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# Comparative analysis of incidence of dentinal defects during root canal preparation with different rotary instruments using stereomicroscope

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**Abstract:**

**Aim of study:** Study the effect of canal preparation with different Niti rotary systems (Edge x7 file and F-one file) with different tapers (0.04 and 0.06) on the incidence of dentinal defect.**Methods and Material:**75 straight palatal roots of the maxillary first molar were collected, and the instrumentation was done to 11 mm root length for all samples except the control group; the samples were divided randomly into five groups (n=15 each), Group (A) was a control, Group (B) with Edge x7 taper (0.04), Group (C) with Edge x7 taper (0.06), Group (D) with F-ONE taper (0.04), and Group (E) with F-ONE taper (0.06) Every sample had a horizontal section from the apex at 2 mm, 4.5 mm, and 7 mm, dentinal defect was evaluated with 25x stereomicroscope, the data were statistically evaluated at significance levels of 5% or more using Fisher's exact test.**Results:** There is no significant difference between different tapers and between different files; in general, taper 0.04 showed less dentinal defects than taper 0.06, and Edge x7 showed less defect than F-ONE.**Conclusions:** F ONE file tapers (0.04 and 0.06) cause slightly more dentinal defect than Edge x7 file tapers (0.04 and 0.06) however, with no significant differences.

**Key-words:** Edge x7, F-ONE, dentinal defect, stereomicroscope.

## Introduction:

Correct diagnosis, treatment planning, anatomical assessment, tooth debridement, root canal shape, and three-dimensional obturation are all parts of root canal therapy.[1], Microcracks and dentinal defects have been connected to chemo-mechanical root canal preparation.[2,3] Due to the formation of lateral pressures that strain the canal walls.[4]

Numerous studies have already linked root canal instrumentation methods to dentinal microcracks.[3,5] Dentinal microcracks have been proposed as the cause of vertical root fractures,[6] which often result in tooth or root extraction.[7] Dentinal cracks cause biofilm entrapment in these fractured sites along the root surface. Because the biofilm is difficult to remove with an instrument and may be a source of infection, endodontic failure may result from it.[8]

Dentinal defects may arise to varying degrees as a result of variations in Nickel-titanium (NiTi) instruments.[9] According to (Yoldas et al., 2012), various parameters, including geometrical designs, cross-sectional forms, different heat treatments, and the kinematics motion of a particular instrument, may affect the production of dentinal defects in NiTi files.[10]

The EdgeFile X7 manufacturing method, referred to as Firewire, combines cryogenic applications with heat treatment to create an unusual crystalline structure in the heat-treated Firewire alloy. This matrix lessens the shape memory effect while increasing the file's flexibility and fracture resistance. The file has a triangular cross-section with a changeable helix angle.[11]

The F-One introduces a revolutionary heat treatment known as AF-R wire in a single-file system. Result in more effective cutters with stronger torsional and cyclic fatigue resistance; the F-One file's flat design and S-shaped cross-section provide a number of benefits, like lowering engagement of blades, prolonging fatigue lifespan, and cleaning the prepared area by removing waste from the canal. The tool has a non-cutting tip and two active cutting point.[12] The current study aimed to evaluate the effect of root canal preparation with two different Niti rotary systems (Edge x7 file and F-one file with different tapers of 0.04 and 0.06) on the incidence of dentinal root canal defect.

## Materials and method:

Ethical approval was received from the College of Dentistry institutional ethics committee board at Mustansiriyah University (approval number and date: REC130 on 30/05/2023).

75 extracted human maxillary first molars were collected from patients ranging in age from (20-30) years old. Only straight palatal roots with no evident root caries, no open apices, no restoration, and a fully developed apex with a centrally placed apical foramen were chosen for this study, and diagnostic radiographs were also used to ensure that there was just one straight canal and no evidence of internal resorption.[13,14], The existence of visible cracks or fractures was examined on all root surfaces using transmitted light and a stereomicroscope (MEIJI Techno, Japan) set at 20X magnification .[14]To form root portions 11 mm long from the apex, crowns were decoronated using a diamond disk (Komet, Germany) and water irrigation. The center placements of the

foramen and canal patency were verified by inserting a size-15 K-file. (Dentsply Maillefer, Switzerland).[15] To get the working length, insert a file into the canal until the tip becomes visible at the apex, then reduce one mm from this length. Only roots with an initial file size of 20 K-files were included in the study .[5]

The canal preparation sequences utilized in this study are completed in compliance with the guidelines provided by the manufacturer. The canals were prepared using a wave one endo motor (Dentsply, Maillefer, Italy) in the crown-down technique, which has a setting of (speed: 500Rpm and torque: 2.5 N) except Group (A) which is control group that left without preparation, Group (B) prepared with Edge x7 taper 0.04, Group (C) prepared with Edge x7 taper 0.06, Group (D) with AF Fanta taper 0.04, and Group (E) with AF Fanta taper 0.06. Each canal was prepared with three sequence file sizes (25#,30#,35#) and a new file was used for each sample and discarded.

Master apical file matching size 35 was used to instrument all root canals. Following each file size, canal was irrigated with 2 ml of 1% NaOCl irrigation after the file was taken from the canal, recapitulated using a size 15 K file, and then irrigated again with 2 ml of NaOCl. 30-gauge endodontic needle was used at 2mm short from working length.[16] As a last flush, 5 milliliter of distilled water was used to get rid of irrigating solutions and debris. Then the canal was dried with an identical paper point size .[17]

Gidding lines were drawn horizontally on the roots at four levels: (1.5) mm, (4) mm, (6.5) mm, and (9) mm from the apex. (figure 1) Then, the roots were placed in a mold filled with clear acrylic with the help of a dental surveyor. [17.] After that, the root was sectioned horizontally with a diamond disc (0.4 mm) under cold water to prevent heating and reduce smearing. [18] To extract three sections (apical, middle, and coronal) at (2) mm, (4.5) mm, and (7) mm from the apex, each with a thickness of about 2 mm. [17,19,20] (figure 2)

Each root segment was inspected with a stereomicroscope (MEIJI Techno, Japan) at 25X magnification; two examiners looked at the samples from the coronal direction.[14,21,22], The quantity and the different types of defects were noted and categorized using the following categorization. (No defect, incomplete crack, craze lines, and complete crack).[5] (figure 3)

The incidence of defected roots in Edge x7 taper 0.04 was found to be (2/15), followed by AF Fanta taper 0.04 which showed (4/15). Then, Edge x7 taper 0.06 which showed (5/15). The highest number of defected roots showed in AF Fanta taper 0.06 (8/15).

The Statistical Package for Social Science (SPSS version -22, Chicago, Illinois, USA) was used for data description, analysis, and presentation. This included descriptive and inferential analysis using the Fisher exact test to determine the association of distribution between two qualitative variables when the expected cell counts less than 5 are more than 20%.

**Results:**

The results revealed that regarding taper of file files, the files with taper 0.04 showed a lower number of dentinal defects

than taper 0.06, but with no significant difference (table 1), regarding the type of file used, the Edge x7 showed a lower number of dentinal defect than AF Fanta but with no significant difference (table 1). Furthermore, whether comparing dentinal defect incidence across groups at the same level or between various levels within the same group, there was no statistically significant difference ($p > 0.05$). (apical, middle, and coronal). Table (2,3,4,5,6,7,8)

**Discussion:**

The stress distribution is more regular in a round canal and, because it has a more rounded canal morphology than other teeth, the nearly straight palatal root of a newly extracted human maxillary permanent first molar was chosen for the current investigation.[23,26] Additionally, utilizing only one kind of tooth helps reduce variations, improve parity, and standardize specimens. [24-26]

One operator (the researcher) instrumented each canal in order to reduce the variables through the investigation to exclude any personal bias. The defect was revealed by two observers**.**[17]

The control group did not develop any dentinal defects, despite the difficulties associated with the root sectioning process. This would suggest that in this research, the root sectioning method did not result in dentinal defects.[17]

According to the findings of this study, instrumentation with Edge x7 showed the lowest dentinal defect in all parts of the roots as compared to the same taper of AF Fanta file, this might be attributed to the parabolic design (Figure 4)، which is responsible for minimizing pressure on the canals' lateral wall,[27] Additionally, this file system's cutting efficiency is maximized by the parabolic architecture. This increased cutting effectiveness could reduce the development of dentin cracks.[28] This concurs with a publication by (Kim et al., 2010) that suggested a connection between the occurrence of vertical root fractures and the design of NiTi instruments.[29]

While the F-one system's flat shape might lead to an uneven or irregular distribution of pressures on the instrument, leading to reduced cutting efficiency. Additionally, one half of the cross-section has a completely flat design, which might allow more debris to accumulate between the file and canal walls, the surrounding walls may then be cut unevenly,[30] This result is also supported by (Hamed et al., 2022) that suggested the F-one flat design results in accumulation of debris that lead to affect its cutting efficacy.[31] furthermore, F-one file has near- identical helical angles [32] which allow debris to accumulate [33] in opposite to the Edge x7 file which has variable helical angle result in reducing the screwing effect and enhancing the removal of debris.[34]

According to the findings of this study, instrumentation with Edge x7 taper 0.04 and AF. Fanta taper 0.04 showed the lowest dentinal defect in all parts of roots as compared to taper 0.06 of AF Fanta file and Edge x7 groups.

The files' taper have a positive influence on the development of dentinal cracks, when the taper increases, the stress on the canal wall increases, result in an increase in the number of dentinal defects.[35] rotary files with greater tapers have a tendency to put more stress on the radicular dentine, which is one of the causes of root dentin cracking.[29,36] The effect of increasing file

taper on dentinal cracks is also supported by (Bhavika et al., 2023) that used files with fixed taper as same as the files used in current study and they conclude the Trunatomy file (26. /0.04) result in less number of cracks than Waldent walflex file (25/0.06).[37]

The more incidence of dentinal defects discovered at the apical level in all groups, followed by the middle and then the coronal levels, this is in line with what.[37-40] found in their studies, that cracks may develop as a result of mechanical stress brought on by repetitive instrumentation and the thin, brittle dentin in the apical region's inability to withstand the tension brought on by direct contact with the instrument tip.

**Conclusion:**

The following conclusions might be drawn based on the results of this in vitro investigation:

1. The dentinal defects were caused by all of the instrumentation systems employed in this investigation.

2. AF Fanta file system taper (0.04 and 0.06) causes more dentinal defects than Edge x7 file system taper (0.04 and 0.06) but with no significant difference.

3. The large taper (0.06) of AF Fanta and Edge x7 systems results in a greater number of dentinal defects than the small taper (0.04) of AF Fanta and Edge x7 systems, but with no significant difference.

4. The apical portion of the instrumented roots showed a high prevalence of dentinal defects.

**Conflict of interest**

The authors reported that they have no conflicts of interest.

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**Table 1:** Fisher's exact test to determine if there was any statistically significant difference between the experimental groups (for Defected roots).

| | No defect | | Defect | | N % | |
|---|---|---|---|---|---|---|
| | N | % | N | % | | |
| A | 15 | 100.00 | 0 | .00 | 15 | 100.00 |
| B | 13 | 86.67 | 2 | 13.33 | 15 | 100.00 |
| C | 10 | 66.67 | 5 | 33.33 | 15 | 100.00 |
| D | 11 | 73.33 | 4 | 26.67 | 15 | 100.00 |
| E | 7 | 46.67 | 8 | 53.33 | 15 | 100.00 |
| Statistics | | | | | | |
| B-C (F. E=1.677, p value=0.195) | | | | | | |
| D-E (F. E=2.222, p value= 0.136 NS) | | | | | | |
| B-D (F. E=0.833, p value=0. 361) | | | | | | |
| C-E (F. E=1.222, p value= 0.269 NS) | | | | | | |

**Table 2:** Association of dentinal defects among groups in apical third.

| | Defect | | | | Total | |
|---|---|---|---|---|---|---|
| | Defect | | No Defect | | | |
| | N | % | N | % | N | % |
| B | 2 | 13.33 | 13 | 86.67 | 15 | 100.00 |
| C | 3 | 20.00 | 12 | 80.00 | 15 | 100.00 |
| D | 3 | 20.00 | 12 | 80.00 | 15 | 100.00 |
| E | 5 | 33.33 | 10 | 66.67 | 15 | 100.00 |
| Statistics | | | | | | |
| B-C (F. E=0.240, p value=1 NS) | | | | | | |
| D-E (F. E=0.682, p value=0.680 NS) | | | | | | |
| B-D (F. E= F. E=0.240, p value=1 NS) | | | | | | |
| C-E (F. E=0.682, p value=0.680 NS) | | | | | | |

**Table 3:** Association of dentinal defects among groups in middle third.

| | Defect | | | | Total | |
|---|---|---|---|---|---|---|
| | Defect | | No Defect | | | |
| | N | % | N | % | N | % |
| B | 0 | .00 | 15 | 100.00 | 15 | 100.00 |
| C | 1 | 6.67 | 14 | 93.33 | 15 | 100.00 |
| D | 1 | 6.67 | 14 | 93.33 | 15 | 100.00 |
| E | 3 | 20.00 | 12 | 80.00 | 15 | 100.00 |
| Statistics | | | | | | |
| B-C (F. E=1.034, p value= 1 NS) | | | | | | |
| D-E (F. E=1.154, p value=0.598 NS) | | | | | | |
| B-D (F. E=1.034, p value= 1 NS) | | | | | | |
| C-E (F. E=1.154, p value=0.598 NS) | | | | | | |

**Table 4:** Association of dentinal defects among groups in coronal third.

| | Defect | | | | Total | |
|---|---|---|---|---|---|---|
| | Defect | | No Defect | | | |
| | N | % | N | % | N | % |
| B | 0 | .00 | 15 | 100.00 | 15 | 100 |
| C | 1 | 6.67 | 14 | 93.33 | 15 | 100 |
| D | 0 | .00 | 15 | 100.00 | 15 | 100 |
| E | 2 | 13.33 | 13 | 86.67 | 15 | 100 |
| Statistics | | | | | | |
| B-C (F. E=1.034, p value=1 NS) | | | | | | |
| D-E (F. E=2.143, p value=0.483 NS) | | | | | | |
| B-D (F. E=---, p value=----) | | | | | | |
| C-E (F. E=0.370, p value=1 NS) | | | | | | |

**Table 5:** Association of dentinal defects among levels in Group B (Edge x7 taper 0.04)

| Group B | Defect | | No Defect | | Fisher exact | P value |
|---|---|---|---|---|---|---|
| | N | % | N | % | | |
| Apical Level | 2 | 13.33 | 13 | 86.67 | 2.812 | 0.316 NS |
| Middle Level | 0 | .00 | 15 | 100.00 | | |
| Coronal Level | 0 | .00 | 15 | 100.00 | | |

**Table 6:** Association of dentinal defects among levels in Group C (Edge x7 taper 0.06)

| Group C | Defect | | No Defect | | Fisher exact | P value |
|---|---|---|---|---|---|---|
| | N | % | N | % | | |
| Apical Level | 3 | 20.00 | 12 | 80.00 | 1.596 | 0.598 NS |
| Middle Level | 1 | 6.67 | 14 | 93.33 | | |
| Coronal Level | 1 | 6.67 | 14 | 93.33 | | |

**Table 7:** Association of dentinal defects among levels in Group D (AF Fanta taper 0.04)

| Group D | Defect | | No Defect | | Fisher exact | P value |
|---|---|---|---|---|---|---|
| | N | % | N | % | | |
| Apical Level | 3 | 20.00 | 12 | 80.00 | 3.200 | 0.310 NS |
| Middle Level | 1 | 6.67 | 14 | 93.33 | | |
| Coronal Level | 0 | .00 | 15 | 100.00 | | |

**Table 8:** Association of dentinal defects among levels in Group E AF Fanta taper (0.06)

| Group E | Defect | | No Defect | | Fisher exact | P value |
|---|---|---|---|---|---|---|
| | N | % | N | % | | |
| Apical Level | 5 | 33.33 | 10 | 66.67 | 1.721 | 0.558 NS |
| Middle Level | 3 | 20.00 | 12 | 80.00 | | |
| Coronal Level | 2 | 13.33 | 13 | 86.67 | | |

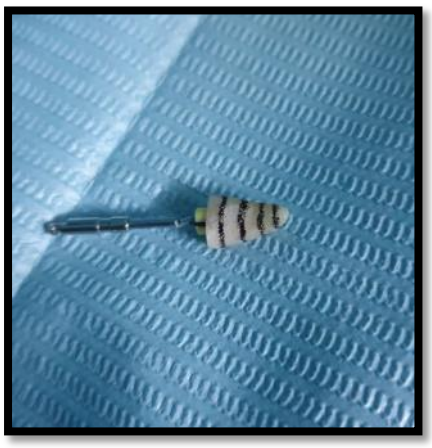


**Figure 1** (root sample with guiding lines)

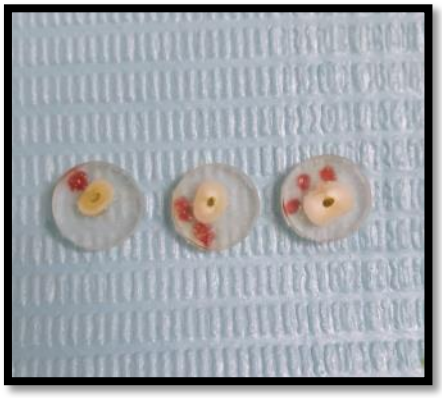
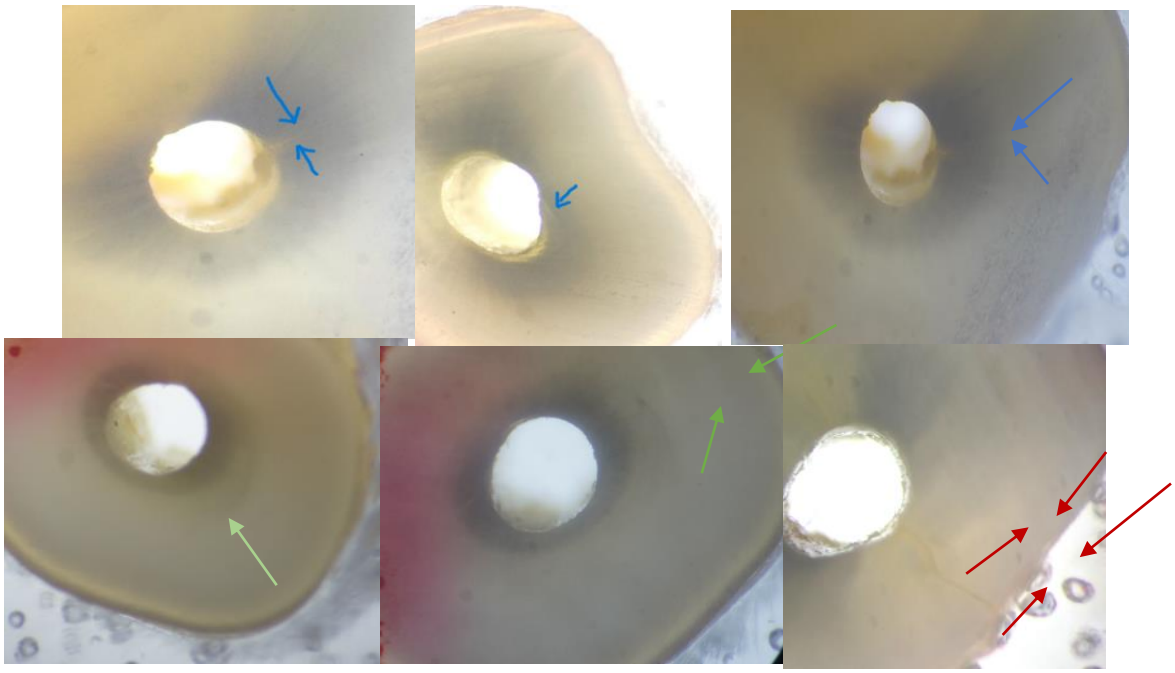
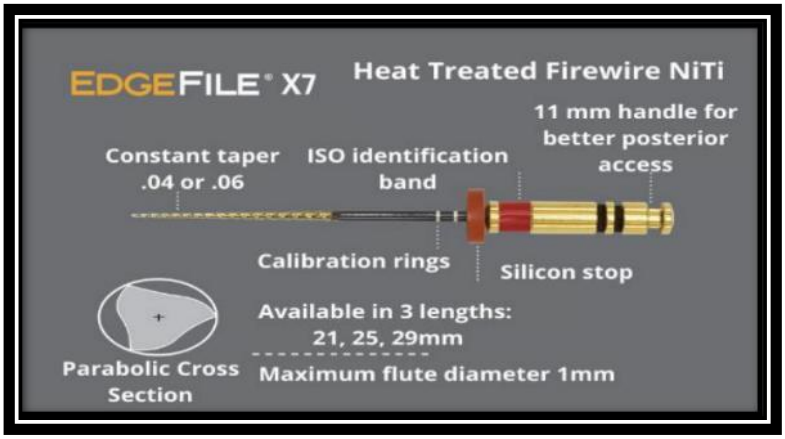


**Figure 2** (one dot for apical part, two dot for middle part, and three dot for coronal part)



**(Figure 3)** root section with dentinal defect (Blue arrow: incomplete cracks, green arrow: craze line and red arrow: complete cracks




**( Figure 4):** EdgeFile X7 instruments (EdgeEndo, 2018).