

MINIMALLY INVASIVE MANAGEMENT OF SEPARATED INSTRUMENTS IN CANALS WITH TYPE II VERTUCCI'S CLASSIFICATION: PROSPECTIVE RANDOMIZED CLINICAL STUDY

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ABSTRACT

Aim: The aim of this study was to compare the outcome of minimally invasive approach (MIA), retaining the separated in one root canal, cleaning and shaping of portals of entry of the two canals and portal of exit of both canals through the other patent canal, in comparison to the outcome of retrieval of the broken instrument by ultrasonics retrieval techniques (URT).

Materials and Methods. Ninety-six study cases with separated instruments were selected in canals with type II Vertucci's classification. The cases were randomly divided into two groups; group (C): conservative root canal retreatment in which the canal with broken file was negotiated to the coronal level of the separated instrument without any attempt of retrieval and group (T): traditional root canal retreatment in which attempt to retrieve the separated instrument was done using ultrasonics and available instrument retrieval systems. The peri-radicular condition was evaluated radiographically using the Periapical Index (PAI) for one year. The Chi-square test statistical tests analyzed the outcome data.

Results. At the baseline examination, there was no significant difference between the two groups regarding the patients' baseline mean periapical indices. After one year, we found that the mean periapical index declined without a significant difference between the two groups.

Conclusion. Within the limitations of this study, it was concluded that conservative management of separated instruments in canals with type II Vertucci's classification is considered successful "minimally invasive alternative" as traditional management of the cases using ultrasonic attempts of retrieval.

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INTRODUCTION

Historically, different instrumentation techniques and instruments were developed, there have been numerous types of instruments that have been separated in root canals. The reported incidence rate of separated hand instruments vary between 0.25 and 6% (1,2). Occurrence of instrument separation during root canal treatment might lead to failure and affects the patients clinician relationship (3-5).

This incidence immediately deters the clinician from thoroughly cleaning and shaping of the root canal system, and thus the outcome of the treatment might be compromised. The clinician needs to assess out the merits and demerits of retrieval of such separated files (6).

File retrieval instrument systems such as the Ruddle IRS (Dentsply-Tulsa, OK, USA), the Masserann kit (Micromega, Besancon, France), Terauchi kit (Dental Engineering Laboratories, Santa Barbara, CA, USA), have been used in the retrieval of separated metallic objects from the canals. Methods for instrument removal involve the removal of dentin using rotary instruments, trephine burs, and ultrasonics. Many case reports have described the modified techniques for management of broken instruments in certain approach to ensure the retrieval of broken instruments with minimal removal of dentin. Several factors are involved when deciding how to deal with separated instruments wedged within the root canal. If removal is tried, the possibilities of success should be weighed against possible complications. The retrieval of the separated instrument can result in excessive loss of root canal dentin and leads to vertical root fracture. (7).

Many studies confirmed that the file retrieval procedures can significantly decrease the root strength and raise the possibility of root fracture. It has been found that trials of removal of these fragments usually end with the removal of a huge amount of root canal dentin, which leads to reduction of the root strength by 30 to 40% (8,9).

Several factors can cause VRF such as the insertion of posts, teeth anatomy, masticatory forces and the retrieval of fractured instruments from the root canal. During management of retained separated instruments, the ultimate objective is not only to remove the separated fragment but also to preserve the structural integrity and increase the survivability of the tooth. Many case reports have described the modified techniques for management of broken instruments in certain approach in order to ensure the retrieval of broken instruments with minimal removal of dentin (10,11).

Causes of separation of rotary instruments include variations in root canal anatomy, such as curving, re-curving, dilacerating, merging or dividing canals (12). Teeth with Type II Vertucci root canal configuration are having more incidence of instruments separation due the presence of an S-type double curvature.

The aim of this study was to compare the outcome of minimally invasive approach (MIA), retaining the separated instrument in one root canal, cleaning and shaping of portals of entry of the two canals and portal of exit of both canals through the other patent canal, in comparison to the outcome of retrieval of the broken instrument by ultrasonics retrieval techniques (URT).

MATERIALS AND METHODS

Patients Selection and Treatment Procedures

This multi-center, with a parallel design 2-arm randomized controlled trial was registered on www.clinicaltrials.gov (ClinicalTrials.gov ID: NCT05342246). The study protocol was approved by FDASU-REC (Faculty of Dentistry, Ain Shams University-Research Ethical Committee institutional review board (FDASU-Rec IR012249), and the study was performed according to all applicable laws and regulations, including the Declaration of Helsinki.

A blinded researcher performed the randomization, and another researcher performed the treatment. Another researcher blinded to the groups analyzed the data. Power calculation was performed using G*Power 3.1 software (2) (Heinrich Heine University, Dusseldorf, Germany). It indicated that the sample size for each group should be a minimum of 35 cases.

Ninety-six study subjects with separated instruments were recruited from 2 private endodontic clinics between March 2017 and February 2020. Patients were selected according to the following inclusion and exclusion criteria.

Inclusion criteria

- Presence of separated instrument in a root with a Vertucci's type II configuration (the level of the SI was evaluated using CBCT scans)
- Age range 35-55 years
- Teeth having a baseline periapical lesion (PAI score ≥ 2) in the affected root

Exclusion criteria

- Patients who refused to undergo radiographic follow-up.
- Pregnant females.
- Patients suffered from a systemic disease.
- Teeth with connected lesions.
- Teeth with root fractures or perforations.
- Teeth with lesion communicating with the alveolar crest.
- Patients with generalized chronic periodontitis or teeth that require periodontal surgery.
- Teeth with resorbed root apex.
- Teeth with a fiber post and teeth with canal curvature more than 25 degrees.

All cases were assessed using CBCT, CBCT images were obtained using Care Stream CS9300 (Carestream Dental LLC, Atlanta, GA, USA) with a voxel size of 0.09 mm, to determine the level of the separated instrument, the root canal configuration, and the existence of periapical infection.

All subjects signed a written informed consent after an oral explanation of the goal of the study, the procedures, benefits, and the potential hazards. The treatment choices presented to the patient included conventional nonsurgical retreatment (instrument retrieval maneuver), or conservative root canal retreatment (treating the patent canal), or extraction.

Two endodontists experienced over 10 years participated as investigators. The investigators confirmed that patient data were kept confidential. The clinical examination involved periodontal pocket depths measurement, mobility testing, the presence or absence of swelling, percussion, and palpation. Standardized parallel periapical radiographs were taken preoperative, postoperative, after six months and after one year of follow-up.

The cases were randomly divided into two groups of conservative root canal retreatment and traditional root canal retreatment. Randomization was done using <http://www.random.org>.

The group of conservative root canal retreatment designated as Group C. For each case in group C, profound anesthesia was administered, dental dam isolation was performed. Under a dental operating microscope (OPMI PICO; Carl Zeiss, Gottingen, Germany) and careful preoperative CBCT assessment, the subject tooth was accessed using a suitable-sized round diamond stone under copious water irrigation. The patent root canal was identified. The old root canal filling was removed using hand and rotary instruments aided solvents. Working length was re-established using an electronic apex locator and confirmed radiographically. Canals were then instrumented using Hy flex EDM file system using the sequence advocated by the manufacturers

with constant recapitulation using #10 file. Briefly, Orifice Opener (25/.12) was used till the middle third followed by #10 hand K-file and glidepath file (10/.05) till full working length then instrumentation on the full working length using Hy flex One file (25/~) till full working length. Each file was used with a brushing motion. An irrigation protocol consisting of 2.6% NaOCl in combination with ultrasonic agitation was used for canal disinfection. The other canal was negotiated to the coronal level of the separated instrument without any attempt of retrieval. The canals were dried using paper points and then obturated using the continuous wave compaction technique. The access was restored, and a postoperative radiograph was taken. Postoperative instructions were provided, and the patient was left for follow-up. Standardized parallel periapical radiographs were taken up to one year .

The group of traditional root canal retreatment designated as Group T. The same procedure was applied to all root canals. Attempt to retrieve the separated instrument was done using ultrasonics and available instrument retrieval systems. Technique described by Ruddle as follows: coronal straight-line access to the canal is ensured then a space is created using hand files to accommodate the Gates Glidden burs used to ensure a sufficient radicular access and a uniform tapering funnel to the obstruction. Modified Gates Glidden burs is then used to create a staging platform at the level of the head of the separated instrument. US tips is placed in intimate contact with the head of the file and operated on lower power in dry conditions with the aid of Stropko (to facilitate visualization) in CCW direction then the tip is gently wedge between the tapered file and canal wall. All canals were the cleaned, shaped and obturated in the same manner done in Group C.

The periapical radiographs were taken using a paralleling technique by an X-ray film holder (Rinn XCP; Dentsply, IL, USA). The X-ray machine

(CS2200; Carestream dental, Atlanta, GA, USA) was set at 60 kV and 7 mA, and exposure time for the periapical radiography ranged from 0.08 to 0.125s.

Clinical follow-up was performed at 1 week, , 6 months and after one year. In each clinical follow-up visit, examination, palpation and percussion test were performed. Radiographic follow-up with parallel technique was performed.

The peri-radicular condition was evaluated using the Periapical Index (PAI) created by Ørstavik et al. (1986)(3). The PAI includes five grades represented on an ordinal scale as follows: grade 1 - normal periapical structures; grade 2 - small changes in the periapical bone or bone structure; grade 3 - changes in the periapical bone structure with mineral loss, characteristic of apical periodontitis; grade 4 - demineralization of the periapical bone within a well-defined radiolucent area; and grade 5 - demineralization of the periapical bone with exacerbations and expansion in bone structure. The radiographs were evaluated individually by two examiners. Any disagreement within the evaluation of the cases was resolved by taking the average. The following cutoff points were defined to categorize the PAI values into health or diseased: grade 1 denoted no disease, and values from grades 2 to 5 indicated the presence of periapical disease.

Statistical analysis

Data were collected, tabulated, and statistically analyzed using SPSS software 20.0 (SPSS Inc, Chicago, IL, USA). Frequencies of qualitative variables were calculated using the Chi-square test.

RESULTS

Figure 1 shows the CONSORT flow diagram for this study. One hundred and fifty study subjects were initially selected. Fifty-four cases were excluded because forty-four cases don't meet the criteria and ten cases declined to participate. Ninety-six cases

were eventually included in the study and were randomly allocated to group C (48 cases) and group T (48 cases). The overall recall rate was 80.2% (77 of 96).

Basic patients' demographics were collected and tabulated in Table 1. Statistical analysis of patients' basic data confirmed that there was no significant difference between the two groups regarding sex (p=0.54), age (p=0.52), and type of teeth subjected

to treatment (p=0.615). There was no significant difference between the two groups regarding the patients' baseline mean periapical indices (p=0.543).

PAI distribution and mean periapical index recorded initially and after one year are tabulated in Tables 2 and 3. The mean PAI declined after one year without a significant difference between the two groups (p=0.678). Representative case of group C is shown in Figure 2.

TABLE (1) Cases distribution of the participants in both groups

		Group C	Group T	P- Value
Gender	Males	25 (52%)	22 (46%)	0.54
	Females	23 (48%)	26 (54%)	
Age (mean ± standard deviation)		42.7 ± 3.75	43.2 ± 3.82	0.52
Teeth	Maxillary Premolars	11 (23%)	9 (17%)	0.615
	Mandibular Molars	37 (77%)	39 (81%)	

**P<0.05 is considered significant*

Table (2) Periapical index (PAI) distribution initially (Initial score) and after one year of follow-up (Final score) of the tested groups

	Group C		Group T	
	Initial score	Final score	Initial score	Final score
PAI (1)	0 (0%)	32 (80%)	0 (0%)	31 (83.8%)
PAI (2)	8 (20%)	6 (15%)	8 (21.6%)	4 (10.8%)
PAI (3)	10 (25%)	2 (5%)	12 (32.4%)	2 (5.4%)
PAI (4)	18 (45%)	0 (0%)	16 (43.3%)	0 (0%)
PAI (5)	4 (10%)	0 (0%)	1 (2.7%)	0 (0%)
Total cases	n = 40		n = 37	

TABLE (3) Periapical index (PAI; mean ± standard deviation) initially (Initial score) and after one year of follow-up (Final score) of the tested groups.

PAI	Group C	Group T	P-value
Initial score	3.54 ± 0.87	3.43 ± 0.79	0.543
Final score	1.20 ± 0.50	1.16 ± 0.47	0.678

**P<0.05 is considered significant*

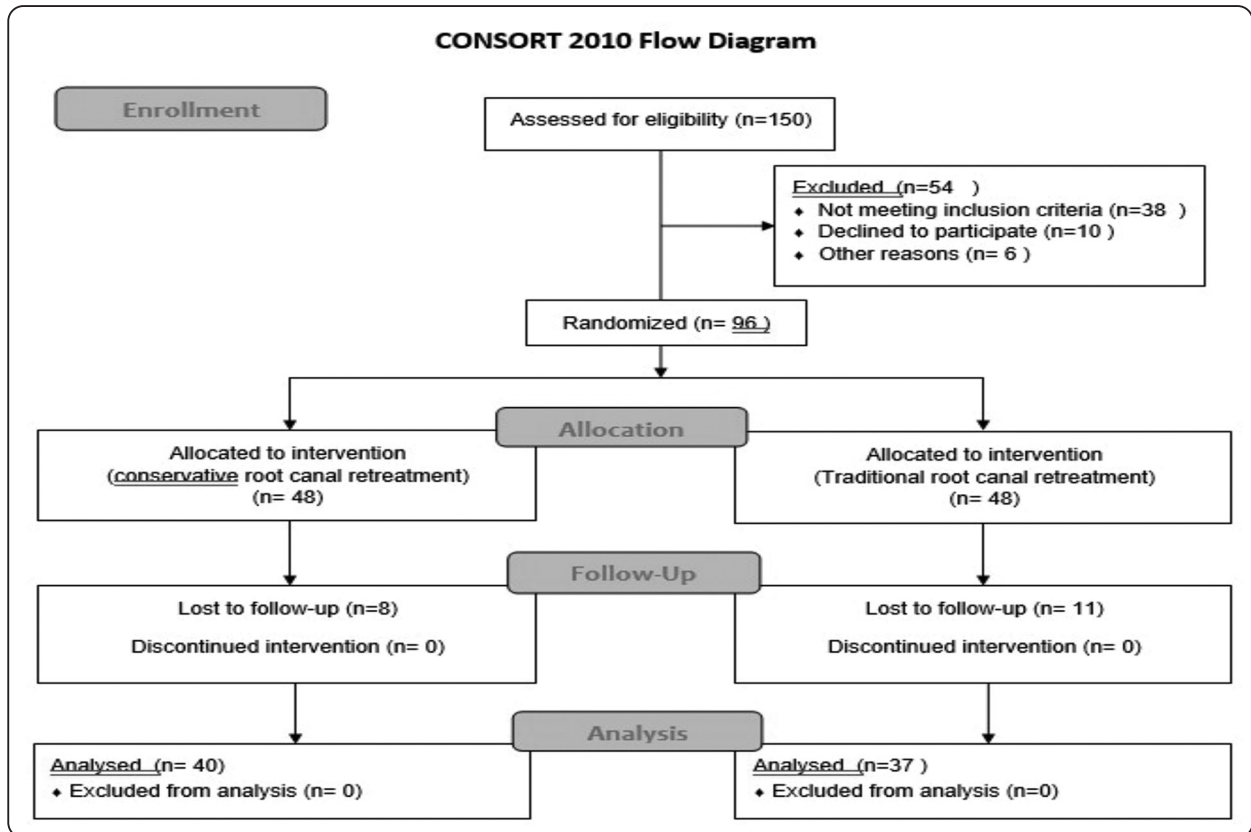


Figure (1): Consort flow diagram

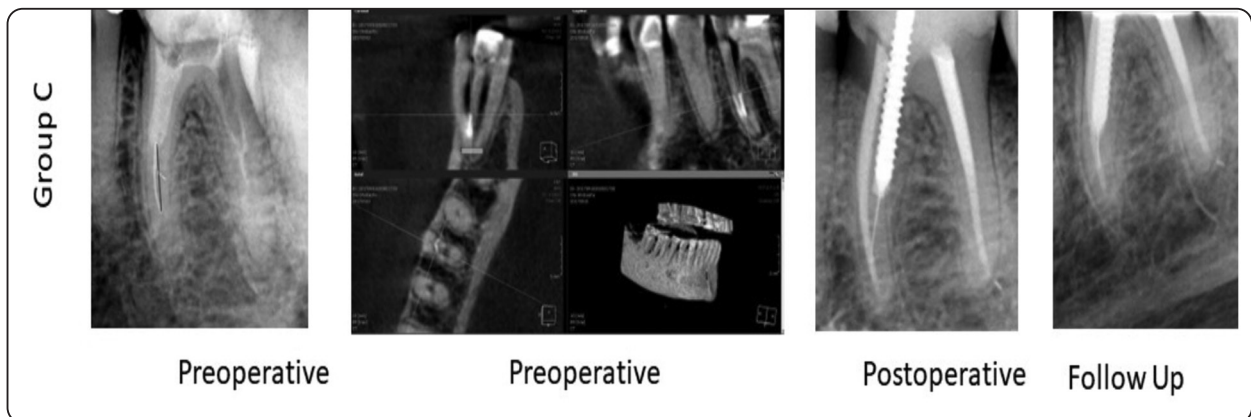


Figure (2): Representative case for group C

DISCUSSION

Vertical root fracture seems to be a more common reason for extraction of endodontically treated teeth currently than in the past. Scientific evidence supports the current principle that tooth survival is likely to be subjective to the distribution, amount,

strength and integrity of remaining tooth structure after root canal treatment (14,15). Minimally invasive techniques should be used in root canal surgical and non-retreatment; conservation of the root canal dentin can increase the long-term survivability of the teeth in the patient’s mouth(16).

Several methods have been suggested for removing or bypassing segments located inside the root canals (17).

The incidence of vertical root fracture was reported in some studies as high as 11 % and 20 %. (18,19) Routine root canal treatment procedures cause the loss of root canal dentine and expose the walls of the root dentine to multiple types of detrimental stresses. According to many studies, canal enlargement of the root width increased liability to vertical fracture. (20,21) Intraradicular post preparation (9) and using excessive pressure during root canal filling (22) can induce VRF and other dentinal defects. In vitro studies showed that the file removal procedures significantly lowered root strength and increased the risk of root vertical fracture. (3,8,23) The removal of a separated fragment from a root canal must be performed with minimum damage to the root dentin and the surrounding tissues (24,25).

Root canal configuration has an impact on the outcome of the root canal treatment. Vertucci type II had a lower incidence of periapical radiolucencies, which may indicate that in some cases satisfactory apical sealing is possible even if a technical error is present in 1 canal and the other has an appropriate filling(23).

In our study, no cases had vertical root fracture after one year; observation period, this might be because all of the retrieval procedures were done by experienced endodontists who were very careful not to sacrifice dentin as much as possible during retrieval in the traditional root canal retreatment group. Moreover, the teeth were strengthened by either crown or post-crown restoration following treatment.

The quality of root canal filling has an impact on the quality of root canal treatment. Some studies recommended that the quality of the root canal treatment was the most important element of the status of the periradicular tissues (26,27). In cases

of inadequate root canal treatment, there is a higher possibility for persistence or development of intraradicular infection, which is the primary cause of post-treatment disease. Our results indicated that quality of root canal filling was a significant factor affecting root canal retreatment outcome and not the present or absence of the broken instrument itself(28). It is confirmed in many studies that when cases were managed by skilled endodontists, prognosis was not significantly affected by the presence of a broken instrument retained inside the root canal (29,30). Therefore, whether the broken file is retrieved or not, endodontists should control intra-radicular infection and perform satisfactory root canal treatment to improve prognosis (22).

The major limitations of the research described in our study were the small sample size after dropouts and the short duration of the follow-up period, which might incorporate more healing cases than healed cases, but to our knowledge it is the first study to evaluate the success rates of management of broken instruments according to the root canal morphology(31). It is important to note that the main cause of loss to follow-up might have been the susceptible geographic area and absence of health systems that guarantee the follow up of the test subjects. In our opinion, if longer period of evaluation of the cases is done vertical root fracture would be of higher incidence in the traditional retrieval method group because of the shaping and enlarging done for the staging platform creation as a preparatory step done before ultrasonic application attempts for retrieval, also there is a great matter of inconsistency in the application of ultrasonics that might be attributed to root cross-section, the size of canals evaluated, preparation of staging platform, and force application technique (32,32).

Further studies for evaluating longer examination periods and comparing it to a more conservative retrieval approach as the one described by Terauchi will be very useful in determining the outcome

of retrieval in comparison to the treatment option proposed in our study.

Within the limitations of this study, it can be concluded that conservative management of separated instruments in canals with type II Vertucci's classification is considered successful "minimally invasive alternative" as traditional management of the cases using ultrasonics attempts of retrieval.

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