



## Comparative evaluation of vertical fracture resistance of teeth instrumented using different rotary file systems: An *in-vitro* study

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### Abstract

**Aim:** To compare the effect on vertical fracture resistance of teeth instrumented with ProTaper Gold, MicroMega 2shape mini and Mani JIZAI rotary file systems.

**Materials and Methods:** 32 freshly extracted mandibular premolar teeth were selected, teeth were decoronated to maintain 14mm of standardized root length. The teeth were then randomly divided into 4 groups where group I served as the control group. Groups II, III and IV were instrumented with ProTaper Gold, MicroMega 2shape mini and Mani JIZAI rotary file systems respectively. After cleaning and shaping the prepared and unprepared teeth were embedded in auto-polymerizing acrylic blocks. The teeth were then subjected to a vertical load in universal testing machine at a cross-head speed of 1 mm/min until vertical root fracture occurred. The forces required to cause the fractures were then recorded. The data was normally distributed and was analysed using one-way ANOVA. A p-value  $\leq 0.05$  was considered to be as statistically significant.

**Results:** Teeth instrumented with Mani JIZAI rotary files showed more resistance to Vertical Root fracture.]

**Conclusion:** Teeth instrumented using Mani JIZAI rotary files showed better resistance to vertical fracture followed by MicroMega 2Shape mini and ProTaper Gold files respectively.

**Keywords:** Vertical fracture resistance, vertical root fracture, ProTaper Gold, MicroMega 2Shape mini, mani JIZAI rotary file

### Introduction

Vertical Root Fracture (VRF) can be defined as a longitudinal fracture that begins in the tooth root and extends vertically towards the coronal portion.<sup>[1]</sup> However, depending on the etiology, these fractures may also begin in the coronal part followed by extending apically. According to various studies, VRF has been found to be associated more frequently with endodontically treated teeth with a prevalence ranging from 4% to as high as 32%.<sup>[2]</sup> The preparation of root canals during endodontic treatment weakens the tooth structure and is considered as one of the causes of increased prevalence of VRFs in such teeth.<sup>[3]</sup>

Canal preparation with rotary Ni-Ti files has numerous advantages over hand instruments that include faster canal preparation leading to less operator fatigue, preserving the shape of curved canals and producing smooth surfaces and a more predictable preparation.<sup>[4]</sup>

Despite their numerous advantages when compared to manual files, rotary files exert a larger stress on the root canal walls and increased incidence of micro-cracks formation in dentin. Also, Ni-Ti rotary instruments are known to cause stress concentration in dentinal walls which increases the risk of root fracture in such teeth.<sup>[5]</sup>

### Materials and methods

A total of 32 freshly extracted mandibular premolar teeth were used for the study. The teeth were randomly divided into 4 groups where each group consisted of 8 samples.

Radiographs were taken in both mesio-distal and bucco-lingual directions to confirm the presence of a single root and single canal with mature apex. Teeth with open apex, multiple canals, calcifications, fractures, cracks, root caries, curved roots, previously root canal treated teeth and teeth with internal/external resorption were excluded from the study. To maintain specimen standardization, the mesio-

distal and bucco-lingual dimensions of the samples were measured with a Vernier calliper at the level of CEJ. The mean mesio-distal (4.5 – 5.0 mm) and bucco-lingual (6.5 – 7.0 mm) dimensions were obtained. Samples that exhibited greater or smaller dimensions than the above mentioned range were discarded.<sup>[6]</sup>

All the teeth were then decoronated near the Cemento-Enamel Junction (CEJ) using a flexible diamond disk in a slow speed hand-piece under copious amount of water coolant to standardize length of 14 mm upto the apex.

The teeth were then randomly divided into 4 groups as follows:

**Group 1 (n=8):** control group – uninstrumented teeth

**Group 2 (n=8):** teeth instrumented with ProTaper Gold (Dentsply Sirona, Ballaigues, Switzerland) rotary file system

**Group 3 (n=8):** teeth instrumented with 2Shape mini (Micro-Mega, Besançon, France) rotary file system

**Group 4 (n=8):** teeth instrumented with JIZAI (Mani, Tochigi, Japan) rotary file system

Eight teeth were left unprepared and served as the control group. The instrumentation of teeth in groups II, III and IV was done by using E-Connect Endomotor (Eighteenth, Changzhou, China) as per manufacturer's instructions. The apical preparation was standardized to ISO size 25. Irrigation of the canals was done with 2 mL of 3% Sodium hypochlorite (NaOCl) after using each instrument in each group. The smear layer was removed by flushing the root canals with 5 mL of 17% EDTA solution and the canals were finally rinsed with 5 mL normal saline and dried with absorbent paper points.<sup>[7]</sup>

The prepared and unprepared teeth were embedded in auto-polymerizing acrylic blocks upto 8mm length from the apex and leaving the cervical 6mm exposed.

The teeth were then subjected to a vertical load in universal testing machine at a cross-head speed of 1 mm/min until vertical root fracture (VRF) occurred and the forces required to cause the fractures were recorded in Newtons.

### Statistical analysis used

The data was checked for normality using Kolmogorov-Smirnov and Shapiro-Wilk test. The results showed that the data followed normal distribution. Since the data was normally distributed one-way ANOVA was applied. Statistical significant difference for VFR was observed among the 4 groups with p value of 0.019. Post Hoc test revealed statistically significant difference only between the Control group and the group instrumented with ProTaper Gold files with p value of 0.025.

### Results

All instrumented groups showed reductions in fracture resistance when compared with the un-instrumented group. Among the instrumented groups, the highest resistance to fracture was seen with the specimens instrumented with the Mani JIZAI files, followed by MicroMega 2Shape mini and the ProTaper Gold files respectively. However, this difference was not statistically different.

### Discussion

VRF is one of the most undesirable event in endodontically treated teeth since it leads to an inevitable extraction of the involved tooth. It is beyond doubt that the introduction of rotary and reciprocating files systems for cleaning and shaping of the canals has made the process much easier, predictable and faster. However, instrumentation of this nature may contribute to VRF by inducing stress or by excessive dentinal removal. There have also been multiple studies in the past that have showed more number of cracks formation and reduction in the fracture resistance of teeth instrumented by rotary files when compared to Hand files (HF).<sup>[8]</sup>

No root canal filling procedures were performed in this study so as to evaluate and compare just the effects of different files on the forces required to fracture the teeth compared with those required in the unprepared control group. Bapna P *et al.* and Kinikar S *et al.* have proved in their studies that VFR of teeth reduces as taper of the files increases.<sup>[7, 9]</sup> The ProTaper Gold files have a variable taper whereas the MicroMega 2Shape mini and the Mani JIZAI provide a 6% taper to the preparation.

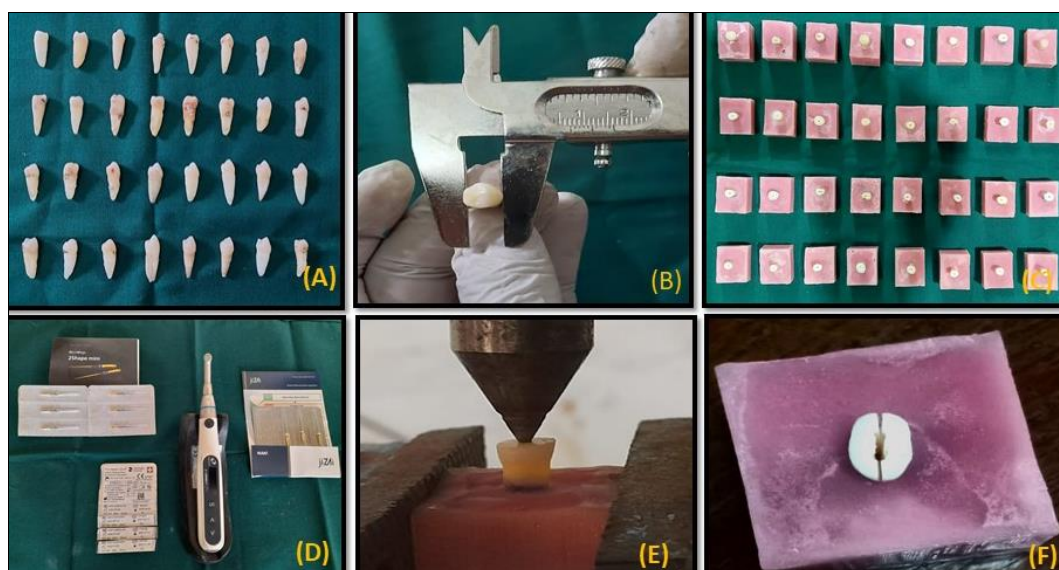
The Mani JIZAI are relatively newly launched file system with a unique off-centre file axis providing a larger space for debris removal, radial lands that are designed to prevent excess engagement on the canal walls and a variable flutes pitch that prevents screw-in effect.

Stiffer file designs generate higher stress concentrations leading to defects in the root dentin that may lead to fracture of the root. This stiffness depends on the cross-section, size, taper, method of manufacturing and the material from which the instrument is manufactured.<sup>[6, 10]</sup> The difference in the VFR among the different file systems in the study may be due to the difference in the stiffness of the files and the amount of removal of dentin associated with each system.

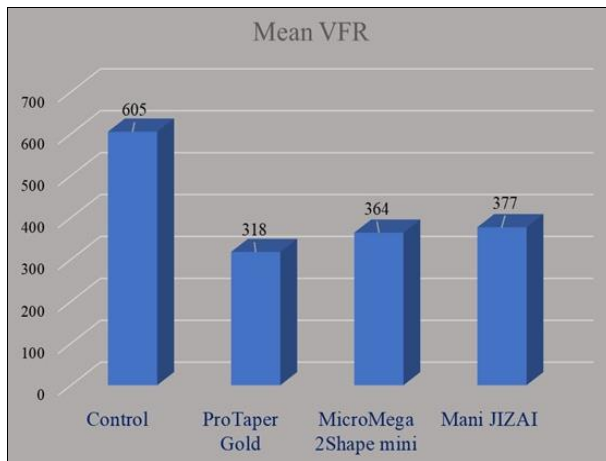
It was also noted that majority of the teeth fractured in the bucco-lingual direction. This confirms the findings of Carvalho *et al.* and Nassar S *et al.* that teeth may be weaker bucco-lingually than mesio-distally.<sup>[11, 12]</sup> It has been proved that after endodontic treatment, teeth become weaker and are known to present a higher risk of fracture<sup>[7]</sup> and this study confirms this finding. Hence, attention should be paid to unnecessary removal of dentin during endodontic treatment, in order to maintain the strength of the teeth.

### Conclusions

Based on this study, it was concluded that endodontically treated teeth are more prone to Vertical root fracture when compared to un-instrumented teeth. The Mani JIZAI rotary files exhibited the highest Vertical fracture resistance followed by the MicroMega 2Shape mini when compared to the ProTaper Gold rotary files, however the difference was not statistically significant.



**Fig 1:** (A): 32 extracted teeth collected (B): mesiodistal and buccolingual dimensions of teeth measured with a Vernier caliper (C): Teeth decoronated and mounted in acrylic blocks (D): armamentarium (E): subjected to vertical load in universal testing machine ( F): peak load of fracture recorded



Groups	N	Mean	Std. deviation
Control	8	<u>605</u>	224.507
ProTaper Gold	8	<u>318</u>	123.361
MicroMega 2Shape mini	8	<u>364</u>	200.199
Mani JIZAI	8	<u>377</u>	173.184
Total	32	416	208.335

**Fig 2:** This fig shows highest Mean Vertical Fracture Resistance in the uninstrumented (control) group. The highest mean VFR in instrumented groups was seen with mani JLZAI files followed by MM 2Shape mini and ProTaper Gold files respectively.

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