ORIGINAL ARTICLE

Evaluation of effect of root canal preparation techniques on inducing root fractures: An in vitro study

Asit Vats[1], Ashwitha Punja[2], Priyadarshini Hegde[2], Mithra N Hegde[2], Rhythm Bains[1], Kapil Loomba[1]

ABSTRACT

This study was done to evaluate the effect of two different root canal preparation techniques on inducing root fractures. Twenty four freshly extracted non-carious human mandibular incisors were randomly assigned to 3 groups of 8 teeth each. In the first group no canal was prepared and served as the control group. In the second group the canals were prepared using only hand instruments while in the third group canal preparation was done using both hand and rotary instruments. The results among each group were compared and statistically analyzed. This study concludes that canal preparation techniques do play a role in the causation of vertical root fractures. However ,their results were not statistically significant when compared to each other.

Keywords: canal preparation techniques, vertical root fractures, stress concentration

INTRODUCTION

The teeth that have been endodontically treated although may have a long term high functional survival rate, yet they are generally more susceptible to fractures as compared to teeth with vital pulps. Thus, coronal and/or radicular tooth fractures continue to remain important reasons for post endodontic extractions[1]. Besides other factors stresses and the forces generated during instrumentation have been linked to an increase risk of root fractures. It was reported that the root canal preparation alone significantly weakened roots and may have created apical root cracks.[2] Thus canal preparation techniques play a vital role in affecting the root fractures. Canal preparation involves dentin removal and may compromise the fracture strength of the roots that could at any stage induce fractures whether complete or incomplete.[3] Advancement from usage of stainless steel to the latest rotary nickel-titanium over the last decade has led to new design concepts and techniques for canal preparation. The file design however, is also likely to affect the shaping forces on the root dentin. [4] With technological advancements, canal preparation techniques have evolved rapidly in the recent years.

The introduction of rotary nickel-titanium (Ni-Ti)instruments for canal preparation has changed the concept of canal shape, size, and taper as compared to hand instrumentation. It is also true that after preparation with hand files the canal shape can be quite irregular . With rotary Ni-Ti preparation, canal shapes are more likely to be rounder and smoother; canal irregularities are likely to be incorporated into the preparation and eliminated.[5]

This study hence been done to compare the effect of various preparation techniques on root fractures.

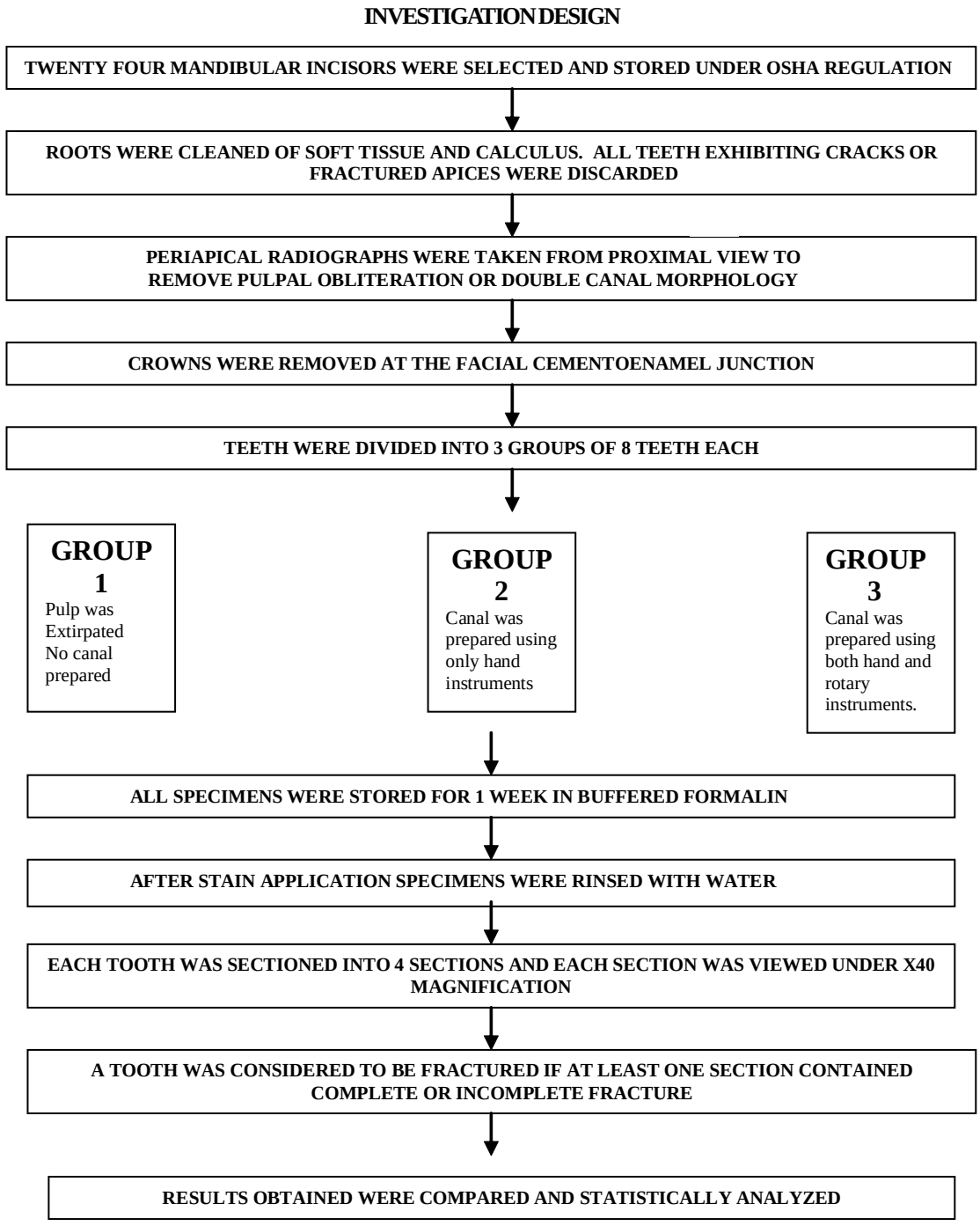
MATERIALS AND METHODS

Twenty four freshly extracted non carious human mandibular lateral incisors were collected. The roots were cleaned of soft tissue and calculus and all the teeth exhibiting cracks, fractured apices and curved roots were discarded. The selected teeth were stored and treated as per cross infection control protocols of OSHA (occupational safety and health administration). Periapical radiographs were taken from proximal view to further eliminate any teeth with pulpal obliteration or double canal morphology.

The teeth were randomly assigned into 3 groups of 8 teeth each .The crowns were removed at the cemento-enamel junction by sectioning, following standardised technique.

Group 1: After removal of the crown, access was obtained with a No.2 round bur in a high speed handpiece using air/ water spray. Pulp tissue was removed with a fine broach. No biomechanical preparation was done in this group. This served as control group.

Department of Conservative Dentisty & Endodontics, [1]Saraswati Dental College, Lucknow, [2]AB Shetty Memorial Institute of Dental Sciences, Manglore, India.
Address for Correspondence:
Dr Asit Vats, 2B,Ist Floor, Prakash Apartments, 44-A,Cantt. Road, Near Burlington Crossing,Lucknow-226001
Mobile: +919838601333
Date of Submission : 15-01-2011
Review Completed : 05-02-2011
Date of Acceptance : 08-02-2011



Group 2: The majority of the pulp tissue was removed as described in group 1.The initial length was determined by placing a no 15 file into the canal. The working length was set at 1 mm short of apex. Canals were prepared to a size of no 30 file. Apical flare was created with the next three larger file sizes stepped back in 1 mm increments. After instrumentation with each file size, the canal was irrigated with 5.25% sodium hypochlorite and recapitulated with a no 30 file.

Group 3: Pulp was extirpated as described in group 1. Root canal was prepared using both hand as well as rotary instrument in the following manner.

1. The hand files used were Malleifer-Dentsply and rotary files ProTaper NiTi rotary files (Dentsply).
2. Proper access and glide path with no 10 and no 15 stainless steel files to the working length was established.

3. The canal and chamber was flooded with sodium hypochlorite and shaping with the shaper S-1 using multiple, passive-pressure passes was done. The canal was then irrigated and recapitulated to no 10 hand file and patency to the full working length was established. Then the preparation was extended with S-1 to the full working length.
4. Shaper S-X was used to improve the straight –line access.
5. Shaping file S-2 was used to full working length. Irrigation, recapitulation and reirrigation was done.
6. Working length was confirmed and maintained with hand file.
7. The preparation was passively extended to within 0.5 mm of the working length with finisher F-1and withdrew after one sec. With the instrument in place, the exact length was verified radiographically before final irrigation.
8. If the F-1 and the no 20 hand files were loose, the preparation was continued with the finisher F-2 .Confirmed with no 25 hand instrument.
9. If the F-2 instrument and the no 25 hand file were loose, the preparation was continued just short of working length with the finisher F-3 file. When the no 30 hand instrument was found to be snug, the preparation was finished.
10. The usage of EDTA glyde (Dentsply) was done following the manufacturer's instructions at every stage.

The teeth were then stored for 1 week in 10% buffered formalin prior to staining. The teeth were subsequently stained with 5% oil red O stain. After stain application specimens were rinsed thoroughly with water. Each specimen was mounted in a resin block and later on sectioned into 4 sections and each section was examined under a microscope at X40 magnification (Polyvar -2) using a microscope attached with macro-magnifier.

Figure 1: Polyvar -2 Microscope

A tooth was considered to be fractured if at least one section contains a complete or incomplete fracture.

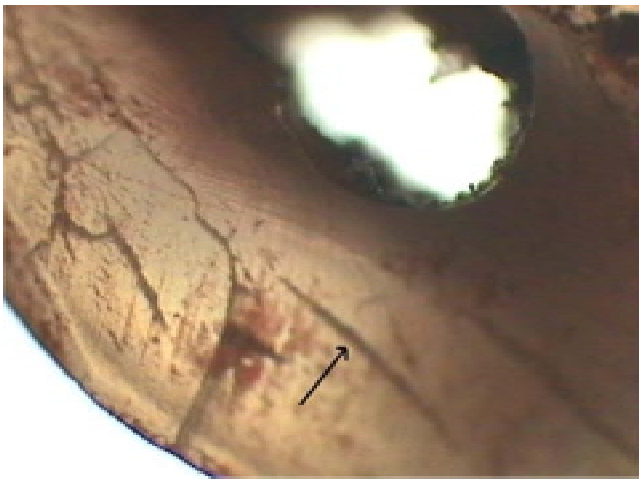


Figure 2: A root cross section illustrating incomplete root fractures occurring in dentin in prepared root canal. The arrow shows fracture line.

RESULTS

This study of incomplete root fractures associated with two different canal preparation techniques along with control group demonstrated both stained and unstained dentinal aberrations. The Figures 3&4 and Tables 1&2 clearly depict the details of the results of the present study and are self explanatory.

This study concludes that canal preparation techniques ,both hand group 2 and hand as well as rotary group 3 do play a role in the causation of vertical root fractures. Their results were not statistically significant when compared to each other.

Table1: Intergroup comparison for number of sections fractured

		GROUP			Total
		1	2	3	
Not Fractured	Count	30	28	29	87
	%	93.8%	87.5%	90.6%	90.6%
Fractured	Count	2	4	3	9
	%	6.3%	12.5%	9.4%	9.3%
Total	Count	32	32	32	96
	%	100.0%	100.0%	100.0%	

X2=0.736 p=0.692 ns

Table 2: Intergroup comparison for number of teeth fractured

		GROUP			
		1	2	3	Total
Not Fractured	Count	7	6	6	19
	%	87.5%	75.0%	75.0%	79.16%
Fractured	Count	1	2	2	5
	%	12.5%	25.0%	25.0%	20.8%
Total	Count	8	8	8	24
	%	100.0%	100.0%	100.0%	100.0%

· X2=0.505 p=0.777 ns

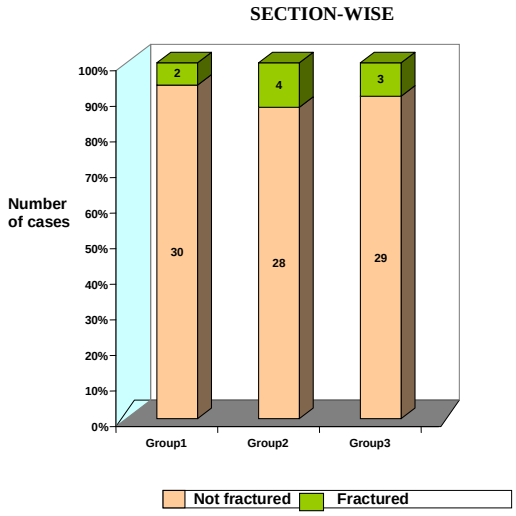


Figure 3

Figure 3: In -vitro comparison of root fractures associated with different preparation techniques

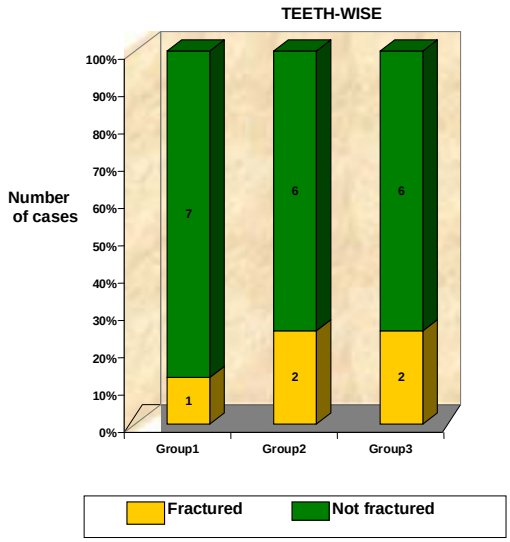


Figure 4

Figure 4: In -vitro comparison of root fractures associated with different preparation techniques

DISCUSSION

Although vertical root fracture (VRF) of endodontic origin is an infrequent event, it is still a major concern because of the consequent tooth loss. Factors that predispose a root to fractures have been extensively investigated and are yet considered debatable and inconclusive. Canal filling procedures or loading in relation to posts are most frequently considered as VRF risks, but VRF may also originate from stress concentrations arising from the final canal shape, the extent of canal enlargement, and irregularities or ''defects'' along canal surfaces induced during clinical procedures.[7] It is reported that canal preparation had created significant dentin defects such as fractures, craze lines, and incomplete cracks.[7]

Two factors might contribute to the development of VRF during the endodontic treatment: First, excessive canal shaping especially in teeth with curved roots or oval canals and second ,excessive removal of tooth structure while gaining access contribute to the overall weakening of the tooth, which promotes a higher incidence of VRF.[8]

During preparation, a canal is shaped by the contact between instrument and dentin walls. These contacts create many momentary stress concentrations in dentin. Such stress concentrations may leave dentinal defects in which VRF can initiate. Higher stresses in the root during instrumentation can be expected to increase dentinal defects and thus increase VRF risks.[6]

Overinstrumentation of root canals with excessive removal of dentin and the presence of noncircular canals and thin canal walls, particularly with certain tooth types, increase the risk for root fracture.[9] Clinical and experimental studies have shown that root fractures occur predominantly in a bucco-lingual direction. Dentin thickness in the bucco-lingual direction, particularly in mandibular incisors, that are more prone to fractures is often double than that of proximal dentin, yet fracture usually runs through this thick region.[10]

Several studies have been done to analyse root fractures using hand and rotary instruments .An in vitro fracture resistance study of 39 mandibular molars with mesiobuccal root canals prepared by using either stainless steel hand files (K-files; Mani Inc, Nakaakutsu, Japan) or 2 nickel-titanium rotary files (Lightspeed; Lightspeed Technology, Inc, San Antonio, TX; and Greater Taper; Tulsa Dental Products, Tulsa, OK) found that the greater apical enlargement achieved with Lightspeed files and the increased canal taper achieved with Greater Taper files did not significantly increase root fracture susceptibility compared with conventional step-back K-file preparations.[11]

However, in another study in which canals had been enlarged with SystemGT (Dentsply Maillefer, Ballaigues, Switzerland)

files, the roots were significantly weaker than those instrumented with either lower taper nickel titanium FlexMaster (VDW GmbH, Munich, Germany) rotary files or hand K-files.[12]

A recent study of 260 mandibular premolars compared the incidence of dentinal defects (craze lines and fractures) after canal preparation with different nickel-titanium rotary files. No defects were found in the unprepared root canals and those prepared with hand K-files and S ApeX (FKG, Dentaire, La Chaux-de-Fonds, Switzerland) rotary files, but ProTaper (Dentsply-Maillefer), ProFile (Dentsply-Maillefer), and SystemGT rotary file preparations resulted in craze lines and partial cracks in 16%, 8%, and 4% of teeth, respectively.[13]

The results obtained from these studies have thus often been inconclusive. In this study in group 1 with no canal preparation showed least incidence of root fractures which comprised of sectionwise 6.3% of total root fractures with only 1 tooth out of 8 being fractured. However group 2 with only hand instrumentation showed 12.5% of incomplete root fractures with only 2 tooth out of 8 was fractured.

Group 3 comprised of 9.4% of the fractures when rotary instruments were used along with hand instrumentation .these results are same as in group 2 where only hand instruments were used. Thus the results are in conformity with studies done by Zandbiglari T *et al.*[12] and Bier CA *et al.*[13]

The study clearly showed that rotary NiTi canal preparation did not reduce fracture susceptibility of the roots tested in the study.

Rotary instrumentation requires less time to prepare canals as compared with hand instrumentation but result in significantly more rotations of the instruments inside the canal. This may cause more friction between the files and the canal walls. No significant difference in the tooth fractures of hand and rotary NiTi canal preparations could be demonstrated.[13]

Attempts to reduce fracture susceptibility of the roots clinically are limited because many factors interact in influencing fracture susceptibility, and most of them are beyond the control of clinicians e.g. root shape, proximal concavity. The clinician can, however, reduce fracture susceptibility by maintaining the canal size as small as practical, and by striving for a smooth round canal without irregularities. In addition, clinicians can identify susceptible teeth before commencement of endodontic treatment, based on root size and taper.[5]

This study concludes that canal preparation techniques ,both hand (group 2) and hand as well as rotary (group 3) do play a role in the causation of vertical root fractures. However ,their results were not statistically significant when compared to each other.

REFERENCES

1. Hansen EK, Asmussen E, Christiansen NC. In vivo fractures of endodontically treated posterior teeth restored with amalgam. Endod Dent Traumatol 1990;6:49–55.
2. Adorno CG, Yoshioka T, Suda H. The effect of root preparation technique and instrumentation length on the development of apical root cracks. J Endod 2009;35: 389–92.
3. Wilcox LR, Rosekelly C, Sutton T. The relationship of root canal enlargement to finger spreader induced vertical root fracture. J Endod 1997;23(8):533-534
4. Lam PP, Palamara JE, Messer HH. Fracture strength of tooth roots following canal preparation by hand and rotary instrumentation. J Endod 2005;31:529–32.
5. Sathorn C, Palamara J. A comparison of the effects of two canal preparation techniques on root fracture susceptibility and fracture pattern. J Endod 2005;31(4):283-287
6. Kim Hyeon-Cheol, Lee Min-Ho. Potential Relationship between Design of Nickel-Titanium Rotary Instruments and Vertical Root Fracture. J Endod 2010; 36(7):1195-1199
7. Shemesh H, Bier CAS, Wu M-K. The effects of canal preparation and filling on the incidence of dentinal defects. Int Endod J 2009; 42, 208–213,
8. Shemesh H, Gijs van S, Wu Min-Kai. Diagnosis of Vertical Root Fractures with Optical Coherence Tomography. J Endod 2008; 34(6):739-7429.
9. Weirong T, Younong Wu. Identifying and Reducing Risks for Potential Fractures in Endodontically Treated Teeth. J Endod 2010; 36(4):609-616
10. Chankhrit S, Palamara JEA. Effect of Root Canal Size and External Root Surface Morphology on Fracture Susceptibility and Pattern: A Finite Element Analysis. J Endod 2005; 31(4), 288-292
11. Lam PPS, Palamara JEA, Messer HH. Fracture strength of tooth roots following canal preparation by hand and rotary instrumentation. J Endod 2005; 31:529–32.
12. Zandbiglari T, Davids H, Schafer E. Influence of instrument taper on the resistance to fracture of endodontically treated roots .Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006; 101:126–31.
13. Bier CA, Shemesh H, Tanomaru-Filho M, Wesselink PR, Wu MK. The ability of different nickel-titanium rotary instruments to induce dentinal damage during canal preparation. J Endod 2009; 35:236–8.