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# Effect of Apical Diameter and Taper of NiTi Files on the Fracture Resistance of Endodontically Treated Tooth- An *Invitro* Study

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## Abstract

**Background:** Overpreparation at root apex to avoid debris accumulation may cause excessive dentinal removal compromising root strength making it prone to fracture. Most commonly used size of files is 30 and 35, taper is 4% and 6%. However, their effect on root strength is unsettled. The present study aims to assess effect of these file size and taper on fracture resistance of endodontically treated tooth.

**Methodology:** Forty extracted mandibular premolars having single root were selected. Teeth were decoronated and standardized to have root length of 12 mm. They were divided into two groups: Group I were instrumented with edge endo file system while group II with Hyflex controlled memory (CM) file system. They were subdivided into subgroup A (30/4%), B (35/4%), C (30/6%) and D (35/6%) containing five samples each. Prepared roots were embedded in acrylic resin till cementoenamel junction. Universal testing machine was used to test fracture resistance. Statistical analysis was done using one-way ANOVA and Post-hoc tukey.

**Result:** Teeth instrumented with Hyflex CM file system having 4% taper and 30 apical preparation size showed better fracture resistance than 6% and size 35, difference was non-significant.

**Conclusion:** NiTi files having smaller apical size and less taper shows increased fracture resistance.

***Keywords*: *Apical Diameter; File Taper; Fracture Resistance; Hyflex Controlled Memory (CM) File System; Edge Endo File System***

## Introduction

To ensure the longevity of endodontically treated tooth, conservative approach should be opted for cleaning and shaping so that it can withstand occlusal forces without fracture. According to a study done by Kasnis., *et al.* root fracture has been reported is third common reason for endodontically treated tooth extraction [1]. The reasons of fracture may include trauma during obturation, angular forces or injudicious instrumentation; nevertheless, it eventually is due to weakened radicular structure after endodontic therapy. Clinicians should be mindful to preserve radicular dentin as much as possible so that the tooth will retain its strength after obturation [2]. However, adequate apical preparation in terms of size and taper is essential to remove debris and bacteria. It also helps irrigant to reach effectively till the apex for better control of infection [3]. To achieve sterile state, overzealous preparation at apical end is likely, thus it may adversely affect long-term prognosis. The current approach in endodontics claims for use of rotatory instruments. They are handy and provide for better cleaning and shaping. NiTi instruments are preferable choice as they are better suited for curved canals. These instruments conform to the anatomy of prepared canals because of 4% or 6% taper when compared to hand instruments. But this may inadvertently result into more removal of dentinal walls at the apex of root which may affect fracture resistance hence precaution is must [4].

NiTi rotary instruments are affected by various factors which will affect their clinical performance. Thus, constant upgrading of the file systems is done by the manufacturers. One of the file systems which has been newly introduced is edge endo files. They have an annealed heat treated NiTi alloy under the name fire wire. This has shown to have improved fatigue resistance with parallelogram cross section to increase cutting efficiency. They are also available in 4% and 6% taper [5]. HyFlex controlled memory (CM) is a newer system NiTi files which has controlled memory (CM) wire technology. They were developed with the feature of improved flexibility and increased cyclic fatigue resistance leading to better adaptation in canal reducing procedural errors. It consists of 4% and 6% taper for canal shaping [6].

While using Niti files, clinician should be careful as they produce a screw-in effect. During the insertion of rotary files, numerous pecking motion done at apical level may result in unwanted removal of tooth structure leading to enlarged apical diameter [7,8]. There has been contrasting literature comparing apical diameter and fracture resistance of tooth for long term prognosis. A group of authors were in favour of minimal apical preparation increase in taper decreases the resistance to fracture [9,10] while another group were of the opinion that increase in taper will not affect fracture resistance [11,12]. Nonetheless, balance between cleaning efficiency and strength of remaining root structure is crucial for long term successful endodontic therapy. Thus, the present study was undertaken to examine the influence of instrument taper and apical preparation size on the fracture resistance of endodontically treated roots under *in vitro* experimental conditions.

## Materials and Methods

This *in vitro* study included single rooted mandibular premolars. The sample size calculation was done as using Gpower software version 3.1.9.7 (Heinrich-Heine-Universitat Dusseldorf, Germany). A priori analysis was done for two tails with an effect size of 4.77 keeping confidence interval and power at 95%. Sample size obtained were 3 per group, keeping in mind loss of sample in processing, a sample of 5 per group was used leading to a total of 40 samples for eight groups.

Forty freshly extracted premolars were obtained from department of oral and maxillofacial surgery (Figure 1a). The premolars included were extracted due to orthodontic purposes. Any premolars with anomaly such as dilaceration; severely curved canals; multiple roots were excluded. The obtained teeth underwent scaling and root planing using hand and ultrasonic instruments. A periapical radiograph in mesiodistal and buccolingual direction was taken to confirm single canal. In case of multiple canals, tooth was excluded. The samples were then decoronated to achieve standardized length of 12 mm each. The root canal of each study sample was then scouted till the apex using a stainless-steel K-File with ISO size 10 to obtain the glide path. They were then broadly divided into 2 groups based on the file system used. Group I comprised of decoronated premolars prepared using edge endo file system (Figure 1b) while group II had decoronated premolars prepared using Hyflex controlled memory (CM) file system (Figure 1c). The groups were further divided into 4 subgroups depending on file size and taper consisting of 5 samples in each which were:

1. Group I: Teeth were instrumented with Edge Endo file system (Figure 1d):

a. Subgroup A: Prepared using file 30/4%.
b. Subgroup B: Prepared using file 35/4%.
c. Subgroup C: Prepared using file 30/6%.
d. Subgroup D: Prepared using file 35/6%.

2. Group II: Teeth were instrumented with Hyflex controlled memory (CM) file system (Figure 1e):

a. Subgroup A: Prepared using file 30/4%.
b. Subgroup B: Prepared using file 35/4%.
c. Subgroup C: Prepared using file 30/6%.
d. Subgroup D: Prepared using file 35/6%.

Torque (2.5 Ncm) and speed (500 rpm) were adjusted for the handpiece of endomotor (NSK) to maintain uniformity and root canal instrumentation were done according to respective subgroups.

After preparation, teeth were enclosed in a transparent plastic film that acts as a spacer for the periodontal ligament space. The samples were then embedded in self-curing acrylic resin up till 2 mm apical of cementoenamel junction to form a block. The stretch film was then removed along with root after curing of resin. Then a light body silicone putty was placed in the block to resemble periodontal ligament. The prepared roots were then re-inserted into the blocks. These prepared roots were fixed to artificial lower jaw of Universal testing machine (ACME Engineers, India) to assess for fracture resistance (Figure 1f). The maximum load leading to the fracture of root was recorded as strength of fracture resistance. The results were organized and statistical test of One-way Anova and Tukey HSD were used. Data was normally distributed as per Levene's test for homogeneity using SPSS version 15 (Statistical package for social sciences, IBM, Chicago, USA). A probability value of 0.05 or less was considered significant.

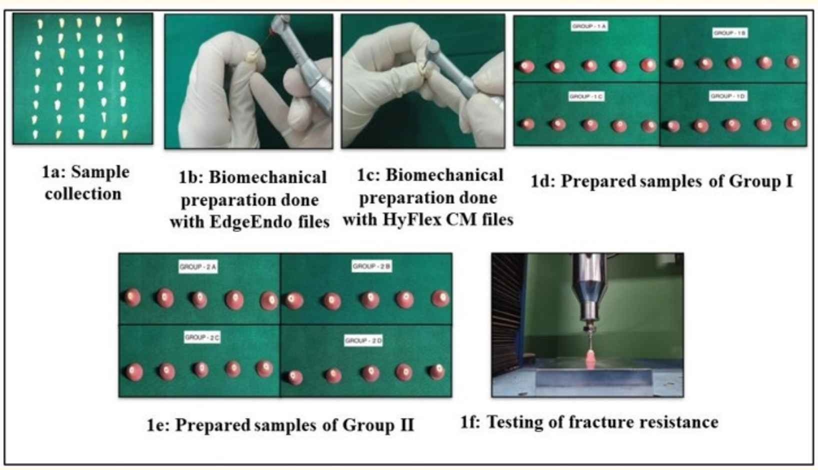


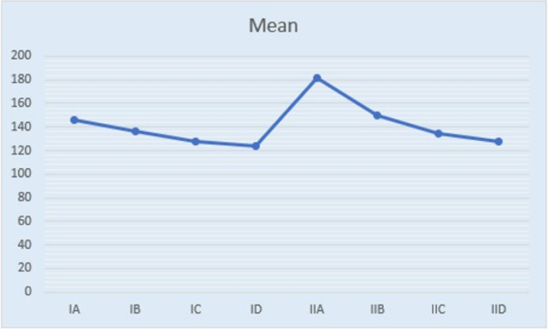

***Figure 1:*** *Figure showing steps involved in the study.*

## Results

Results were expressed in terms of mean and standard deviation (Table 1 and graph 1). The fracture resistance was seen highest with group IIA (Hyflex controlled memory files) with 30/4% taper. The next best was group IIB (Hyflex controlled memory files) with 30/6% taper. The least fracture resistance was seen with group ID (EdgeEndo files) with 35/6% taper. There was statistically significant difference amongst group IIA and all the groups except for group IIB (Table 2). The rest of the groups do not have statistically significant difference amongst them. The result has shown that Hyflex controlled memory has performed better that EDGEENDO files in all groups. The smaller file of 30 has performed better than file 35 and 4% taper had shown better fracture resistance than 6% taper.

| Fracture load (N) | Mean | Std. Deviation | 95% Confidence Interval for Mean | |
|---|---|---|---|---|
| | | | Lower Bound | Upper Bound |
| Group IA - EdgeEndo 30/4% | 145.8 | 16.0023 | 125.93 | 165.66 |
| Group IB- EdgeEndo 35/4% | 136.4 | 8.92608 | 125.31 | 147.48 |
| Group IC- EdgeEndo 30/6% | 127.3 | 13.6638 | 110.33 | 144.26 |
| Group ID- EdgeEndo 35/6% | 124.3 | 17.6939 | 102.33 | 146.26 |
| Group IIA- Hyflex controlled memory (CM)30/4% | 182 | 26.6364 | 148.92 | 215.07 |
| Group IIB- Hyflex controlled memory (CM)35/4% | 150 | 14.3614 | 132.16 | 167.83 |
| Group IIC- Hyflex controlled memory (CM)30/6% | 134.3 | 19.6805 | 109.86 | 158.73 |
| Group IID- Hyflex controlled memory (CM)35/6% | 127.9 | 17.3291 | 106.38 | 149.417 |

***Table 1:*** *Table showing descriptive statistics (One-way Anova) of fracture load of all the eight groups.*




***Graph 1:*** *Graph showing mean fracture load obtained.*

| Group | Mean Difference (I-J) | Std. Error | Sig. | Group | Mean Difference (I-J) | Std. Error | Sig. |
|---|---|---|---|---|---|---|---|
| Group IA- EdgeEndo30/4%-Group IB- EdgeEndo35/4% | 9.40 | 11.04 | 0.98 | Group IC- EdgeEndo 35/4%-Group IIA- Hyflex Controlled Memory (CM)30/4% | -54.70* | 11.04 | 0.00 |
| Group IA- EdgeEndo30/4%-Group IC- EdgeEndo30/6% | 18.50 | 11.04 | 0.70 | Group IC- EdgeEndo 35/4%-Group IIB- Hyflex Controlled Memory (CM)35/4% | -22.70 | 11.04 | 0.46 |
| Group IA- EdgeEndo30/4%-Group ID- EdgeEndo35/6% | 21.50 | 11.04 | 0.53 | Group IC- EdgeEndo 35/4%-Group IIC- Hyflex Controlled Memory (CM)30/6% | -7.00 | 11.04 | 0.99 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Group IA- EdgeEndo30/4%-Group IIA- Hyflex Controlled Memory (CM)30/4% | -36.20* | 11.04 | 0.04 | Group IC- EdgeEndo 35/4%-Group IID- Hyflex Controlled Memory (CM)35/6% | -0.600 | 11.04 | 1.00 |
| Group IA- EdgeEndo30/4%-Group IIB- Hyflex Controlled Memory (CM)35/4% | -4.20 | 11.04 | 1.00 | Group ID- EdgeEndo35/6%-Group IIA- Hyflex Controlled Memory (CM)30/4% | -57.70* | 11.04 | 0.00 |
| Group IA- EdgeEndo30/4%-Group IA- EdgeEndo30/4%-Group IIC- Hyflex Controlled Memory (CM)30/6% | 11.50 | 11.04 | 0.96 | Group ID- EdgeEndo35/6%-Group IIB- Hyflex Controlled Memory (CM)35/4% | -25.70 | 11.04 | 0.31 |
| Group IA- EdgeEndo30/4%-Group IID- Hyflex Controlled Memory (CM)35/6% | 17.90 | 11.04 | 0.73 | Group ID- EdgeEndo35/6%-Group IIC- Hyflex Controlled Memory (CM)30/6% | -10.00 | 11.04 | 0.98 |
| Group IB- EdgeEndo35/4%-Group IC- EdgeEndo30/6% | 9.10 | 11.04 | 0.99 | Group ID- EdgeEndo35/6%-Group IID- Hyflex Controlled Memory (CM)35/6% | -3.60 | 11.04 | 1.00 |
| Group IB- EdgeEndo35/4%-Group ID- EdgeEndo35/6% | 12.10 | 11.04 | 0.95 | Group IIA- Hyflex Controlled Memory (CM)30/4%-Group IIB- Hyflex Controlled Memory (CM)35/4% | 32.00 | 11.04 | 0.10 |
| Group IB- EdgeEndo35/4%-Group IIA- Hyflex Controlled Memory (CM)30/4% | -47.70* | 11.04 | 0.00 | Group IIA- Hyflex Controlled Memory (CM)30/4%-Group IIC- Hyflex Controlled Memory (CM)30/6% | 47.70* | 11.04 | 0.00 |
| Group IB- EdgeEndo35/4%-Group IIB- Hyflex Controlled Memory (CM)35/4% | -13.60 | 11.04 | 0.91 | Group IIA- Hyflex Controlled Memory (CM)30/4%-Group IID- Hyflex Controlled Memory (CM)35/6% | 54.10* | 11.04 | 0.00 |
| Group IB- EdgeEndo35/4%-Group IIC- Hyflex Controlled Memory (CM)30/6% | 2.10 | 11.04 | 1.00 | Group IIB- Hyflex Controlled Memory (CM)35/4%-Group IIC- Hyflex Controlled Memory (CM)30/6% | 15.70 | 11.04 | 0.84 |
| Group IB- EdgeEndo35/4%-Group IID- Hyflex Controlled Memory (CM)35/6% | 8.50 | 11.04 | 0.99 | Group IIB- Hyflex Controlled Memory (CM)35/4%-Group IID- Hyflex Controlled Memory (CM)35/6% | 22.10 | 11.04 | 0.49 |
| Group IC- EdgeEndo 35/4%-Group ID- EdgeEndo35/6% | 3.00 | 11.04 | 1.00 | Group IIC- Hyflex Controlled Memory (CM)30/6%-Group IID- Hyflex Controlled Memory (CM)35/6% | 6.40 | 11.04 | 0.99 |

***Table 2:*** *Table showing Post hoc tukey comparing the mean fracture load of all the eight groups.*

## Discussion

The remaining dentin thickness after root canal preparation has been a subject of interest in the endodontist as it is fair predictor of not only the strength and fracture resistance of tooth but also the efficiency of files used. The present study differs from those on remaining dentin thickness as the prime focus is only apical preparation rather than entire length of canal. The reason to choose the apical diameter is because it is now well established that lesser the remaining dentin thickness lesser will be the strength [13], however, an appropriate enlargement of apex is necessary to completely remove bacterial load and disinfection of the canal [14]. Thus, apical preparation can serve as landmark for making the decision on file size and taper.

Akhlaghi., *et al.* [15], concluded that a file size of 30 and a taper of 6% was appropriate in removal of smear layer and canal disinfection. The present study also used a file size of 30 and 35 to prepare the canals and taper used was 4% and 6% in an *in vitro* set up. It has been recommended that this size allows for better penetration of irrigants and canal disinfection. At the same time, it is debatable whether a larger diameter at the apical end will adversely affect the fracture resistance of tooth or not. The present study has shown that 4% taper bore more load as compared to 6% taper, thus, study by Akhlaghi., *et al*. cannot be compared directly, however it was used to refer that file size of 30 is good enough for final preparation with respect to root canal disinfection.

In the present study, NiTi files were considered as they are now the first choice owing to flexibility and ability to prepare the curved canals with precision. The size and taper are considered in methodology is also one of the most used in preparation of root canals. Hyflex CM and edge endo system were used. The performance of Hyflex was significantly better than that of edge endo. The results also indicate larger taper of the same size file reduces fracture resistance. Kim., *et al*. has testified that design and stiffness of NiTi files affect their properties and may result in untoward movement leading to excessive dentin removal at apical end [18]. As per manufacturer's guide, edge endo files are flexible which can adapt to canal once it is in motion. But this property may have resulted in more dentin removal which could be attributed to less fracture resistance in our study. In a study conducted by Caicedo and Clark, Hyflex CM files have shown greater flexibility and better adaptation to canal anatomy thus reducing the risk of procedural errors [5]. The present study had also obtained superior results with Hyflex CM files confirming their proposition. Hyflex CM files have known to have controlled memory effect which reduces canal straightening effect reducing unwanted removal of dentin and producing greater fracture resistance [19].

The present study used mandibular premolars as they are easily available, comprising of single canal, an adequate amount of dentin is still left after preparation reducing the risk of bias involved. A static fracture resistance test was used and specimens used were not filled with any obturating material to avoid bias. The present study confirmed that change in apical diameter and taper affects fracture resistance. The studies which supports this notion includes those of done by Sabeti., *et al*. where they established that increasing tip size of file reduce fracture resistance [20]. Zandbiglari., *et al*. also showed same outcome in their study despite of sealing root canals with sealer [9]. Yidiz., *et al*. concluded that larger tapers increases risk of fracture [4]. On contrary, Krikeli., *et al*. found no difference in fracture resistance when smaller and larger taper files were compared [10]. Similarly, Turky and Gamal have not found any difference when the diameter of 25, 30 and 35 were compared.

The literature has shown that continuous increase in taper does not reduce the infected dentin and preparation with 25 files is adequate for intracanal disinfection [22]. According to Tabrizizadeh., *et al*. larger apical diameter showed more microleakage. Although these studies are not in direct corelation with that of our study, nevertheless strengthen the notion of applying conservative approach than reckless preparation of root canals [23].

The premolars used were primarily those of young patients thus age factor was not considered. The storage of sample and dynamic testing may have affected the outcome in present study. The study was done *in vitro* thus, *in vivo* condition with root canal filling may vary in fracture resistance. Since the research gap in apical diameter and fracture resistance is still present, further studies in different experimental setting can be pursued.

## Conclusion

Within the limitation of present study, it can be concluded that taper of 6% increases the fracture probability as compared to 4% taper. The increase of apical diameter from 30 to 35 also adversely affects fracture resistance. Thus, NiTi files having smaller apical size with less taper shows increased fracture resistance of endodontically treated teeth. Hyflex controlled memory technology was found to be better than annealed heat technology of edge endo files.

## Conflict of Interest

Authors declare no conflict of interest.

## Source of Support

Nil.

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