Effect of repeated use on the shaping ability of Protaper Universal rotary files

Hani F. Ounsi,[1] Giovanni Franciosi,[2] Raffaele Paragliola,[3] Cecilia Goracci,[4] Simone Grandini[5]

Abstract

Aim: To assess the effect of repeated use in resin simulators on the shaping ability of Protaper Universal rotary instruments. **Materials and Methods:** 60 resin blocks simulating curved root canals were divided in 6 groups. Ten new sets of Protaper instruments were used successively 6 times to shape the resin blocks. Digital photos of the blocks were taken in both mesiodistal and buccolingual directions after each instrument and surfaces were calculated using AutoCAD software. Comparison was done for each third of the canal separately using one and 2-way ANOVA and Tukey post hoc tests. Statistical significance was set to 0.05. **Results:** Statistical analysis was performed only for the third were the instrument is supposed to work (i.e., coronal for the SX, middle for the S1 and S2, and apical for the F1 and F2). One-way ANOVA revealed no significant differences between 1st, 2nd, 3rd and 6th use ($p=0.059$) in the coronal third. Two-way ANOVA revealed significant differences in the middle third between S1 and S2 ($p<0.001$) and significant difference between the uses ($p=0.007$). Tukey post hoc test revealed significant differences between 1st and 6th ($p=0.008$) and 2nd and 6th use ($p=0.03$). Two-way ANOVA in the apical third revealed significant differences between F1 and F2 ($p<0.001$) and significant difference between the uses ($p<0.001$). Tukey post hoc test revealed significant differences between 1st and 3rd use ($p=0.05$), 1st and 6th ($p<0.001$), 2nd and 6th use ($p<0.001$), and 3rd and 6th use ($p<0.001$). **Discussion:** Using plastic blocks allowed better comparability by having identical baseline shape and material for the instruments to cut through. The reduction in shaping efficiency observed might force dentists to make the instrument work longer inside the root canal, and therefore risk instrument separation. Also, a reduction in cutting efficiency might have a detrimental effect on bacterial load reduction. Clinically, this reinforces the necessity for manual gauging and tuning prior to filling the root canal system to ensure proper shaping and cleaning is achieved especially in the apical part.

Keywords: *Shaping ability, repeated use, nickel titanium*

Introduction

Nickel-titanium (NiTi) endodontic rotary instruments have become very popular in endodontics due to their superelastic properties and efficiency in canal preparation.[1]

[1] *Department of Dental Sciences, University of Siena, Siena, Italy*
[2] *Department of Dental Sciences, University of Siena, Siena, Italy*
[3] *Department of Dental Sciences, University of Siena, Siena, Italy*
[4] *Chair of Dental Materials, University of Siena, Siena, Italy*
[5] *Chair of Endodontics and Restorative Dentistry, Department of Dental Sciences, University of Siena, Siena, Italy*

Corresponding Author: *Professor Simone Grandini*
Chair of Endodontics and Restorative Dentistry, Department of Endodontics and Restorative Dentistry, Dean of the School of Dental Hygienists, University of Siena, Italy
grandini@unisi.it / simogr@gmail.com
Tel: +39 0577 585772,+39 335 7045335

They differ in taper, tip size, cross-section, helix angle, and blade pitch.[2,3] The main concern regarding reuse of nickel titanium instruments has always been their tendency to undergo cyclic fatigue and separate without any warning signs such as visible defects or plastic deformation.[4,5] Repeated clinical use of these instruments resulted in significant reduction in their cyclic fatigue resistance.[6-10] To date, the number of times in which a NiTi rotary instrument can be reused remains uncertain.[11-13]

From another stand point, repeated clinical use of nickel titanium instrument raised concern on the potential of prion transmission. Prion protein is resistant to conventional sterilization methods especially when infected tissues become dried on glass or metal surfaces.[14] This prompted health control authorities to limit such instruments to single

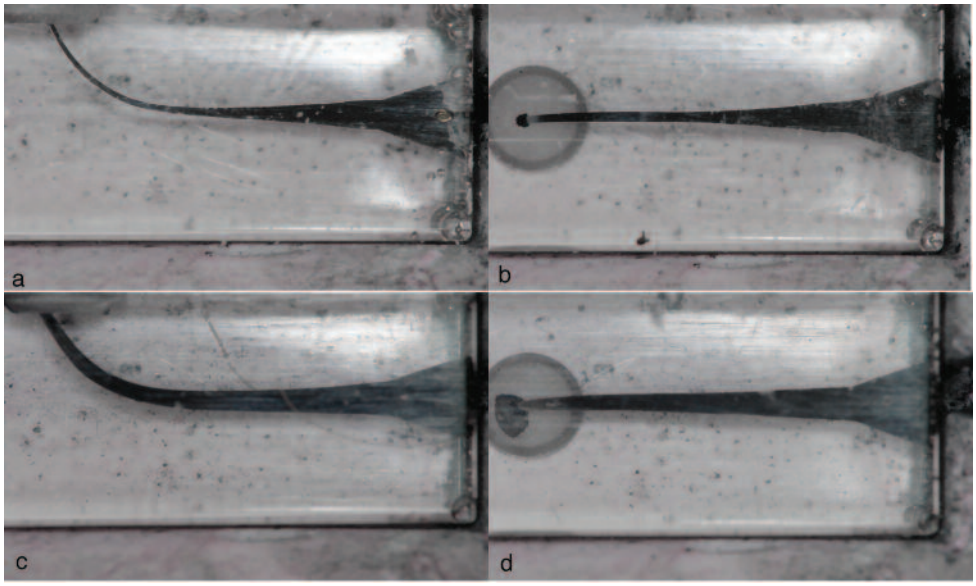

Figure 1: Photos after instrumentation with SX (a,b) and F2 (c,d) in mesiodistal (a,c) and buccolingual (b,d) directions.

use in some countries.[15] Although prion disinfection protocols are extremely aggressive on nickel titanium instruments,[16] clinicians often elect to reuse these instruments on more than one patient due to financial reasons.[13] As the quality of canal preparation contributes to the success of the root canal treatment, it is surprising that current studies on the reuse of NiTi instruments are focused entirely on the quality of the reused instruments instead of the quality of the canal preparation.

The aim of this study was to assess the effect of repeated use in resin simulators on the shaping ability of Protaper Universal rotary instruments. The null hypothesis was that there is no difference in the areas measured after shaping with new instruments, instruments that are used once, twice, or after 6 uses.

Materials and methods

Ten new sets of Protaper Universal instruments (Dentsply-Maillefer, Ballaigues, Switzerland) were used in this study. Sixty resin blocks simulating curved root canals (Dentsply-Maillefer) were randomly divided into 6 groups: group 1 (samples noted 1-1, 2-1,...,10-1) was prepared with new Protaper instruments, group 2 (samples noted 1-2, 2-2,...,10-2) was prepared with Protaper instruments used in group 1 (2nd use), group 3 (samples noted 1-3, 2-3,...,10-3) was prepared using the Protaper instruments used in group 2 (3rd use), group 4 (samples noted 1-4, 2-4,...,10-4) was prepared using the Protaper instruments used in group 3 (4th use), group 5 (samples noted 1-5, 2-5,...,10-5) was prepared using the Protaper instruments used in group 4 (5th use), and group 6 (samples noted 1-6, 2-6,...,10-6) was prepared using the Protaper instruments used in group 5 (6th use). Shaping was performed by the same experienced operator and pathfinding was performed to full length using #10 K-files (Dentsply-Maillefer) with Glyde (Dentsply-Maillefer) as lubricant. Protaper instruments were then used in a crown-down fashion and a pure picking motion (no lateral pressure) using an endodontic electric motor (VDW Gold, VDW, Munich, Germany) at the respective preset speed and torque values for each instrument. The sequence was SX, S1, S2, F1 and F2, and irrigation was performed between instruments using gauge 30 endodontic needles (Canal Clean, Biodent, Paju City, Korea) and 2.5% sodium hypochlorite (2ml each time). Patency was also confirmed between instruments using #10 K-file. Canal shaping was done according to manufacturer's instructions with instrument reaching full length (with the exception of the SX) only once and holding this position no longer than 2 seconds.

Black ink (Pelikan, Schindellegi, Germany) was used as contrast material and was injected in the simulated root canal space after each instrument and photos of the blocks were taken in both mesiodistal and buccolingual directions using a copy-stand and a digital camera (Nikon D60 with Medical Nikkor, Nikon Corp, Tokyo, Japan). Precise positioning of the blocks was ensured using a silicone mold (Figure 1). The 300 digital photos obtained were imported into AutoCAD 2004 (Autodesk Inc, San Rafael, CA) and analyzed by an operator blinded to purpose of the study. The canals were divided equally using a digital template into coronal, middle and apical thirds and surface measurements (in mm2) of each area were obtained for each photo.

Table 1
Mean surface areas for SX instrument (coronal third). Different letters denote statistically different values.

	SX	
Coronal	**Mean**	**SD**
1st use	3553.66 ^{A,B}	89,84
2nd use	3542.27 ^{B}	82,93
3rd use	3506.45 ^{B,C}	59,75
6th use	3470,47	48,75

Comparison was done for each third of the canal separately. Normality and homogeneity of variances were verified for each third using the Kolmogorov-Smirnov and Levene tests respectively, then results were statistically analyzed using one-way ANOVA (coronal), two-way ANOVA (middle and apical), and Tukey post hoc tests. Statistical significance was set to 0.05.

Results

To simplify further calculations, the mean of mesiodistal and buccolingual values was considered rather than using them individually. For each instrument, surface measurements were performed for each third (Tables 1-3). However, statistical analysis was performed only for the third were the instrument is supposed to work (i.e., coronal for the SX, middle for the S1 and S2, and apical for the F1 and F2).

Regarding the coronal third, one-way ANOVA revealed no significant differences between 1st, 2nd, 3rd and 6th use ($p=0.059$).

Regarding the middle third, two-way ANOVA revealed significant differences between S1 and S2 ($p<0.001$) and significant difference between the uses ($p=0.007$). Tukey post hoc test revealed no differences between 1st, 2nd and 3rd use, and no differences were noted between 3rd and 6th use. However, significant differences were noted between 1st and 6th ($p=0.008$) and 2nd and 6th use ($p=0.03$).

Regarding the apical third, two-way ANOVA revealed significant differences between F1 and F2 ($p<0.001$) and significant difference between the uses ($p<0.001$). Tukey post hoc test revealed no differences between 1st and 2nd, or 2nd and 3rd use. However, significant differences were noted between 1st and 3rd use ($p=0.05$), 1st and 6th ($p<0.001$), 2nd and 6th use ($p<0.001$), and 3rd and 6th use ($p<0.001$).

Discussion

Nickel titanium instruments have been in use for more than a decade and this is the first study assessing the effect of repeated use on the quality of the preparation rather than the effect of repeated use on the instrument. As the results have shown statistically significant differences, and within the limitation of this study, the null hypothesis had to be rejected.

This paper challenged the shaping ability Protapers in plastic blocks. The main advantage in using plastic blocks is that it allows better comparability by having identical baseline shape and material for the instruments to cut through. On the downside, since plastic is softer than dentin,[17] caution must be exercised in extrapolating these results to clinics as instruments may behave differently in dentin. However, since the results already showed differences between uses on resin blocks, we can assume that testing on the harder dentin would eventually generate even more differences. Dentists would eventually be forced to make the instrument work longer inside the root canal therefore exposing themselves to the risk of instrument separation.[18] Furthermore, the present study tested for instruments working in 6 canals which could correspond clinically to using it in 2 molars with 3 canals each. Theoretically according to these results, the instruments would enlarge the 6 canals differently. Practically however, root canals have different dimensions to start with and for an upper molar for instance, instruments will work more in the mesiobuccal canal then in the palatal canal. There is also of course a difference between statistical significance and clinical significance.[19] Procedures need of course to be evaluated to determine if they provide statistically significant results and clinically relevant benefits. If both are established, then the therapeutic modality should be considered for

Table 2
Mean surface areas for S1 and S2 instrument (middle third). Different letters denote statistically different values.

	S1		S2	
Middle	**Mean**	**SD**	**Mean**	**SD**
1st use	1474.46 ^{A,B}	60,82	1561.61 ^{A,B}	36,50
2nd use	1483.80 ^{B}	67,82	1537.62 ^{B}	49,33
3rd use	1447.89 ^{B,C}	31,98	1531.00 ^{B,C}	48,14
6th use	1394,62	53,49	1535,89	59,49

Table 3
Mean surface areas for F1 and F2 instrument (apical third). Different letters denote statistically different values.

	F1		F2	
Middle	**Mean**	**SD**	**Mean**	**SD**
1st use	1123.13 ^{A,B}	51,65	1202.11 ^{A,B}	46,02
2nd use	1102.59 ^{B}	34,76	1175.41 ^{B}	76,39
3rd use	1055.39 ^{B,C}	66,61	1126.27 ^{B,C}	123,20
6th use	949,31	143,46	1002,35	148,91

incorporation into treatment protocols. Currently, there is primarily a tendency to rely on using statistical significance testing, which then often is considered enough to rule that a given technique/instrument supplied a clinically meaningful result. This is problematic because it is possible for a procedure/instrument to yield a statistically significant improvement, while the result may not be clinically significant (and vice versa).

The reduction in volume observed could be attributed to a reduction in cutting efficiency of the instrument due to a modification of the cutting edges. Svec and Powers[20] showed evidence of flaking, pitting, and crack formation on the surface of Profiles following use in extracted molars. More recently, Wei et al.[9] assessed Protaper files after clinical use and reported similar signs of surface wear in addition to roll over of the cutting edges of the instrument. Although there is no definite regulation about the number of uses for nickel titanium rotary instruments, a reduction of their cutting efficiency will definitely increase working time inside the canal (or force the dentist to increase apical pressure on the instrument). This is in accordance with previous studies concluding that multiple reuse of dull instruments will increase the risk of instrument separation.[21] The operator should thus during treatment take into consideration all the factors that may influence instrument fatigue, such as root canal anatomy,[10] operator experience,[22] and instrument design.[23] Creation of a manual glide path with stainless steel hand files before introducing rotary files has been described as being an effective way to reduce stresses on the files and thus reduce file separation.[24-26]

From a biological standpoint, a reduction in cutting efficiency would have a detrimental effect on dentin removal, and as such would impact negatively on the mechanical contribution of nickel titanium rotary instruments in bacterial load reduction.[27,28] Clinically, this prompts the necessity for manual gauging and tuning prior to filling the root canal system to ensure proper shaping and cleaning is achieved especially in the apical part.

Conclusion

Within the limitations of this study, the final shape obtained in plastic blocks following Protaper Universal nickel titanium rotary instrument use varied significantly between the first and the sixth use. As these instruments may be

used clinically for multiple molars,[12,13] further studies are required to assess the shaping efficiency loss after 9 or 12 uses which would correspond to 3-4 molars. Also further studies are required to assess if different instrument designs or materials would similarly affect final canal shape after multiple uses.

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