Research Article

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Comparative Assessment of The Fracture Resistance of Teeth Instrumented by Two Different Nickel Titanium Rotary Systems

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ABSTRACT

Aim: *This study aimed to compare the fracture resistance exhibited by roots on instrumentation using two endodontic rotary systems: SANI S3 and EdgeEndo X7 rotary file systems.*

Materials and Methods: *Sixty recently extracted human mandibular premolars comprising single root canals were selected in this study. All specimens were decoronated and mounted perpendicularly in self-cure acrylic resin blocks exposing 6 mm of the roots out of the acrylic resin blocks. The specimens were divided into two experimental groups, according to NiTi rotary systems used and one control group (n = 20). After instrumentation, the specimens of both experimental groups were then filled using master Gutta-percha cones size 35 (0.04 taper) and obturation was done using continuous wave compaction technique. The specimens were kept at 37 °C and 100% humidity for 2 weeks to allow complete setting of the sealer. Root fracture resistance was assessed using a universal testing machine (Instron) and the amount of load necessary for root fracture was recorded in Newtons (N).*

Statistics: *Data were collected, tabulated and statistically analyzed using one-way ANOVA test and Tukey's post-hoc test.*

Results: *Group C (control) exhibited the highest mean fracture force (357.13 ± 20.61) while group A (SANI S3) showed the lowest mean fracture force (192.60 ± 22.73). One-way ANOVA test showed statistically significant differences between tested groups. Regarding inter-group comparisons using Tukey's test, there was a significant statistical difference between groups (A and B) and between groups (A and C). Furthermore, there was a statistically significant difference between groups (B and C). (P<0.05)*

Conclusion: *1-Root canal instrumentation with NiTi rotary files possessed a negative impact on roots and higher risks of root fractures compared to intact unprepared roots.*
2-Design of NiTi files with improved cutting efficiency could diminish the risk of crack formation in root canal dentinal walls.

Keywords
EdgeEndo, Fracture resistance, NiTi, rotary instruments, SANI.

Introduction
Mechanical preparation of root canal systems to facilitate disinfection is considered a necessary step in endodontic treatment. The introduction of nickel titanium (NiTi) endodontic rotary instruments with their wide range of various properties have gone through a major change in root canal instrumentation. The majority of clinicians prefer to choose nickel-titanium (NiTi) rotary file systems because they offer several advantages such as shortening the treatment period and greater cutting efficiency [1].

However, motorized nickel-titanium (NiTi) files possess an effect on integrity and strength of root canal dentin [2,3]. In addition, an excessive taper results in more removal of dentine reducing the fracture strength [4]. Another element directly related to the fracture resistance is the creation of microcracks in radicular dentine. All the currently used rotary and reciprocating files create microcracks ranging from 18% to 60% in the roots instrumented [5].

SANI S3 rotary system (Chendgu Sani medical equipment Co., Ltd.; Sichuan, China) is a nickel titanium rotary system claimed by the manufacturer to have unique features such as super flexibility, simplicity and smart design. The manufacturer also claims that this system offers high auto-adaptation to the root canal walls to keep the natural form of the root canal and offers a safety design that could prevent dentin overcutting [6].

EdgeEndo X7 rotary system is made of an Annealed Heat Treated (AHT) nickel-titanium alloy manufactured using FireWire technology (EdgeEndo; Albuquerque, New Mexico, USA). All files included in that system are constant tapered with variable pitch. The manufacturer claims that the system possesses superior strength and elite flexibility [7].

The present study aimed to compare the fracture resistance exhibited by roots on instrumentation using two endodontic rotary systems: SANI S3 and EdgeEndo X7 rotary file systems.

Materials and Methods

Specimen Selection

The methodology of the present study was reviewed by the local ethical committee and the study was conducted. Sixty recently extracted crack and caries-free human mandibular premolars comprising single root canals with fully formed apices were acquired. The roots with standardized dimensions and weights were selected to ensure homogeneity [8].

Periapical radiographs were taken by exposing both mesiodistal and buccolingual sides to ensure that the selected teeth had a single root with a mature apex. Teeth were stored in saline solution at room temperature till the time of testing. All teeth were decoronated by sectioning at the cementoenamel junction using a diamond-coated bur under continuous water-cooling to obtain root segments with a standard root canal length of 14 mm determined by inserting a size 15 K-file till the tip is visible in the apical foramen and withdrawn by 0.5 mm (Figure 1).

A glide path was prepared manually using size 15 k-type file. All NiTi rotary files were used with a torque-controlled endodontic motor (X-Smart; Dentsply Maillefer) and each instrument was strictly used in five canals only.

Specimen Mounting

To simulate the periodontal attachment, the specimen's root surface was coated with a thin layer of polyvinylsiloxane (PVS) impression material and all specimens were mounted perpendicularly in self-cure acrylic resin blocks exposing 6 mm of the roots out of the acrylic resin blocks.

Figure 1: Photograph showing decoronated specimens.

Specimen Grouping

The specimens were divided into two experimental groups, according to NiTi rotary systems used, and one control group (n = 20).

Group A (SANI S3 system): The specimens in this group were instrumented using SANI rotary files with a preprogrammed X-Smart endodontic micromotor (Dentsply Maillefer) at 400 Rpm speed and 2 Ncm torque. The coronal third was preflared using SU, followed by sequential files till working length (WL); 1S (#20/0.04), 2S (#25/0.06) and 3S (#35/0.04).

Group B (EdgeEndo X7 system): The specimens in this group were instrumented using Edge Endo files with a preprogrammed X-smart endodontic micromotor at 400 Rpm speed and 2 Ncm torque. From the various sequences of files included in this system, files used in this study were selected in the following sequence: The coronal third was preflared with file #17 followed by files (#20/0.04), file (#25/0.06) and file (#35/0.04).

Group C (control): The specimens in this group remained untreated, and no instrumentation or filling was performed.

Before introducing each file, the root canal was irrigated with 5% NaOCl (JK dental, Egypt), and the canal was recapitulated. EDTA cream (T-EDTA cream, Nexobio, Korea) was used as a lubricant for all files with every insertion and reinsertion.

After instrumentation, a final flush was applied using 5 mL of 17% aqueous EDTA (Calix-E-EDTA solution, DHARMA, USA) for 1 min for removal of the organic portion of the smear layer and 5 mL of 5% NaOCl for 1 min followed by the final rinse with 5 mL of distilled water. The canals were then dried with sterile paper points. The specimens were then filled using size 35 master gutta-percha cones (0.04 taper) and the apical fit was confirmed using digital radiography.

Obturation was done using continuous wave compaction technique with EQ Plus system (Metabiomed Co., LTD, Korea). Guttapercha pellet (Metabiomed Co., LTD, Korea) was inserted into the gutta-percha slot of the corded obturation gun by pulling out the plunger and adjusting the temperature at 200°C. The master gutta-percha cone (size #35/0.04 taper) that matched with the prepared root canal was coated with CeraSeal root canal sealer ((Metabiomed Co., LTD, Korea) and inserted into the canal. The excess gutta-percha was cut by a heated obturating pen tip. The heated pen tip with gutta-percha was inserted to 4 mm short of the working length. The warmed gutta- percha was compacted with a hand plugger (Dentsply Maillefer, Switzerland). The rest of the canal was filled with the obturating gun and compacted with a larger plugger.

After completing obturation, periapical radiographs of all specimens were taken to assess the quality of root filling. Any root with inadequate obturation was excluded and replaced with a newly prepared specimen. The access cavity was closed using temporary filling (3M™ Cavit™). The specimens were kept at 37°C and 100% humidity for 2 weeks.

Root fracture resistance was assessed using a universal testing machine (Instron). All of the specimens were placed on the lower plate of the testing machine while the upper part included a metal instrument with a rounded tip that is 4 mm in diameter. The tip was oriented in the center of the canal orifice and force was applied vertically to the long axis of the root at a crosshead speed of 0.5 mm/min until root fracture (Figure 2). The amount of load necessary for root fracture was recorded in Newtons (N). A curve showing failure was plotted using the machine's testing software (Bluehill LE, Norwood, MA, USA) on a computer connected to the testing machine.

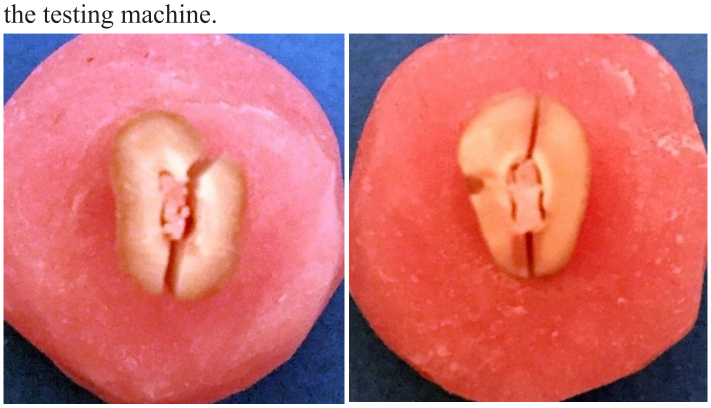

Figure 2: Photographs showing tested specimens after fracture.

Statistical Analysis

Data analysis was done using the Statistical Package for the Social Sciences software (IBM SPSS statistics for windows, Version 19.0. Armonk, NY, IBM Corp.). Data analysis was one-way variance analysis (ANOVA) as data were normally distributed by the Shapiro Wilk test. Furthermore, Tukey's post hoc test was used for the pair-wise comparison between groups.

Results

The mean force required to fracture root specimens of group C (control) was 357.13 ± 20.61, group B (Edge Endo group) was 259.10 ± 20.45, and group A (SANI S3 group) was 192.60 ± 22.73. Group C (control) exhibited the highest mean fracture force (357.13 ± 20.61) while group A (SANI S3) showed the lowest mean fracture force (192.60 ± 22.73).

One-way ANOVA test showed statistically significant differences between tested groups. Regarding inter-group comparisons using Tukey's test, there was a significant statistical difference between groups (A and B) and between groups (A and C). Furthermore, there was a statistically significant difference between groups (B and C). ($P<0.05$) (Table 1) (Figure 3) (Figure 4).

Table 1: Means of force (measured in Newton) required for root fracture among groups.

Group	Mean ± SD	Min	Max
Group A	192.60 ± 22.73	143.81	226.91
Group B	259.10 ± 20.45	226.77	290.37
Group C	357.13 ± 20.61	313.25	388.19

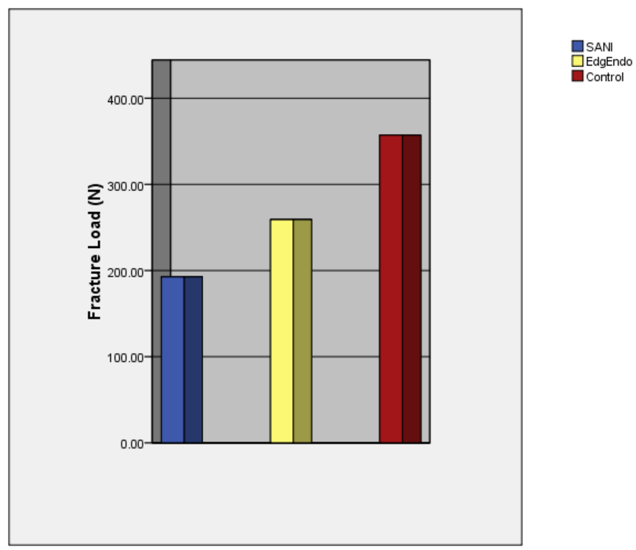

Figure 3: Bar chart showing the mean forces required to fracture the root specimens of different groups.

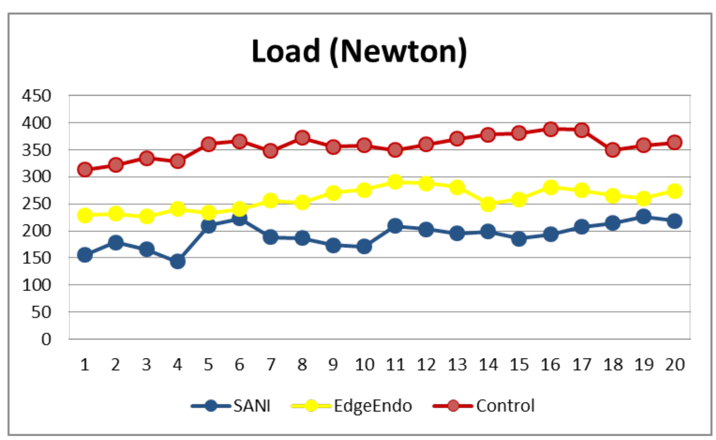

Figure 4: Line chart representation of pattern of load distribution in experimental groups and control group.

Discussion

Satisfactory endodontic outcomes are believed to depend on efficient chemo-mechanical root canal preparation. However, this procedure possesses a risk of root fracture [9,10]. The continuous contact between the endodontic cutting instrument and dentin walls during preparation creates many instant stresses in dentin surfaces which might elevate the risk of root fractures [10-12]. Moreover, mechanical instrumentation of the root canal system using NiTi instruments may result in the development of microcracks in root canal dentinal walls [13].

Standardization of the specimens during mechanical tests is considered a crucial factor in fracture resistance evaluation [14]. Therefore, similar teeth were selected and root lengths during decoronation were equalized. In this study, mandibular premolars were used because they are probably prone to be influenced by forces during root canal instrumentation as a result of their smaller dimensions and thin dentinal walls. If rotary files fail to induce cracks in mandibular premolar teeth, it is unlikely that they will induce cracks in other teeth [15].

Two different brands of NiTi rotary systems (SANI S3 and Edge Endo) with comparable sizes were selected for this study. SANI S3 rotary system was chosen in this study based on the search for affordably priced files having good properties. As claimed by the manufacturer, this system is characterized by its super flexibility and pre-bending properties. EdgeEndo rotary system is made of heat-treated nickel-titanium alloy (Fire-Wire). The manufacturer claims that their files can be used in place of some other competitors offering similar properties at half the cost [7]. To standardize the experimental design, all files used in this study were selected featuring similar taper and rotated at the same speed (400 Rpm) and torque (2 Ncm).

Group C (control) showed the highest statistically significant fracture resistance value. This confidently explains and confirms the negative impact of root canal instrumentation procedure using NiTi files on fracture resistance of root canals compared to intact unprepared roots. Group B showed a higher statistically significant fracture resistance value in comparison to the other experimental group. This might be attributed to the parabolic design that is in charge of minimal pressure on the lateral wall of canals [16]. Also, this parabolic design maximizes the cutting efficiency of this file system. This improved cutting efficiency could result in less dentin crack formation [17]. This is in acceptance with Kim et al. who reported a potential relationship between the design of NiTi instruments and the incidence of vertical root fractures [18].

Conclusions

1. Root canal instrumentation with NiTi rotary files possessed a negative impact on roots and higher risks of root fractures compared to intact unprepared roots.
2. Design of NiTi files with improved cutting efficiency could diminish the risk of crack formation in root canal dentinal walls.

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