ha rivelato che l'incremento nella superficie canalare è stato leggermente maggiore nel gruppo WOGG (P=0.051). Lo spostamento del centroide non è risultato significativo, anche se il trend è sembrato più favorevole per il gruppo PG, fatta eccezione per il terzo apicale. Lo spostamento del centroide non ha riportato differenze statisticamente significative.*
Conclusioni: *Entrambi i sistemi sembrano produrre una sagomatura omogenea e ben centrata.*

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Introduction

The goal of the endodontic treatment is the appropriate shaping with respect to the original root canal anatomy (1). The canal scouting with stainless steel sizes 08-10 K-files allows the initial patency and the tactile feedback (2). The subsequent glide path phase lowers the risk of taper lock and torsional stress of the NiTi instruments (3, 4, 5). The root canal shaping permits disinfection and helps the tridimensional filling (6, 7). The glide path and shaping techniques need manual or mechanical nickel-titanium (NiTi) instruments. The latter can be classified according to the kind of movement used: rotary or reciprocating (8).

ProTaper Next (PTN) rotary shaping instruments have a M-wire alloy, a rectangular section and an asymmetrical axis, which permits a "swaggering" movement. These features lead to a reduced contact between the instrument and the canal walls, a more efficient cleaning of debris and a better flexibility (9, 10, 11, 12).

Lately, WaveOne Gold (WOG) reciprocating system was introduced. The reciprocating movement, the new design and alloy properties aim to improve the cyclic fatigue resistance, the root canal shaping ability and the removal of debris (13, 14). WaveOne Gold Glider (WOGG) is a single reciprocating glide path file, which was recently proposed in combination with WaveOne Gold. No comparison is available yet. The micro-computed tomography (micro-CT) is a useful tool for the evaluation of the shaping geometrical outcomes, allowing a non-invasive and reproducible analysis of high-resolution scans before and after treatment (15). The aim of this study *in vitro* is to evaluate the shaping ability of the rotary instrumentation system ProGlider and ProTaper Next compared to the reciprocating system WaveOne Gold Glider and WaveOne Gold.

Materials and Methods

A total of 39 teeth were selected for extraction for peridontal disease: permanent maxillary first molars, without caries, cracks and extended restorations. The specimens were fixed in a customized support and preliminary micro-CT scans were accomplished to attain a root canal anatomy outline (SkyScan 1172, Bruker micro-CT). The morphological parameters of the mesio-buccal (MB1) canals were obtained. Of 39 teeth selected, nine were excluded due to anatomical issues. Thirty samples were randomly assigned to the two groups: ProGlider and ProTaper Next rotary shaping system (group PG-PTN) (n=15) and WaveOne Gold Glider and WaveOne Gold reciprocating shaping system (group WOGG-WOG) (n=15). A single blind operator performed randomization, allocation, and statistical analysis. After a traditional access cavity creation, canal scouting was accomplished in all specimens with #10 K-file at working length (WL). In Group PG-PTN, glide path was performed with Proglider (PG) rotary single file (size 0.16, taper .02 to .082 at D16) (Dentsply Sirona). Then shaping was concluded with ProTaper Next (PTN) X1 (tip size 0.17 mm, taper .04) and X2 (tip size 0.25 mm, taper .06) (Dentsply Sirona) using an endodontic engine X-Smart Plus (Dentsply Sirona) with 16:1 contra angle (300 rpm, 4 Ncm) in continuous rotation up to WL. In Group WOGG-WOG glide path was achieved with WaveOne Gold Glider (WOGG) reciprocating single file (tip size 0.15, taper .017 to .085 at D16) (Dentsply Sirona). Then shaping was ultimated with WaveOne Gold (WOG) Primary (size 0.25, taper .07) (Dentsply Sirona) using an endodontic engine X-Smart Plus (Dentsply Sirona) with 16:1 contra angle having the approved WaveOne Gold settings in reciprocating rotation up to WL. New instruments were used for each specimen. Irrigation was completed with 5,25% NaOCl and 12% EDTA in alternation.

Table 1

3D and 2D parameters utilized for post glide path analysis in each group (PG=ProGlider, WOGG=WaveOne Gold Glider)

		Centroid shift (mm^{-1})	
Group	Level of analysis	Range	Mean±SD
	Coronal	0.02-0.89	$0.32{\pm}0.25^a$
PG	Middle	0.11-0.64	$0.38{\pm}0.29^a$
	Apical	0.26-0.69	$0.38{\pm}0.14^a$
	Coronal	0.18-0.97	$0.40{\pm}0.30^a$
WOGG	Middle	0.16-0.90	$0.44{\pm}0.26^a$
	Apical	0.15-0.83	$0.24{\pm}0.30^b$

Different superscript letters in the same column indicate significant differences between groups (P<0.05). For 2D parameters (centroid shift) significance was compared for the same level of analysis (coronal, middle or apical).

Table 2

3D and 2D parameters utilized for post shaping analysis in each group (PTN=ProTaper Next, WOG=WaveOne Gold)

		Centroid shift (mm^{-1})
Group	Level of analysis	Mean±SD
	Coronal	$0.59{\pm}0.37^a$
PTN	Middle	$0.72{\pm}0.27^a$
	Apical	$0.44{\pm}0.30^a$
	Coronal	$1.04{\pm}0.36^a$
WOG	Middle	$1.15{\pm}0.39^a$
	Apical	$0.60{\pm}0.43^a$

Different superscript letters in the same column indicate significant differences between groups (P<0.05). For 2D parameters (centroid shift) significance was compared for the same level of analysis (coronal, middle or apical).

The selected samples were scanned at high-resolution before preparation, after glide path and after shaping (100 kV, 100 μA, 16 μm resolution, Al+Cu filter and 360° rotation for a total of 2400 projections). Afterwards, the images were reconstructed with NRecon software (SkyScan 1172, Bruker micro-CT) using standard parameters for beam hardening and ring artifact correction and the reconstructed volumes were analyzed with CTAn software (SkyScan 1172, Bruker micro-CT). The increase in canal volume and surface area was calculated for each sample through 3D renderings. Root sections orthogonal to the canal axis were set at 3 different levels: apical (A), 1 mm from the apical foramen; middle (M), set at the point of maximum curvature and coronal (C), set in correspondence to the middle portion of the root canal coronal third defined by 3D calculation of the root canal length from apex to orifice. These levels were selected as most representative of the critical shaping portions (16). The bidimensional parameters were analyzed at each level. The distribution of the data was analyzed with a Shapiro-Wilk normality test. The differences of the root canal curvature at baseline were analyzed with a Kruskall-Wallis and post hoc Dunn tests (P<0.05). One-way ANOVA and post hoc Turkey-Kramer tests were used to analyze the increase of canal surface area and volume, the centroid shift and the impact of the instrumentation on RDR and RA parameters at each level of analysis (P<0.05). All of the statistical analyses were conducted with the Minitab 15 software package (Minitab Inc., State College).

Results

There was no incidence of instrument fracture during canal preparation. Post glide path comparisons are reported in Table 1. The increase of root canal volume between groups was not significantly different (P>0.05), whereas root canal surface area difference was at the limit of significance (P=0.051) and was greater in WOGG group. RDR was statistically significant (P=0.014) in the coronal third, showing values closer to 1 in the PG group. RA value showed no differences between groups (P>0.05). In the coronal and middle third, centroid shift parameter was not significant (P>0.05) even if the trend seemed more favorable to PG group, while in the apical third the difference between the two groups was significant (P=0.020) with data in favor of WOGG. Post shaping comparisons are reported in Table 2.

Volume and canal surface area increase were significantly different and showed a reduced removal of dental tissue by the PTN group compared to the WOG group (P=0.003). In the coronal third (C), RA and RDR were at the limit of significance (P=0.087). RDR was closer to the value of 1 for the PTN group, which had a greater tendency to work symmetrically, while RA, representing the canal widening, was close to 1 for the WOG group. At the point of maximum curvature (M) RDR was at the limit of significance (P=0.056) while RA was significant and demonstrated a reduced root canal widening for the PTN group (P=0.019). Apically RDR was not significant, while the value of RA was significant with values closer to 1 for the WOG group (P=0.040). Between the two groups there were no statistically significant differences about the displacement of the centroid in any of the three levels of analysis (P>0.05).

Discussion

The data obtained show a statistically significant difference between PTN and WOG group for what concerns the tridimensional parameters, with a higher increment in the WOG group.
About the bidimensional parameters, in the coronal third PG instrument seemed to facilitate a more symmetrical shaping and a lower tendency to canal transportation with an RDR value closer to 1. This result may be due to the geometrical features of WOGG, which has a higher conical shape in the coronal and medium third.
However, the ratio between the post- and pre-instrumentation areas (RA) is barely significant in the coronal third, where the WOG tended to produce a minor widening of the canal.
This data could be easily understood by comparing the geometry and the different taper variations between the groups: the WOG Primary shows a 3% taper at 13 mm from the tip, while PTN X2 has a 6% taper. At the maximum curvature point there were no statistically significant differences between the groups.
Post-shaping RA values were statistically significant in the medium third, where PTN systems resulted more conservative. PTN X2 is smaller than the envelope of motion it creates, so being more flexible and sensitive to the curvatures (17).

References

1. *Schilder H. Cleaning and shaping the root canal. Dental Clinics of North America. 1991; 18: 269-96.*
2. *Burklein S, Schafer E. Critical evaluation of root canal transportation by instrumentation. Endodontic Topics. 2013; 29: 110-24.*
3. *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. Journal of Endodontics. 2009; 35: 408-12.*
4. *American Association of Endodontists. Colleagues for Excellence. Rotary Instrumentation: an Endodontic Perspective. 2008. URL http://www.aae.org/uploadedfiles/publications_and_research/endodontics_colleagues_for_excel- lence_newsletter/winter08ecfe.pdf.*
5. *Patiño PV, Biedma BM, Liébana CR, Cantatore G, Bahillo JG. The influence of a manual glide path on the separation rate of NiTi rotary instruments. Journal of Endodontics; 2005; 31: 114-*
6. *Peters OA. Current challenges and concepts in the preparation of root canal systems: a review. Journal of Endodontics 2004; 30: 559–67.*
7. *Hulsmann M, Peters OA, Dummer PMH. Mechanical preparation of root canals: shaping goals, techniques and means. Endodontic Topics. 2005; 10: 30-76.*
8. *Haapasalo M, Shen Y. Evolution of nickel-titanium instruments: from past to future. Endodontic Topics. 2013; 29: 3-17.*
9. *Alovisi M, Cemenasco A, Mancini L, Paolino D, Scotti N, Bianchi CC, Pasqualini D. Micro-CT evaluation of several glide path techniques and ProTaper Next shaping outcomes in maxillary first molar curved canals. International Endodontic Journal. 2017; 50: 387-397.*
10. *Elnaghy AM, Elsaka SE. Evaluation of root canal transportation, centering ratio, and re-*

Finally, at the apical level of analysis, WOGG was more centered in the canal, probably thanks to its specific reciprocating movement and the lower apical diameter. In the apical third, the reciprocating movement seemed to permit a more conservative preparation, proved by a RA significantly lower in the WOG group (18).

Conclusions

Even though it is necessary to increase the number of the samples in order to achieve a higher statistical significance, within the limits of this study WOGG seems to produce a homogeneous and well-centered glide path, revealing itself as a reliable reciprocating instrument.
Therefore, combining the WOGG with the WOG system, the operator could keep the same configuration of the endodontic motor, optimizing the ergonomics and the working time.

Clinical Relevance

The root canal anatomy preservation after glide path and shaping with modern NiTi rotary and reciprocating shaping systems was evaluated. The reciprocating system removed more dentin especially in point of maximum curvature remaining well centered in the apical third.

Conflict of Interest

We affirm that we have no financial affiliation (e.g. employment, direct payment, stock holdings, retainers, consultantships, patent licensing arrangements or honoraria) or involvement with any commercial organization with direct financial interest in the subject or materials discussed in this manuscript, nor have any such arrangements existed in the past three years.
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maining dentin thickness associated with ProTaper Next instruments with and without glide path. Journal of Endodontics. 2014; 40: 2053-6.

11. *Pasqualini D, Alovisi M, Cemenasco A, Mancini L, Paolino DS, Bianchi CC, Roggia A, Scotti N, Berutti E. Micro-computed tomography evaluation of Protaper Next and BioRace shaping outcomes in maxillary first molar curved canals. Journal of Endodontics. 2015; 41: 1706-10.*
12. *Zhao D, Shen Y, Peng B, Haapasalo M. Root Canal Preparation of Mandibular Molars with 3 Nickel-Titanium Rotary Instruments: A Micro-Computed Tomographic Study. Journal of Endodontics. 2014; 40: 1860-4.*
13. *Adıgüzel M, Capar ID. Comparison of Cyclic Fatigue Resistance of WaveOne and WaveOne Gold Small, Primary, and Large Instruments. Journal of Endodontics. 2017; 43: 623-627.*
14. *Özyürek T, Yılmaz K, Uslu G. Shaping Ability of Reciproc, WaveOne Gold, and HyFlex EDM Single-file Systems in Simulated S-shaped Canals. Journal of Endodontics. 2017; 43: 805-809.*
15. *Paque F, Ganahl D, Peters OA. Effects of root canal preparation on apical geometry assessed by micro-computed tomography. Journal of Endodontics. 2009; 35: 1056-9.*
16. *Jafarzadeh H, Abbott PV. Ledge formation: review of a great challenge in endodontics. Journal of Endodontics. 2007; 33: 1155-62.*
17. *Elnaghy AM, Elsaka SE. Assessment of the Mechanical Properties of ProTaper Next Nickel-Titanium Rotary Files. Journal of Endodontic. 2014; 40: 1830-4.*
18. *Berutti E, Paolino DS, Chiandussi G, Alovisi M, Cantatore G, Castellucci A, Pasqualini D. Root canal anatomy preservation of WaveOne reciprocating files with or without glide path. Journal of Endodontics. 2012; 38: 101-4.*