Canal Aberrations Promoted by Three Nickel-Titanium Rotary Instruments in Simulated S-Shaped Canal

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Abstract

Objective: The aim of this study was to compare canal aberrations promoted by three nickel-titanium (NiTi) rotary systems in simulated S-shaped canal.

Methods: Glide paths were prepared in thirty simulated S-shaped canal blocks. The blocks were then randomly assigned into three groups (n=10): ProTaper Universal (PTU), ProTaper NEXT (PTN) and iRace (IRA) and prepared per its manufacturer's recommendation up to apical size #25. Pre-operative images were taken as baseline. Post-operative images were magnified to identify canal aberrations. Intra-operative images were investigated for aberrations occurred between each file used.

Results: PTN produced the least number of canal aberrations, followed by IRA and PTU respectively. The incidences of aberration between PTN and PTU were significantly different ($p<0.05$).

Conclusion: The ProTaper NEXT system should be the choice for S-shaped canal preparation because of the least canal aberrations.

Keywords: NiTi rotary files, S-shaped canal, Canal aberrations

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Introduction

Preparing S-shaped canals is one of the challenging procedures in root canal preparation. Shaping with stainless steel files in multi-curvatures canals leads to canal deviation and aberrations such as ledge, zip and transportation. Yoshimine et al. suggested that NiTi file systems with less tapered and more flexible should be used in S-shaped canals instrumentation [1]. Flexibility allows instrument negotiation through the canal without creating severe deviation and aberrations. Bonaccorso et al. proposed that NiTi file with taper greater than 0.04 and size greater than 30 should not be used for the apical preparation of S-shaped canal [2]. In order to maintain the canal shape, preparation of the good glide path was mandatory for facilitating root canal preparation. Nowdays, NiTi rotary instruments for glide path preparation have been proposed and proved for less modification of canal curvature and canal aberration compared to hand-operated instruments [3].

Over the two decades of rotary file development and use, there are a lot of changes in designs, metallurgy and file motions. ProTaper Universal (Dentsply Maillefer, Tulsa, OK) was considered the second generation of NiTi rotary files because of its active cutting edges with variable taper [4]. It is made from conventional NiTi with convex triangular cross section. Previous study showed Protaper Universal had more tendency to ledge or zip compared with K3 and Race in simulated S-shaped resin blocks [1]. iRace (FKG Dentaire, SA, Switzerland) is a set of NiTi rotary files in a Race family. It has triangular cross-section with alternating cutting edges and is made from conventional NiTi with electropolished surface, which increases its resistance to file separation. Because of its design and electropolished surface, iRace is also considered the second generation of NiTi rotary files [4]. It is highly flexible and recommended for using in curved canal according to manufacturer's claim. In 2013, the ProTaper NEXT (Dentsply Maillefer, Tulsa, OK) system was introduced to the market. The instruments combine a variable taper design with a new offset-center rectangular cross-section which limits the dentin-instrument contact points to two points. It is considered the fifth generation of NiTi rotary files because of the offset motion [4]. It is made by M-wire technology (Heat treatment of conventional NiTi alloy) which provided better flexibility [4]. The new ProTaper NEXT might be suitable for shaping in S-shaped canal.

Currently, no studies directly compare the canal aberrations of the ProTaper NEXT system with the previous NiTi rotary systems in the S-shaped canal. Therefore, this study aimed to compare the canal aberrations among ProTaper NEXT, ProTaper Universal and iRace systems in that circumstance.

Materials and methods

Thirty simulated S-shaped canal blocks (Endo Training-Bloc-S, .02 Taper; Dentsply-Maillefer, Ballaigues, Switzerland) were taken for pre-operative images using a stereomicroscope (Keyence VH8000, OSK, Japan) on a fixed customized stand. Glide paths were established in each canal using stainless steel #10 K-files (Dentsply Maillefer) and #13, 16, and 19 PathFiles (Dentsply Maillefer) to the terminus of the simulated canal. The blocks were then randomly assigned into three groups (n=10): ProTaper Universal (PTU), ProTaper NEXT (PTN) and iRace (IRA). Each canal was instrumented by its assigned rotary system using an endodontic motor (X-Smart Plus, Dentsply Maillefer) with each manufacturer's speed and torque setting. In the PTU group, SX, S1 and S2 file were used in several stroke with brushing motion, followed by in and out stroke of F1 and F2 file. In the PTN group, SX, X1 and X2 files were functioned in several stroke with brushing motion. In the IRA group, R1 and R2 files were used in the same manner as F1 and F2 files in the PTU group. All files were used once. During root canal preparation, Glyde (Dentsply Maillefer) as a lubricant and tap water as an irrigant were used. After each file used, recapitulation were performed and the blocks were repositioned to a fixed customized stand and were taken for intra-operative images. After canal instrumentation is finished, post-operative images were taken from blocks injected with erythrosine dye by a Max-i-probe (Dentsply Maillefer). All blocks were instrumented by the first investigator who was competent in all systems and the images were evaluated by the second investigator with the blind analysis technique. The post-operative images were magnified to investigate for incidence of canal aberrations (Fig. 1), which were defined as ledges or elbows. Intra-operative images were investigated for file that cause aberrations. The data were analyzed using Statistical Package for Social Sciences (SPSS) software (Version17; SPSS Inc, Chicago, IL). The incidence of aberrations was compared using the chi-square test. A 0.05 significance level was set for statistical analysis.

Results

In the PTU group, 9/10 samples demonstrated aberrations, with elbow in 3 samples and elbows and ledges in 6 samples. The aberrations in 4 samples were observed after using F1 files and in the other 5 samples after using F2 files. In the PTN group, 2/10 samples had aberrations which were ledge and elbow. Both aberrations were seen after using X2 file. In the IRA group, 6/10 samples had aberrations, with ledge in 5 samples and elbow in 1 sample. All aberrations in 6 samples were noticed after using R2 file. The samples with and without aberrations in experimental groups were demonstrated in figure 1. Statistical analysis showed only the PTU group had a significantly higher incidence of aberrations than the PTN group ($p<0.05$, Chi-square test) (Fig. 2).

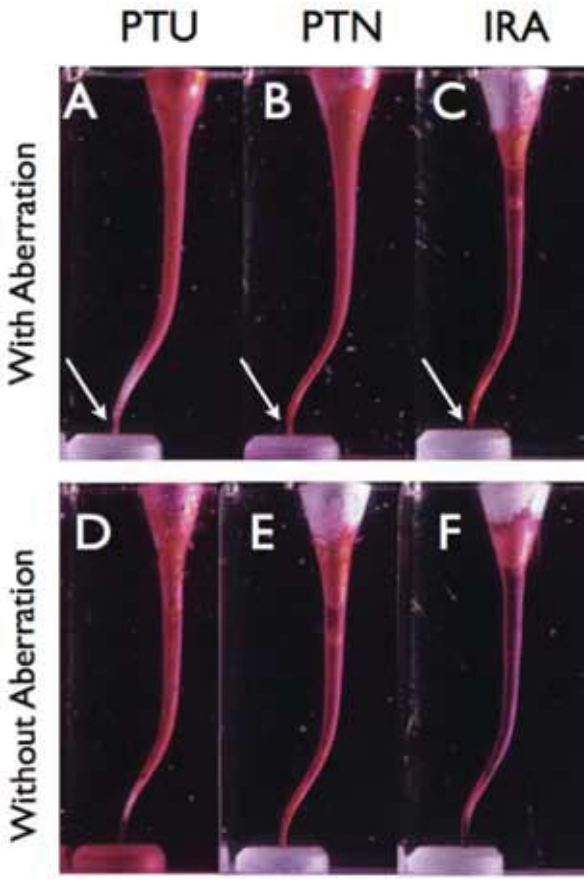

Figure 1. Post-operative images. Upper row demonstrated simulated S-shaped canal with aberration. (A) PTU, (B) PTN, (C) IRA. Lower row demonstrated simulated S-shaped canal without aberration. (D) PTU, (E) PTN, (F) IRA.

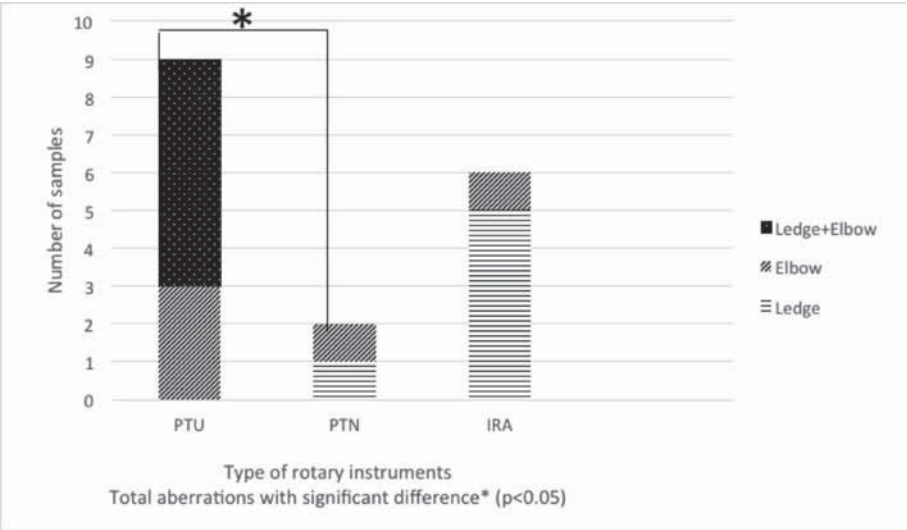

Figure 2. Number of canal aberrations using different rotary instruments.

Discussion

PTU resulted in the greatest canal aberrations, which is in accordance with previous studies [1, 2]. Aberrations in PTU might be explained by the "jump in taper" of the file tips (S2: 20/.04 to F1: 20/.07), as was mentioned by Yoshimine et al. [1]. F1 and F2 file had low flexibility especially at the file tip due to its large taper (F1:.07 and F2:.08). Although the files were withdrawn after it reached working length, the stiffness of the file tip might be an important factor causing aberration at the apical 1/3 of simulated S-shaped canal.

The double curves canals limited the rotary files to go along the curvature, and the NiTi rotary files have shape-memory effects that would try to maintain their original shape. Therefore, the tip of files moved to the opposite side of the curvature creating elbow and ledge. The file with low flexibility may increase the chance of elbow and ledge formation. Elbow was defined as the narrowest area of the hourglass appearance at the apical part of the root canal. Ledge was defined as the step at the root canal wall. Both aberrations were commonly found in root canals prepared by stainless steel files because of their stiffness [5].

Incidence of aberrations in IRA was lower than in PTU but higher than in PTN. Although IRA files has smaller taper (R1: 15/.06, R2: 25/.04) which resulted in more flexibility, but the technique of canal shaping was different from the PTU and PTN. IRA files were carried right to working length without pre-coronal flaring as manufacturer's recommendation, whereas the PTU and PTN used the crown-down technique.

PTN files were made from the M-Wire technology which was the heating of conventional NiTi alloy during production. M-Wire are expected to have higher strength and more wear resistance than similar instruments made from conventional NiTi wires because of its unique nano-crystalline martensitic microstructure [6]. At the file tip, PTN has smaller taper than PTU files with gradual jump in taper (X1: 17/.04 to X2: 25/.06). A new offset-center rectangular cross-section limits the dentin-instrument contact points to two points which creates less contact to canal wall, improves debris removal and reduces the chance of file separation. All of the above factors made the PTN file more flexible and thus having the least numbers of aberrations in all experimental groups.

Although simulated resin blocks demonstrated slight differences in hardness between dentin. Many studies in S-shaped canals were previously done in simulated resin blocks due to a difficulty of sample standardization [1, 2, 3, 7, 8]. Therefore care must be taken in extrapolate the result into clinical situation

Conclusion

Under the condition of this study, the ProTaper NEXT systems should be suitable for S-shaped canal preparation due to less canal aberration than the ProTaper Universal and iRace system.

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The authors deny any conflict of interest related in this study.

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