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Evaluation of Different Approaches for Management of Separated Endodontic Instruments. (In-Vitro Study)

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Abstract:

Objective: to evaluate different approaches (ultrasonic troughing, and trephine bur with extractors) to manage separated endodontic instruments.

Methods and Materials: A block of wax containing mandibular molars were scanned to get preoperative CBCT to select a total number of 32 mandibular molars that were later divided into two groups (n=16) according to file retrieval procedure: Group (A) (control group): the broken segment was retrieved by ET-25 ultrasonic tips, Group (B): the broken segment was retrieved by micro-extractor (Zumax retrieval kit). Traditional endodontic access cavity was created, orifice opener was used to make coronal third enlargement up to 4mm of the cervical root, glide path is ensured up to file #20/.02, shaping of the canal was made up to file #20.04 and cleaning of the canal was achieved using sodium hypochlorite 5.25% for one minute between each file. A 2nd CBCT was made before file breakage and the sample was mounted at the same place in the wax block. 5mm apical to the canal orifice, the apical 4-mm of a size 25/.04 NiTi instrument with was intentionally fractured in the mesiobuccal canal. A 3rd CBCT was made to confirm the location of the broken instrument in the canal while the sample remained in the same position in the wax block. Staging platform was created using dental microscope, Gates Glidden burs size (1,2,3) and modified Gates Glidden (no.3). The broken segments were subjected to the retrieval procedures assigned for each group and the specimens were scanned to get postoperative CBCT. The 2nd CBCT and the postoperative CBCT were constructed on a (software) to measure canal volume changes, efficiency and practicality of each method.

Results: regarding canal volume change, results showed no statistically significant difference between file retrieval techniques whether ultrasonic or zumax. The highest mean value was recorded by Group A ultrasonic group 37.5610 ± 11.64880 in Comparison to Group B Zumax which recorded a mean value of 36.5370 ± 12.79829 at the p-value level set at 0.05*. Regarding efficiency, this study showed that instrument retrieval attempts using ultrasonic technique is more efficient than zumax instrument retrieval kit. Regarding practicality, results showed a statistically significant difference between ultrasonic and zumax measurements with p-value set at 0.000000003. The mean of the Ultrasonic group was 30.2000 ± 0.9613 while the zumax group recorded a higher. Mean of 40.6000 ± 0.5251

Conclusion: micro trepan technique made more changes in canal volume than ultrasonic technique. Moreover, ultrasonic technique showed more efficiency and practicality than microtrepan technique.

Keywords: Broken file, Retrieval, Zumax, Ultrasonic, ET-25.

Introduction:

Endodontics is considered a crucial branch of dentistry. It is the study of the structure, function, and health of the tooth pulp and periapical region, as well as the associated pathosis, with an emphasis on preventive and therapeutic management[(1)]. As with all other fields, endodontics has profited from a number of scientific and technological developments that have resulted in the development of nickel-titanium (NiTi) rotary devices, which have led to a significant revolution in dental treatments[(2)]. Thus, it can only be expected that this technology has been used extensively

in recent years; the notion of biomechanical shaping of the root canal and creation of new approaches that can eliminate some harmful practices of traditional endodontics were increased because of such innovations[3].

Despite the advantages of NITI files, concerns among endodontists grew because of the high incidence of file fractures in root canals[4]. It is advised to attempt to remove the fragment in order to thoroughly clean and shape the root canal system if it is located in the middle or coronal thirds of the canal, or if it is positioned before the curve and there are favorable conditions, such as sufficient root dentine thickness[3]. Although there is no standardized technique for managing instrument separation, there are various approaches to overcome this mishap with varying degrees of efficiency, including the Masserann kit, instrument removal system, Taruchi loop, BTR pen, Zumax retrieval kit, and ultrasonic procedure[5].

Using an operating microscope for dental procedures with ultrasonic tips is one of the most common methods[6]. This technique involves using specifically designed tips to trephine the dentin around the fractured file in an anticlockwise motion until the broken instrument gets loose and jumps out of the canal[5]. The broken instrument removal kit from Zumax employs a tube technique to grasp and extract the fragment with three various sized trephine burs, an extractor, and a tweezer with a crab-claw tip[5].

This study's objective was to assess the Ultrasonics and Micro-extractor in removing fractured fragments concerning the following variables: loss of radicular dentin through measuring volumetric dentin loss using CBCT, rate of removal, and the time consumed for removal to evaluate efficacy and practicality of each device. The adopted hypothesis was that the trepan bur and micro-forceps technique would result in less radicular dentin loss with easier steps and more time conservation.

Materials and methods:

-Ethical committee approval

This research was approved by the ethical committee of The British University in Egypt faculty of dentistry with research approval number: FD BUE REC 21-014

-Sample size calculation:

A power analysis was designed by adopting an alpha level of (0.05) a beta of (0.2) i.e., power=80% and an effect size (d) of (1.51) calculated based on the results of Yang, Qian, et al[7]; the predicted sample size (n) was a total of (16) samples per group. Sample size calculation was performed using G*Power version 3.1.9.7.

-Teeth Collection:

Mandibular Molars that were extracted due to periodontal disease and caries were collected at The British University in Egypt (BUE), Faculty of Dentistry, the Oral Surgery Department after taking the approval of patients who had extraction procedures. The teeth were cleaned using Ultrasonic scaler, disinfected in 0.4% thymol for 24 hours[7], and then stored in distilled water with thymol at room temperature to be used within 3 months[8]. Mandibular molars were embedded in a wax block and were scanned[9] to get preoperative CBCT to select 32 molars according to the following criteria; The teeth selected had mesiobuccal canals that were comparable in length, shape, size (3-5 mm canal radius), curvature (25-35 degree)[10].

-Specimen preparation:

Traditional endodontic access cavities were created using a round carbide bur mounted in a high-speed hand piece under copious water coolant, with the roof of the pulp chamber completely removed to allow straight line access to the canal orifices and walls flared with tapered stone with rounded ends[11]. Orifice opener (size 17/0.12) was then used to make coronal third enlargement up to 4 mm of cervical root canal[12]. After coronal flaring K files size 10, size 15, and size 20 were used to check the glide path and gain patency[13]. Then instrumentation was made using endo endo rotary motoy(Econnect Pro, Eighteeth) set at speed 350 RPM and torque 2 rotary using file size 20/0.04, and irrigation sodium hypochlorite (NaOCL) 5.25% was used for one minute between each file and 2nd CBCT was made to record canal volume after instrumentation[7].

-Instrument separation:

It was planned for the instrument to be broken 5mm apical to the orifice. To achieve that Fanta AF blue rotary file size 25/0.04 was notched 4mm from its tip to half its thickness using low speed diamond disk with thickness of 0.3mm[14]. The notched files broke 5mm apically from the canal orifice when the notched instrument touched the dentin wall of the canal. This procedure

was employed using the same rotary motor at speed of 250 rpm. A third CBCT was made to confirm the site of the broken instrument in the canal[7]. Creation of a staging platform was made using a dental microscope and a Gates Glidden burs (no 1, 2, 3) to observe the most coronal aspect of the broken instrument, a coronal enlargement of the canals in the shape of a funnel was carried out. A staging platform was then set up at the most coronal aspect of the broken instrument using modified Gates Glidden burs (no. 3) [15].

-Sample grouping:

Selected teeth were randomly divided in two groups (n=16) according to file retrieval method: Group (A) (control group) where the broken segment was retrieved by ET-25 ultrasonic tips. While group (B) the broken segment was retrieved by micro-extractor (Zumax broken file retrieval kit).

The procedure of retrieval was carried out under a dental operating microscope at a magnification of 16X. Using a stop-watch timer, the time needed to complete the entire procedure was recorded, starting from the staging platform step until the retrieval was completed, and the allotted time limit was 45 minutes. The trial was considered unsuccessful if the separated fragment wasn't removed within 45 minutes[5].

- **Group A (Ultrasonic):**

To loosen and release the fragment from the canal, dentin surrounding it was trephined 1–1.5mm deep using fine ultrasonic tips (ET25) in an anti-clock wise direction. In order to have enough energy without breaking the ultrasonic tips, the ultrasonic generator's power was set at 6[16,7]. To ensure continuous vision of the electrified tip around the damaged instrument, all ultrasonic operations below the orifice was carried out in a dry environment[17].

- **Group B (Zumax broken file retrieval kit):**

Following the previously mentioned steps to create the staging platform, a 1- to 1.5-mm length of the fragment was exposed using a trephine bur (Zumax retrieval kit) with 0.8, 1.0, and 1.2-mm diameters. The bur was then rotated by an endodontic motor in a counter clock wise direction (500 rpm). The micro-extractor device was used to remove the fragment if the broken

instrument could not be made loose simply by using the trephine bur. The operator who performed all instrument removal attempts was the same[18].

-Postoperative CBCT (4th CBCT):

Following the removal of the instruments, all teeth were rescanned utilizing CBCT imaging with the previously stated scanning parameters. Preoperative (2nd CBCT) and postoperative CBCT(4th CBCT) scans were constructed using 3D slicer software to evaluate canal volume change[19].

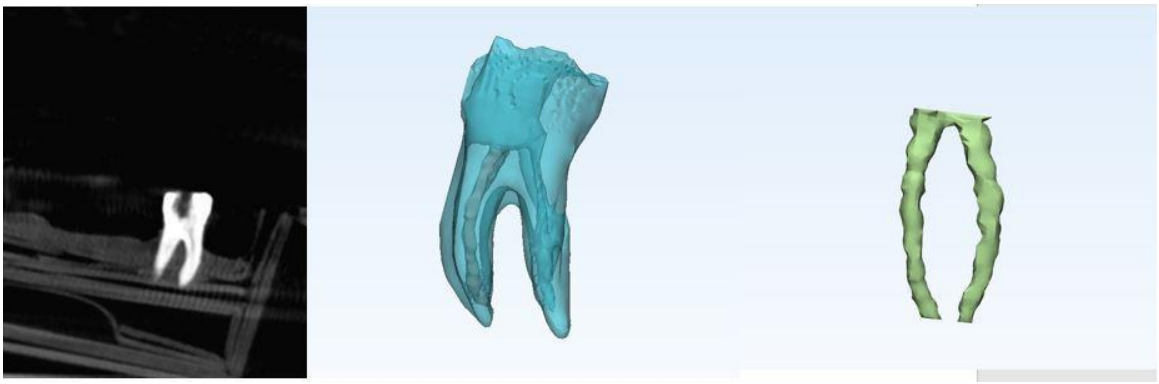

Figure 1: Image showing phases of inverting CBCT into segmented sample and extracting canal volume through 3D slicer program

-Sample assessment:

Canal volume changes and its reflection on dentin loss was measured through volumetric changes of the canal in mm3 before and after file retrieval by constructing the 2nd CBCT and post removal CBCT on 3D slicer then measuring the canal volume on each CBCT.

Efficiency was measured in percentage by calculating the number of successful attempts of each device from the total number of attempts. Perforations, ledges and fractured file pushed in the apical third were excluded,

Practicality was measured by time in minutes needed to perform successful instrument retrieval and presence of statistical difference between each device. Each attempt that exceeded 45 minutes considered failure and was replaced.

-Statistical analysis:

Statistical analyses were performed using Microsoft Excel and IBM SPSS Statistics. The normality of the data was assessed using the Kolmogorov-Smirnov (KS) test, and all datasets were found to be normally distributed. For the comparison of preoperative and postoperative canal volumes (measured in mm^3) within each group, a paired-samples t-test was conducted. Additionally, a third paired-samples t-test was performed to compare the means of the volumetric changes between the two groups

Results:

I. Canal Volume changes:

No statistically significant difference between File retrieval techniques using Ultrasonic and Zumax groups. The highest mean value was recorded by Group A 37.5610 ± 11.64880 in Comparison to Group B which recorded a mean value of 36.5370 ± 12.79829 at the p-value level of significance set at 0.05* (table 2, 3).

Table 1: Paired Differences between ultrasonic and Zumax

	Mean	Standard Deviation	P Value
Ultrasonic_Vol_diff - ZumaxVol_diff	**1.02400**	**10.42085**	**0.665**

p-value level of significance set at 0.05*

Table 2: showing Group A and Group B mean and standard deviation of preoperative and postoperative volumetric change

	Mean	Standard Deviation
US	**37.5610**	**11.64880**
ZX	**36.5370**	**12.79829**

II. Efficiency

Retrieving using ultrasonic tip ET-25 showed 84.2 % success rate. While retrieving using Zumax instrument retrieval kit showed 72.7 % success rate. This study showed that instrument retrieval attempts using Ultrasonic technique is more efficient than Zumax instrument retrieval kit.

III. Practicality

Results showed a statistically significant difference between Ultrasonic and Zumax measurements with p-value level of significance set at 0.000000003. The mean of the Ultrasonic group was 30.2000 ± 0.9613 while the Zumax group recorded a higher. Mean of 40.6000 ± 0.5251.(table 4)

Table 3: paired differences between ultrasonics and zumax in minutes

	Mean	Standard Deviation	p value
Zumax mins – Ultrasonic min	**10.40000000**	**4.45326610**	**0.000000003**

P value 0.000000003

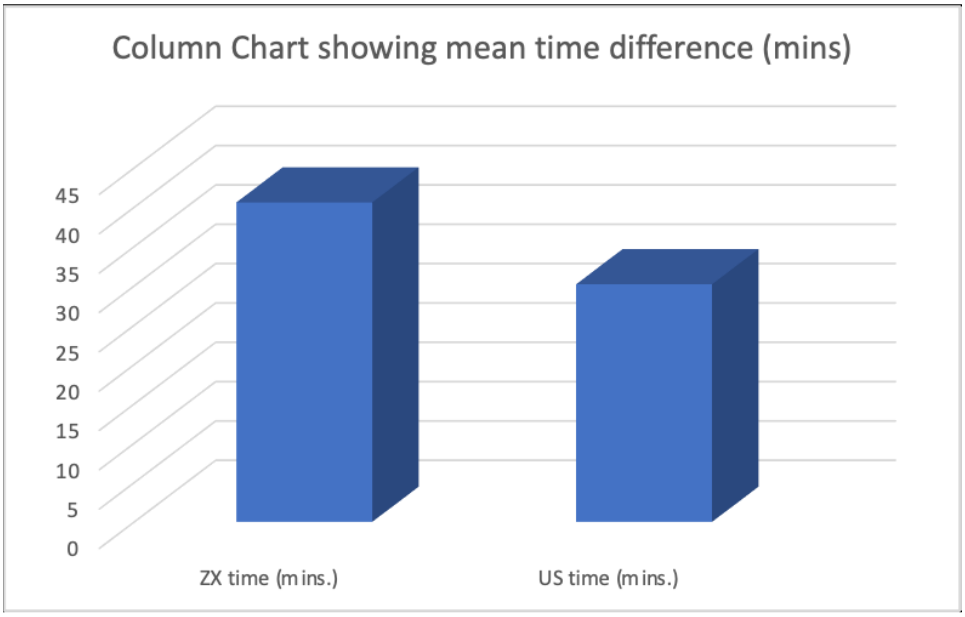

Figure 2: Bar chart showing mean time difference between zumax and ultrasonic

Discussion:

The retrieval of a separated endodontic instrument is considered a difficult technique. Furthermore, this treatment put the root structure at significant risk of perforation and vertical fracture[20]. The remaining structures must be able to withstand vertical forces applied during obturation. This must be considered prior to such an operation when the instrument is positioned

in roots of low thickness, such as lower molars, where the distal wall thickness of the mesial root is around one mm^3 in a pre-prepared canal.[21]

Several instrument retrieval kits are now available in market trying to overdue this problem, recently zumax medical co. introduced the zumax file retrieval kit which according to what manufacturer claimed have the advantage of retrieving fractured file with limited amount of removed dentin from canal walls[22].

When instruments were subjected to experimental cyclic stress fracture at the site of maximal flexure, which corresponds to the canal's greatest curvature occurred. Files broke with fewer rotations when the radius of curvature decreased, or the angle of curvature increased; comparable results have been recorded for different instrument types So, File breakage was made 5 mm apical from the canal orifice[23].

Human molars were utilized as the source of this study's samples because instrument separation occurs most frequently during molar treatment (77% to 89% of all instances). And lower molar treatment had a higher chance of separation (50%-55%), compared to upper molar treatment (25%-33.3%)[24].

In terms of lower molars, mesial root canals have a distal and buccolingual curvature. In fact, the mesio buccal root canal's lingual curvature is more severe than its buccal curvature. As a result, instrument separation occurs three times more frequently in mesio buccal root canals than in mesio lingual ones[25,26]. So mesio buccal canal of lower molars has been chosen to be the sample for this study.

The literature acknowledged that micro-CT and CBCT were superior procedures for assessing the amount of removed dentin[27]. However, Xu et al[19] discovered that evaluating dentin removal with CBCT images was more accurate and practicable than utilizing micro-CT, which had limited availability. In this study, CBCT was utilized to assess changes in the canal volume after removing broken instruments[5]. Four CBCT images were taken to assess the canal volume changes before and after file removal. The first CBCT was preoperative to confirm teeth anatomy, second CBCT was after instrumentation to file size 20/0.04 of the canal, Third CBCT was after file breakage, Fourth CBCT was post operative after file retrieval.

Regarding canal volume assessment, it was measured through finding the difference in canal volume before and after file retrieval[28], this was carried out through constructing the 2nd CBCT and 4th CBCT on computer software (3D slicer) to get accurate measurements of the canal volume. results showed no statistically significant difference between file retrieval techniques using ultrasonic and Zumax groups. The highest mean value was recorded by ultrasonic group 37.5610 ± 11.64880 in Comparison to Zumax group which recorded a mean value of 36.5370 ± 12.79829 at the p-value level of significance set at 0.05*

These results were in agreement with Alomairy[29] who concluded no statistical significant difference between the ultrasonic and instrument removal system in terms of the canal volume change. Moreover, Matoses et al[14] found that there is no difference in amount of dentin removed between the ultrasonic and endo rescue appliance.

On the other hand, Yang et al[7] found that the ultrasonic technique had significantly more impact on canal volume, and furcal root dentin thickness change than the micro trepan technique this might be due to file employed in their study which was rotary files size 25 taper 6% that needs more removal of dentin during shaping before retrieval.

Regarding efficiency, this study aimed to discover the efficiency of both procedures through measuring the percentage of success of each procedure, this study showed that instrument retrieval attempts using Ultrasonic technique was more efficient than Zumax instrument retrieval kit. The results of the current study revealed that in ultrasonic group, a total of 16 fragments were removed and 3 fragments failed to be removed, resulting in a success rate of 84.5%. Similarly, in the Zumax kit group, a total of 16 fragments were successfully removed and 6 segments failed to be removed, yielding a success rate of 72.7%. The high success rate in both groups might be attributed to the fact that the fragments were visible under the dental operating microscope[5].

These results were in accordance with Alomairy[29] as he found that the overall success rate for removal of fractured instrument fragments in this study was (80%) removed by the US technique and (60%) were removed with micro tube technique.

These results were different than Barakat and Attia[5] who found that zumax had a success rate of 90% and superior to BTR. This can be attributed to the different retrieval kits (BTR pen) and sample size used in their study.

Regarding practicality, the maximum retrieval time for the separated instruments was 45 minutes. This was in accordance with Suter et al, who recommended a retrieval time of 45 to 60 minutes due to the possibility of operator fatigue or excessive dentin removal, which can lead to higher risks of perforation[5]. Results showed a statistically significant difference between Ultrasonic and Zumax measurements with p-value level of significance set at 0.000000003. The mean of the Ultrasonic group was 30.2000 ± 0.9613 while the Zumax group recorded a higher mean of 40.6000 ± 0.5251

The result of this study agreed with Terauchi et al[30] who found, 89.8% of the instruments were removed in an average of 221 seconds utilizing only ultrasonic instruments. The length of the instrument and the curve of the root canal both affected how long it took to remove the instrument. Furthermore, preparation durations increased proportionately as separated instrument lengths increased and as the loop device became necessary.

These results contradicted Alomairy[29] who found no statistical difference between the two devices and this could be attributed to the absence of standardization of the curvature of the sample. Also Barakat and attia[5] found a statistical difference between Zumax kit and the BTR pen, where the mean ~~of~~ time of retrieval using the Zumax kit was less. This could be attributed to the change of the sample size and to the fact that they compared Zumax to a different retrieval method.

The results of this study disclosed that the US group showed less canal volume, better efficiency and practicality than Zumax group. Therefore, the initially suggested hypothesis was rejected.

Conclusion:

Broken file retrieval using ultrasonic tip et-25 showed less canal volume changes before and after broken file retrieval, more efficiency and practicality than zumax broken file retrieval kit.

Conflict of interest:

Authors have no conflict of interest to declare.

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