International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: 6.614
Available Online at www.journalijcar.org
Volume 9; Issue 02 (B); February 2020; Page No.21237-21239
DOI: http://dx.doi.org/10.24327/ijcar.2020.21239.4168

Research Article

EFFECT OF ROOT CANAL INSTRUMENTATION OF DIFFERENT SIZES ON FRACTURE RESISTANCE OF ROOTS IN MANDIBULAR PREMOLARS

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A R T I C L E I N F O

Article History:
Received 06th November, 2019
Received in revised form 14th December, 2019
Accepted 23rd January, 2020
Published online 28th February, 2020

Key words:

Fracture resistance, premolar, Taper, MAF

A B S T R A C T

Objective: To measure the fracture resistance of mandibular premolar roots following root canal instrumentation with different sizes.
Methods: A total of 60 human permanent mandibular premolars with a straight single canal were decoronated and assigned to 6 groups (n=6). In the control group, the roots were unistrumented, whereas roots in 5 experimental groups were instrumented to different master apical files (MAF) and tapers (MAF/ taper): 40/0.10, 45/0.10, 45/0.15 50/ 0.05, 55/0.05 .All roots were subjected to vertical loading until fracture.
Results: Fracture load values for instrumented roots were lower than the intact roots of the control group. In 50/0.05, 55/0.05 the fracture load values were significantly lower than the fracture load value for the control group ($p<0.05$) with a 30% decrease. No significant difference in the fracture modes were detected among the 6 groups ($p>0.05$)
Conclusion: Mechanical instrumentation adversely affects the fracture resistance of roots. When the roots of mandibular premolars were instrumented to a MAF equal to or larger than 50 with a taper of 0.05 or to a MAF of 45 with a taper of 0.15, the fracture load values suddenly decreased.

INTRODUCTION

The mechanical instrumentation of the root canal is a primary procedure in the root canal treatment. Compared with conservative instrumentation which cannot produce satisfactory cleaning and shaping, larger instrumentation can contribute to removing infected tissue, achieving appropriate penetration of irrigants, and creating space for the delivery of medications and subsequent obturation materials. However aggressive instrumentation may weaken tooth structure and increase the risk of perforation, ledge and transportation of canal. Rotary instrumentation has been associated with more cracks compared with hand instrumentation[i,ii]. At present, little is known about optimal instrumentation sizes and how instrumentation affects root fractures. These cracks can gradually degenerate into VRFs[iii]. Advances in nickel-titanium (NiTi) rotary instruments have led to the introduction of canal instrumentation systems with different file designs, metallurgical alloys, and rotational motions. Despite having several advantages compared with the traditional hand instruments, these files are associated with high stress generation within the root canals[i,iv]. Different NiTi instrument designs are associated with different levels of stress and resistance of roots to fractures[v,vi].

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Increase canal taper advocated by various greater taper rotary nickel-titanium instruments has allowed different canal shapes and sizes to be achieved. Most of the new systems incorporate instruments with a taper greater than the ISO standard 0.02 taper design and little is known about the influence of instrument taper on the fracture strength of tooth roots. The purpose of this study was to fracture resistance of premolars with different final canal instrumentation size.

MATERIALS AND METHODS

Selection of Teeth

60 straight, single- rooted mandibular premolars with mature root apices and single canal extracted on periodontal or orthodontic grounds were used. Teeth with gross caries involving the root, cracks on the root surface and for exceptionally short and thin roots were excluded. All teeth were stored in 10% neutral buffered formalin for at least 2 weeks and then in distilled water until they were tested. The teeth were thoroughly cleaned with an ultrasonic scaler. Teeth were randomly divided into six groups of 10 teeth in each group.

Instrumentation

Each tooth was decoronated 2mm coronal to the cemento-enamel junction (CEJ) with a diamond disc to facilitate straight line access for instrumentation and obturation. Proper access was established and the apical patency was determined by inserting an ISO # 08 K-file until it appeared at the apical foramen. Working length was determined by placing a size 10 K-file into the canal until it appeared at the apical foramen; this length was measured and the working length was set 0.5mm short of this distance. The flat surface 2mm above the CEJ was used as the reference point.

The tooth were randomly assigned to six groups (n=6). The roots assigned in the control group were uninstrumented, whereas the roots in the 5 groups were instrumented to different master apical file (MAF) and different master apical tapers (MAF/ Taper) as follows: 40/0.10, 45/0.10, 45/0.15,50/0.05, 55/0.05. canal prepration was performed using hand K- files (M-acess, Densply Maillifer, Ballaigues, Switzerland) according to step back technique. Distilled water was used as an irrigant between each instrument. When instrumentation was completed; all samples were examined using a stereomicroscope at 15x magnification. No cracks or craze lines were found.

Fracture Resistance Testing

All roots were imbedded in acrylic resin with a 2mm of coronal exposure. The roots were subjected to vertical loading using a universal testing machine. (Instron) with a cross head speed of 0.5 mm/min. the occurance of fracture was determined when the applied load suddenly decreased. The fracture load values were recorded in Newtons (N) at the peak of load displacement curve. For most specimens an auidible crack was also heard.

Statistical analysis: The one way analysis of Varaiance (ANOVA) and the Tukey post hoc test were used to compare the fracture load values. The statistical significance level was set at =0.05.

Table 1 Fracture load values (N) of roots with different instrumentation sizes and reduction in comparision with control group (%)

Instrumentation size(MAF/Taper)	Fracture load(N)	Reduction(%)
Unistrumented	1442 ± 130^{a}	0
40/0.10	$1190 \pm 332^{a,b,c,d}$	13.2
45/0.10	$1120 \pm 281^{a,b,c}$	18.2
45/0.05	$1260 \pm 130^{b,c,d}$	10.6
50/0.05	$1004 \pm 123^{b,c,d}$	30.1
55/0.05	$940 \pm 130^{c,d}$	31.4

$^{a\text{-}d}$Means with the same superscript letter did not differ significantly($p>0.05$)

RESULTS

The statistical analysis of root weights revealed no significant difference among the groups ($p>0.05$).The fracture load values were lower for roots after instrumentation than for the intact ones in the control group. In the 45/0.15,50/0.05,55/0.05 MAF/taper groups, the fracture load values were significantly lower than those of the control group, with a decrease of approximately 30% ($p<0.05$). The fracture load values for the control group and the 40/0.01,45/0.01, 45/0.05 groups did not differ significantly ($p>0.05$) .The reduction was between 7.3% and 18.3%.

DISCUSSION

There increasing acceptance of rotary instrumentation as a technique for cleaning and shaping of the root canal space. Due to this it is important to examine the effect of specific tapers imparted by rotary instrumentation of the root canal as it relates to VRF. Zandbiglari *et al*[vii] also found that greater tapered instruments removed more root dentin and as a result these teeth were susceptible to fracture than those with hand instruments. In the present study, freshly extracted mandibular premolars with a straight round canal were selected, and the length standardized. Distilled water was used as irrigant, thereby avoiding the effect of NaOCl on the properties of dentine[viii].

In the present study, the linear compressive (static) loading was used to test the fracture resistance of the root. It is a frequently applied method due to its efficiency and complarable outcome parameters.

In the present study, all roots were vertically embedded in acrylic resin without simulation of periodontal ligament. The studies by Soares et al.[ix] and Marchionatti et al[x] suggested that fracture resistance under static loading would not be affected by simulation of periodontal ligament.

The results of this study indicate that mechanical instrumentation adversely affects the fracture resistance of roots. In the present study, the force required to fracture premolars when instrumented to 45/0.15,50/0.05, 55/0.05 was 30% lower than that of their intact counterparts. Prado et al[xi] , observed that fracture resistance of premolars decreased by 43.7% even after instrumentation to only 45/0.02.

Mechanical instrumentation and irrigation are sound endodontic principles and essential components of successful endodontics. The penetration of irrigants to the apical third of canals and the removal of debris are dependent on the final size of the instruments that are used. With respect to proper instrumentation size, the use of a MAF three sizes larger than the initial apical file (IAF) has been recommended. However, the size of the IAF tends to be relatively small, potentially resulting in inadequate cleaning. It has been suggested that for satisfactory cleaning of mandibular premolars the single canal should be instrumented to at least 40- 70 with no recommended taper.

In present study, the force required to fracture a root, significantly decreased after the roots of mandibular premolars were instrumented to 50 or larger with a relatively small taper (0.05).

In the present study, the force required to fracture a root, significantly decreased when roots of mandibular premolars were instrumented to a taper of 0.15 regardless of whether the MAF was 40 or 45. In the present study, we observed that an instrumentation size above 45/0.10 could cause the change of fracture resistance of the premolars.

Fracture load values of the mandibular premolars decreased as the apical diameter from 40 to 55 and taper from 0.05 to 0.15 increased. This decrease may be partially explained by the loss of root structure.

Wilcox et al[xii] showed that the fracture susceptibility of roots was directly related with the dentine wall thickness. The effects related to stress distribution may also contribute to changes in the fracture load values. The fractures predominantly occurred in the buccolingual direction even though dentine is typically thicker in this direction than in the mesiodistal direction. Lertchhirakarn et al[xiii] suggested that this

phenomenon might be attributed to the concentration of tensile stress on the inner surface of the buccolingual canal wall.
To conclude, this study observed the effect of root canal prepration size on the root fracture resistance, and provided reference for clinical selection of prepration sizes and tapers for mandibular premolars. The present work showed that the fracture load values were significantly reduced when the roots of mandibular premolars were instrumented to an apical size equal to or larger than 50 with a taper of 0.05 or to an apical size of 40 or 45 with taper of 0.15. when clinical practitioners determine the root canal prepration size, the potential weakening effect of large instrumentation size should be taken into consideration.

The appropriate prepration size for teeth of different types with various anatomical characteristics is still subject to further study.

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