A Comparison of Three Methods for Preparing Centered Platforms Around Separated Instruments in Curved Canals

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Abstract

This study compared three methods for creating the most centered staging platform (SP) around separated instruments (SI) in curved canals. Green .04 ProFiles, notched at D_3, were separated in the apical third of 42 mesiobuccal canals of maxillary and mandibular molars. Teeth were divided into three groups. SPs were prepared in group 1 with Gates Gliddens (GG) to a size #3; group 2 with LightSpeed to a size 90; and group 3 with incrementally cut rotary .06 ProFiles to size 82. Pre- and postoperative digital radiographs were imported into AutoCAD to measure the deviation of SP from the head of the separated instrument. Pearson's correlation showed a positive relationship between deviation of the SP and the distance of the SI from the elbow of the canal. ANOVA showed that LightSpeed instruments were significantly more effective in preparing a centered staging platform around separated instruments in curved canals when compared to GG drills and ProFiles ($p < 0.05$). *(J Endod 2006;32:48–51)*

Key Words

LightSpeed instruments, nickel-titanium, ProFile separation, staging platform

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Despite their many advantages, nickel-titanium (NiTi) instruments have inherent properties that lead to their unexpected separation in root canals (1). The removal of a fractured instrument is challenging and often associated with anxiety for both clinician and patient (2). In addition, fracture of root canal instruments can jeopardize the prognosis of the case, especially when the separated segment prevents root canal debridement in infected cases (3, 4).

A major factor that determines the feasibility of whether a fractured instrument can be retrieved is position of the separated instrument in relation to the curvature of the root canal (5, 6). The primary causes of NiTi separation has been attributed to torsional and fatigue failure of NiTi alloy (7). A fracture mode involving crack propagation parallel to the local flute orientation, connecting pitted regions on the surface, has also been reported (8). It has been shown that rotary NiTi instruments tend to fracture at the midpoint of the curvature within simulated root canals (9). Therefore, most instruments break in the apical third of canals because this is where canals typically curve and possess their smallest diameters. The use of stainless steel hand files to prepare the apical one-third of the curved canals before introducing the rotary files has been reported to reduce the incidence of instrument separation (10). Avoiding repeated use of ProFile instruments has also been reported to reduce instrument separation (11).

The ultrasonic technique, in conjunction with magnification and illumination, is usually the first option to remove separated instruments. To use ultrasonic instruments one must flare the canal coronally to the fractured instrument to create a "staging platform" (12). The staging platform is made by enlarging the canal to the separated instrument by sequential use of Gates Glidden (GG) drills, whose tips have been altered by cutting them perpendicular to their long axis. A technique using ultrasonic tips to create a staging platform was consistently successful when part of the fractured instrument was located in the straight portion of the canal. However, when the fractured instrument was located around a curve, there was a decrease in success rate, accompanied by major damage to the root canal (13).

The use of rigid GG drills in the curved portion of the canal may damage the root canal during preparation of staging platforms. It has been shown that even in the hands of inexperienced operators NiTi hand instruments allow preparation of root canals with less procedural errors (14). It has been speculated that because of their superelasticity and flexibility NiTi instruments may cause less damage to the canal during preparation of staging platforms (15). Therefore, the purpose of this study is to compare the degree of transportation caused by stainless steel GG drills, NiTi LightSpeed instruments, and incrementally cut ProFiles when preparing staging platforms around instruments separated in the apical third of curved root canals.

Materials and Methods

A standard plexiglass jig as shown in Fig. 1 was used in this study, which has been described in detail in an earlier publication (16). A turntable consisted of three clear plastic boxes (Store-it, Nicole, Mt. Laurel, NJ), which were snapped on top of each other. In the top box extracted teeth were secured with cured acrylic. The degree of rotation of the turntable was measured by a protractor glued to the platform below the turntable. The sensor of the digital radiography unit was secured to a plexiglass wall located behind the turntable.

Forty-two human extracted maxillary and mandibular molars with varying degrees of root curvatures were selected for this study. The teeth were accessed with a #4 round

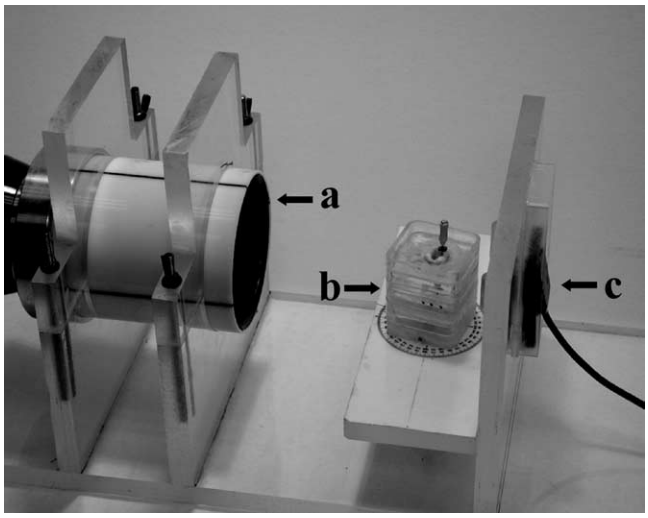

Figure 1. Plexiglass jig holding X-ray tube head (a), the turntable (b) containing the specimen, and the digital radiographic sensor (c).

bur in a water-cooled high-speed handpiece, and the mesio-buccal canal was preflared coronally with GG drills #4, #3, and #2. The working length was determined by subtracting 1 mm from the length at which the file tip extruded through the apical foramen. The canal was then enlarged to the working length with a size 15 K file.

The #15 K file was placed in the root canal and a series of radiographs were taken, while incrementally rotating the turntable until the file in the root canal appeared straight on the radiograph. The box was then rotated 90 degrees to reveal the maximum curvature of the root canal and a radiograph was taken. The degree at which the final radiograph was taken was recorded and all subsequent radiographs of the sample were taken at the same degree.

The teeth were then instrumented with Series 29, .04 taper ProFiles (Dentsply Tulsa Dental, Tulsa, OK). A #6 ProFile was introduced into the canal at 300 rpm in a high torque electrical handpiece. The instrument was withdrawn when resistance was met and followed by a #5, #4, #3, and #2 ProFiles. The cycle was repeated until ProFile #6 (Green) reached the working length.

Under the surgical operating microscope .04 taper, #6 ProFiles, with an apical diameter of 0.36 mm, were weakened at the D3 level by notching them with a diamond wheel. The notched files were introduced to the full working length and rotated with a high torque handpiece until they separated.

The teeth with separated files were repositioned on the radiographic jig at the previously established degree of rotation and a second radiograph was taken with a #7 (Brown), .06 taper ProFile placed coronally to the separated instrument. The readjusted working length was established at the coronal extent of the separated instrument.

The radiographs were used to determine the length of the separated instrument, the angle of curvature and the distance of the separated instrument from the elbow of the canal with AutoCAD 2000 (Autodesk Inc., San Rafael, CA). Schneider's technique was used to measure the angle of curvature because this technique concomitantly identifies the elbow of the curvature.

The samples were randomly distributed into three groups. In all groups the canal was lubricated with RC Prep (Premier Dental, Norristown, PA) and irrigated with 2.5% sodium hypochlorite between each instrument. The instruments used for preparing root canals and staging platforms were discarded after using them approximately five times. An operating microscope was used when needed. However, all samples were examined with an operating microscope at the completion of the staging platforms. The staging platforms in the three groups were prepared by the following methods.

In group 1 GG drills #1 through #3 in a slow speed handpiece were used to prepare the staging platform. Before their use the GG drills were modified by grinding their guiding tips with a carborandum stone to prepare a flattened end at the maximum cross-sectional diameter of the

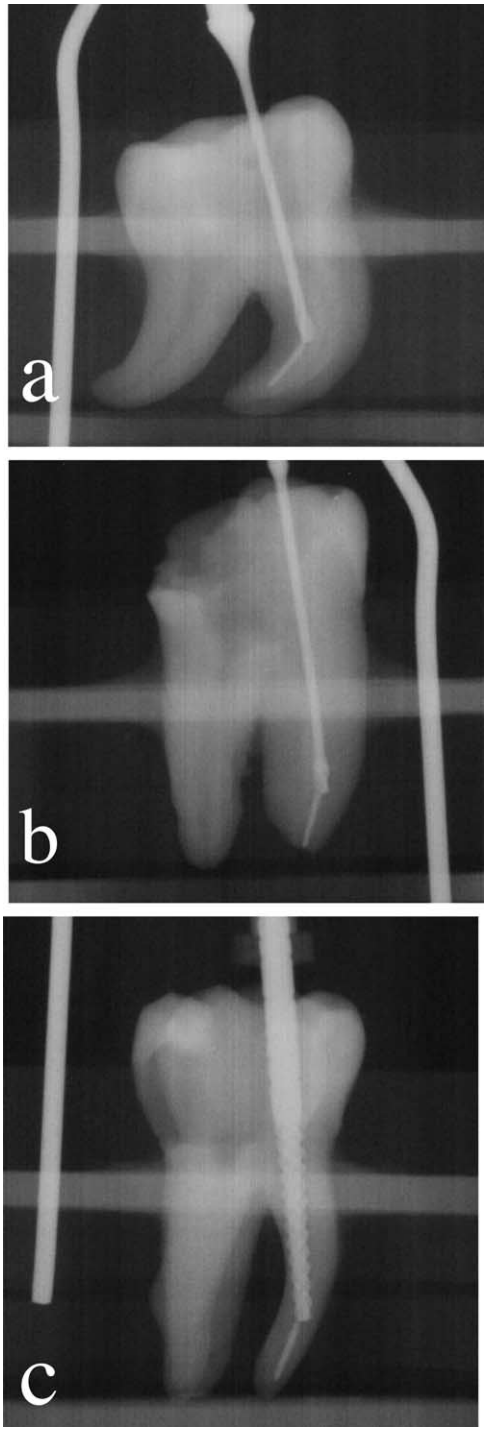

Figure 2. Final radiographs showing that the staging platform did not completely encircle the separated instruments in any one of the groups. (a) Group 1, GG drills, (b) group 2, LightSpeed instruments, and (c) group 3, incrementally cut ProFiles.

TABLE 1. Means and SD of angle of curvature, distance of separated instrument from elbow, length of the separated segment, and deviation of staging platform from separated instrument

Group	n	Angle of Curvature (Mean ± SD)	Distance of Separated Instrument from Elbow (Mean ± SD)	Length of Separated Instrument (Mean ± SD)	Deviation of Staging Platform (Mean ± SD)
1	14	151.79 ± 13.06[a]	2.35 ± 1.68[a]	3.62 ± 0.16[a]	0.55 ± 0.29[a]
2	14	148.14 ± 13.32[a]	2.24 ± 1.64[a]	3.51 ± 0.26[a]	0.31 ± 0.20[b]
3	14	149.21 ± 12.44[a]	2.54 ± 2.03[a]	3.47 ± 0.21[a]	0.58 ± 0.29[a]

Values in columns sharing the same superscript are not significantly different ($p = <.05$).

SD, standard deviation.

GG drills. The instruments were used in a crown down manner until GG #3 reached the head of the separated instrument.

In group 2, LightSpeed files (LightSpeed Technology Inc., San Antonio, TX) were used in a high torque handpiece at 1000 rpm to create a staging platform. The tips of the LightSpeed files were modified in a similar manner as the GG drills. The preparation was started by pecking with a LightSpeed #50 and continued until a LightSpeed #90 reached the adjusted working length.

In group 3 the staging platform was created by incrementally cutting a 31 mm #7, .06 taper ProFile (Brown). Each time the file was incrementally cut by 1 mm and taken to the adjusted working length. The instrumentation was continued until the file had been shortened by 6 mm. The tip diameter of the last modified file was estimated to be approximately 0.825 mm.

A final radiograph of each canal was taken with the preparation instrument placed in the root canal (Fig. 2). AutoCAD was again used to measure the distance between midpoints of the head of the separated instrument and the staging platform. This determined the distance in mm by which the staging platform deviated from the head of the separated instrument.

Statistical analysis included ANOVA and Pearson correlation regarding deviation of staging platform, angle of curvature, length of separated instrument, and distance of separated instrument from the elbow of the canal.

Results

The mean and standard deviation of the distance between the midpoints of the head of the separated instrument and the staging platform for the three groups are given in Table 1. ANOVA gave statistically significant differences among groups ($p = 0.006$). Tukey's post hoc test showed that group 2 was significantly different from group 1 ($p = 0.021$) and group 3 ($p = 0.010$). A Pearson's correlation two-tailed test showed a positive correlation (0.493) between the deviation of the staging platform and the distance of the head of the separated instrument from the elbow of the canal. ANOVA test showed no statistically significant differences among groups regarding length of the separated segment, the angle of curvature and the distance of the head of the separated instrument from the elbow of the canal (Table 1).

Discussion

This study used a standardized technique and also attempted to keep the differences among groups to a minimum. The absence of any statistically significant differences among groups regarding different parameters studied (Table 1) showed that the differences between groups were kept to a minimum. Use of the radiographic jig allowed us to take radiographs from the same angle showing the maximum curvature of the root canal. In this study, a size 6 ProFile was separated in the canals because in a recent clinical report this instrument size was commonly found to fracture in the mesiobuccal canals of molars (17). The higher incidence of separation of this instrument may be a result of its decreased resistance to cyclic fatigue, as it has been shown that as the instrument size increases there is a corresponding decrease in its resistance to cyclic fatigue (18). Both LightSpeed rotary instruments and GG drills were used to enlarge the staging platforms to a #90 ISO size. However, the last incrementally cut ProFiles had an estimated diameter of 0.825 mm, because cutting the tip more than 6 mm made it too stiff for further instrumentation. The study also describes a new and predictable methodology to objectively evaluate preparation of staging platforms by different instrumentation techniques.

Pearson's correlation analysis of the grouped data showed that deviation of the staging platform was directly related to an increase in the distance of the separated instrument from the elbow of the canal. Therefore, the greater the distance of the separated instrument from the elbow of the canal, the more difficult it will be to make a staging platform to retrieve it.

The preparation of a staging platform is essentially shaping and enlarging the canal to the separated instrument rather than to the apical constriction. Therefore, principles related to instrumentation of root canals can also be applied to preparation of staging platforms. The results of this study show that preparation of staging platforms is best accomplished with the use of modified LightSpeed files. The shaft of the Lightspeed file is nontapered, smooth, and of a smaller diameter than the cutting segment, resulting in a more flexible instrument. Thompson and Dummer (19) described a mean transportation of 0.06 mm using LightSpeed rotary files, which is much lower than 0.31 mm obtained in our study. The difference is because we removed the noncutting tips of the LightSpeed instruments and enlarged the canals to much larger sizes.

The staging platforms prepared in this study failed to completely encircle the heads of separated instruments. In the LightSpeed group, which showed the least deviation of the staging platform, the diameter of the head of the separated instrument was approximately 0.50 mm because .04 ProFiles were separated at a mean distance of 3.51 mm from their tips. The staging platform had a diameter of 0.90 mm and with a deviation of 0.31 mm it failed to expose the distal margin of the separated instrument. One might argue that canals could have been enlarged to smaller sizes. However, it has been recommended that SPs should be prepared to a size #3 or #4 GG (13). On the other hand, if canals are not opened sufficiently then visualization through a microscope becomes difficult. The best visualization was offered by the incrementally cut ProFiles because of highly tapered preparations.

It should be remembered that root canal perforations could occur during attempts to remove separated instruments (5, 20). The apical third of the canals are more prone to this procedural error when deviation or transportation takes place. In one sample of GG drills and two samples of incrementally cut ProFiles root perforations were encountered. The reasons for a small number of perforations in our samples could be a result of the fact that we worked in a controlled environment

on extracted teeth and also because we enlarged canals to a green .04 ProFile before separating the instrument. Instruments can be removed from the apical third of the curved canals as long as they can be visualized through a microscope (21). Because in most of our cases the staging platforms deviated to the extent that they failed to completely encircle the separated instruments, we do not recommend that staging platforms be prepared so deeply in the apical one-third of curved canals. Until further evidence becomes available, it is recommended that instruments separated in the apical one-third of curved canals should be left alone as attempts to remove or bypass them may lead to root perforation (4). If further treatment is required, apical surgery, intentional replantation, or extraction should be considered.

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