Shaping Abilities of Two Different Engine-Driven Rotary Nickel Titanium Systems or Stainless Steel Balanced-Force Technique in Mandibular Molars

Michael J. Matwychuk, DMD, MS, Walter R. Bowles, DDS, MS,* Scott B. McClanahan, DDS, MS,* Jim S. Hodges, PhD,† and Igor J. Pesun, MS, DDS‡*

Abstract

The purpose of this study was to compare apical transportation, working-length changes, and instrumentation time by using nickel-titanium (Ni-Ti) rotary file systems (crown-down method) or stainless steel hand files (balanced-force technique) in mesiobuccal canals of extracted mandibular molars. The curvature of each canal was determined and teeth placed into three equivalent groups. Group 1 was instrumented with Sequence (Brasseler USA, Savannah, GA) rotary files, group 2 with Liberator (Miltex Inc, York, PA) rotary files, and group 3 with Flex-R (Union Broach, New York, NY) files. Pre- and postoperative radiographs were superimposed to measure loss of working length and apical transportation as shown by changes in radius of curvature and the long-axis canal angle. Sequence rotary files, Liberator rotary files, and Flex-R hand files had similar effects on apical canal transportation and changes in working length, with no significant differences detected among the 3 groups. Hand instrumentation times were longer than with either Ni-Ti rotary group, whereas the rotary NiTi groups had a higher incidence of fracture. *(J Endod 2007;33:868–871)*

Key Words

Apical transportation, balanced-force technique, rotary instrumentation

From the *Division of Endodontics, University of Minnesota School of Dentistry, Minneapolis, MN; †Biostatistics/Developmental and Surgical Sciences, University of Minnesota, Minneapolis, MN; and ‡Department of Restorative Dentistry, Division of Prosthodontics, Faculty of Dentistry, University of Manitoba, Winnipeg, MB Canada.

Address requests for reprints to Dr. Walter Bowles, 8–166 Moos Tower, 515 Delaware St. S.E., Minneapolis, MN 55455. E-mail address: bowle001@umn.edu.

0099-2399/$0 - see front matter

doi:10.1016/j.joen.2007.03.005

Root canal therapy involves the use of instruments and irrigants to shape and chemomechanically prepare the root canal system to receive a three-dimensional filling of the entire root canal space (1, 2). The goal of instrumentation is to produce a continuously tapered preparation that maintains canal anatomy, keeping the foramen as small as possible (1, 3).

Historically, root canal instrumentation has involved the use of stainless steel hand files. Stainless steel files, however, increase in stiffness with larger instrument size. Use of stiffer instruments within curved canals generates high lateral forces, resulting in aberrations, such as canal transportation (4). Because the thickness of the root dentin in the furcation area may be only 1.2 to 1.3 mm, transportation of the canal towards the furcation can result in perforation of the root (5).

With the advent of superelastic nickel-titanium (NiTi) instruments, achieving a correct canal shape, even in curved canals, is thought to be more predictable. When comparisons have been made to instrumentation using stainless steel hand files, NiTi rotary files have been shown to be faster (6–10). They have also been shown to reduce apical extrusion of debris (11, 12), to better maintain the original canal curvature (13), and to provide better taper (14) and canal shape (15).

Hand instrumentation with stainless steel instruments remains a benchmark to which many new file systems are compared. Instrumentation using the balanced-force technique (16) has been shown to reduce apical transportation (17–19) and result in a cleaner (20), more round apical preparation (17) compared with other hand instrumentation techniques.

Sequence (Brasseler USA, Savannah, GA) and Liberator (Miltex Inc, York, PA) NiTi file systems are two recently introduced rotary nickel-titanium instruments. Interestingly, both Sequence and Liberator rotary files lack radial lands, which have been credited with reducing both transportation and working-length changes in other rotary file systems. Few studies to date have evaluated Sequence and Liberator rotary files for instrumentation effectiveness. The purpose of this study was to compare apical transportation, working-length changes, and instrumentation time by using Sequence (rotary), Liberator (rotary), and Flex-R (Union Broach, New York, NY) files (hand instrumentation) in mesial roots of extracted mandibular molars.

Materials and Methods

A Plexiglas jig was designed to hold the teeth based on the technique by Iqbal et al. (21). Three clear plastic boxes (Craft Organizer; Darice Inc, Strongsville, OH) snapped on top of each other were secured to a Plexiglas platform. The lowermost box was glued to a protractor that formed the turntable. A hole was drilled into the upper-most box, and each extracted tooth was secured with clear orthodontic cold-cured acrylic. The X-ray tube was fastened in Plexiglas arches so that it remained stationary and could be accurately positioned during the experiment. The sensor of a digital radiographic unit (Suni Medical Imaging Inc, San Jose, CA) was secured to the Plexiglas wall located behind the turntable. A segment of orthodontic wire was bent in an "L" shape and glued to the Plexiglas wall facing the digital sensor. The wire was used to simulate a Cartesian system for accurately superimposing the pre- and post instrumentation radiographs and as a reference to calibrate length measurements on radiographic images.

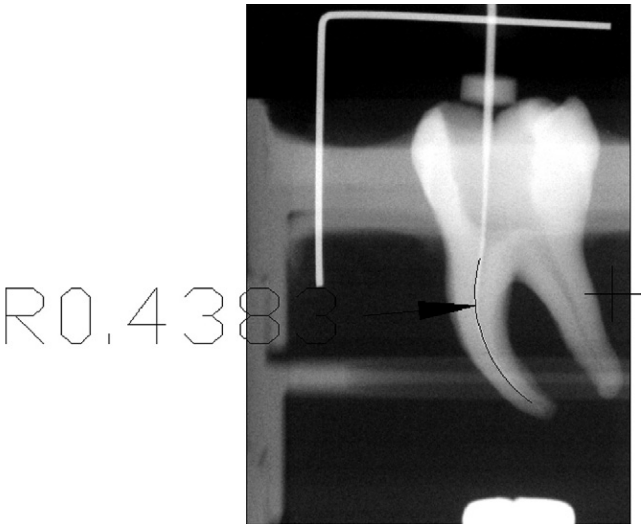

Figure 1. Technique for determining radius of canal curvature (Iqbal et al [21]).

Seventy mesiobuccal canals of extracted mandibular molars with varying root curvatures were used in this study. Teeth were included in the study if they had complete root formation and excluded if double curvatures of the canals were detected radiographically. After mounting the teeth in the clear plastic jig, an endodontic access cavity was prepared. Apical preparation was performed by using stainless steel 0.02 taper #15 and #20 Flex-O K-files to the working length. A 0.02 taper #20 NiTi hand file was placed in the mesiobuccal canal to working length, and a series of radiographs were taken. The box was incrementally rotated on the turntable until the curved file in the root canal appeared straight on the radiograph (20). The box was then rotated 90° to reveal the maximum curvature of the canal. The degree at which the maximum curvature was perpendicular to the X-ray beam was recorded, and all subsequent radiographs of the sample were taken at the same setting.

The radius of curvature for each canal was calculated on initial radiographs by using AutoCAD 2005 (Autodesk Inc, San Rafael, CA) to measure a line of best fit on the inner edge of the file (Fig. 1). Teeth were stratified into 8 groups based on radius of curvature and then divided into 3 groups in such a manner that the average curvature of root canals in the three groups was as close as possible (20). Straight-line access was obtained with Gates Glidden drills on all teeth before instrumentation. The time for canal preparation was recorded after achieving straight-line access.

Group 1 consisted of 24 teeth, which were instrumented with Sequence .04 taper rotary files according to the manufacturer's recommended sequence of instrumentation. Crown-down instrumentation was followed by apical enlargement until a #35/.04 preparation was achieved at the desired working length.

Group 2 consisted of 25 teeth, which were instrumented by using Liberator rotary files following the manufacturer's recommendation for preparation of small canals. The final apical preparation size was #35/.04; the desired working length was achieved by using a combination of .02 and .04 taper rotary files.

Group 3 consisted of 21 teeth, which were instrumented by hand. Teeth were prepared by using a modification of the balanced-force technique suggested by Hata et al. (22). Flex-R 0.02 taper files were used to achieve a size #35 apical preparation.

Instruments in all three groups were discarded after one use. The number of fractured and permanently deformed instruments during enlargement was recorded.

After instrumentation, a #35 NiTi file was placed to working length in each canal, and a digital radiograph was made with the canal in the same orientation as the preinstrumentation canal.

Software for Analysis

Pre- and postinstrumentation digital radiographs were downloaded in JPEG format from the Suni digital radiographic system (Suni Medical Imaging Inc, San Jose, CA) and imported into Adobe Photoshop (Adobe Systems Inc, San Jose, CA). The images were then passed through filters to obtain better contrast for superimposition. Pre instrumentation images were inverted to negative, so the file would appear black compared with noninverted postinstrumentation images. AutoCAD 2005 was used on postinstrumentation images to calculate the radius of curvature in the same manner as before instrumentation.

Digital images of pre- and postoperative radiographs were superimposed by using Idrisi 2.0 software (Clark Labs, Worcester, MA). A Cartesian plane created by the orthodontic wire defined four distinct and unchangeable points and a unique mathematical coordinate (x, y) for each of the points on the radiographic images (23) (Fig. 2).

NIH Image J software (National Institutes of Health, Bethesda, MD) was used to evaluate instrumentation effects on working length and canal angulation changes. The long-axis technique of canal angle measurement as described by Hankins and ElDeeb (24) was used. Working length changes were measured in the same software after the program was calibrated to the known width of the orthodontic wire on the image.

A one-way analysis of variance was used to evaluate instrumentation times and change in canal curvature or working length changes. After a significant F test, we used the Tukey-Kramer post hoc test to determine which pairs of groups differed.

Figure 2. Pre- and post-instrumentation radiographic images superimposed with Idrisi software (Clark Labs, Worcester, MA).