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Post operative pain and swelling evaluation following guided endodontic microsurgeries done using different treatment modalities. A clinical study

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Abstract:
Background: *The aim of the study was to evaluate the effect of Piezosurgery and Trephine bur as cutting tools on post-operative sequelae including pain and swelling following guided endodontic microsurgeries.*
Materials and Methods: *Twenty healthy male patients aged between 18 and 45 years old were selected in the study. Mandibular first molar teeth with failed non-surgical treatment or re-treatment due to iatrogenic errors at the apical 3mm of the mesial root canal including canal ledging, zipping and transportation, root perforation, separated instrument, and canal calcification were selected. Piezosurgery assisted cavity preparation and root-end resection were performed in Groups I and II, and Trephine bur assisted cavity and root-end resection was performed in Groups III and IV. An apical curettage was performed and the over-extended objects such as separated instruments or gutta percha were removed. The PRF clots was placed inside the bone cavity in groups I and III while the bone cavity was kept for 2 min to allow the blood clots to be formed in groups II and IV. The degree of pain and swelling were recorded for five days every 24, 48, 72, 96, and 120 hours postoperatively.*
Results*: All the postoperative pain assessment scores were comparable between the tested groups in different time points: there was no statistically significant difference between the median and range of the pain scores of Groups. Moreover, there was statistically significant in each single group when comparing median pain score over time ($p<0.001$). All the postoperative swelling assessment scores were comparable between the tested groups in different time points, at 72 h, there was Statistically significant difference between the median and range of the swelling scores of Groups I and Groups II, III and IV ($p= 0.043$).*
Conclusion: *Regarding the post operative pain assessment, there was statistically non- significant differences between groups, however Piezosurgery assisted cavity preparation technique with PRF improve the postoperative swelling.*

Key Words: *Endodontic Microsurgery, Piezosurgery, Trephine bur, PRF*

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I. Introduction

The outcome of endodontic surgery depends on several factors such as the site, size and extent of the bony cavities in addition to the techniques used for the osteotomy and root end-resection [(1,2)]. The extent and technique used for the osteotomy influence the degree of postoperative complications such as pain and swelling [(3)]. Also, increasing the cutting temperatures above 47 °C during surgical procedures, even for intermittent periods, leads to irreversible osteonecrosis that has a negative impact on the post-operative recovery time and complications [(4,5)]. The concept of guided endodontic microsurgery has been extensively investigated in recent years for minimally invasive, precise, and efficient osteotomy and root end resection [(6,7)] using either conventional tools such as surgical cutting burs or/and relatively recently cutting devices such as piezosurgery, trephine bur, and laser. The study aimed to evaluate the effect of Piezosurgery and Trephine bur as cutting tools on tissue recovery and post-operative sequelae including pain and swelling following endodontic microsurgeries.

II. Patients and Methods

This a randomized clinical trial was designed according to the guidelines stated by the Royal College of Surgeons of England (RCS) [(8)]. The study was approved by the Ethics Committee of the Faculty of Dental Medicine, Al Azhar University for Research on Human Subjects Number **722/1224.**

Study Design: Randomized clinical trial

Study Location: Endodontic department outpatient Clinics, Faculty of Dental Medicine, Al Azhar University, Cairo, Egypt.

Study Duration: September 2018 to September 2022
Sample Size Calculation: According to the power analysis of the study the minimum sample size was 4 patients in each of 4 groups which has an 80 % power to detect a difference between means of 0.099 with a significance level (alpha) of 0.05 (two-tailed).
Sample size: Out of Fifty-two patients, Twenty patients were selected.
Selection of the Patients: Twenty healthy male patients aged between 18 and 45 years old were selected from the outpatient clinic of the Endodontic Department, Faculty of Dental Medicine, Al Azhar University, Cairo, Egypt to be included in the study. The selected patients have no general medical contraindications for oral surgical procedures (Scores 1–2) according to the classification of the American Society of Anesthesiologists (ASA) [(9)].
Inclusion criteria: Mandibular first molar teeth were selected according to specific inclusion criteria including:
1. Teeth presented with failed non-surgical treatment or re-treatment. Failure is due to iatrogenic errors at the apical 3mm of the mesial root canal including canal ledging, zipping and transportation, root perforation, separated instrument and canal calcification.
2. Teeth presented with normal pocket depth ranges from 1 to 3mm, up to grade II tooth mobility.
3. Teeth presented without periapical radiolucency (Class A) or with periapical radiolucency not more than 1 mm in diameter both mesiodistally and buccolingually (Class B) according to the preoperative endodontic microsurgical classification of teeth [(10)].
4. Teeth presented with non-fused mesial and distal roots and the mesial roots are range from 10 to 15 mm. in length, Type III root canal configuration (Two canals run separately from orifice to apex) [(11)]. The root canal curvature angle was measured using the Weine technique [(12)] to be not less than 160° in both directions buccolingually and mesiodistally.
5. At the apical 3 mm of the mesial radiographic root apex, the distance from the outer surface of the buccal cortical plate of bone to the buccal side of the mesial root is 1.5 ± 0.5 mm (**Depth I)**. The buccolingual dimension of the mesial root is 7 mm ± 2mm **(Depth II)**. The distance from the lingual surface of the mesial root to the outer surface of the lingual cortical plate of bone is 3.5 ± 0.5 mm. **(Depth III)**.

Procedure methodology: The selected patients have signed a written informed consent after exploring all steps of the study. The patients were informed about the protocol of emergency in case of serious complications during the surgical intervention. Preoperative cone beam computed tomography scanning was performed under standard specifications (3D PLANMECA Cone Beam) (Voxel size 250μm, FOV: 110 mm, 120 kV, 5 mA, 9 s) (PLANMECA ROMEXIS ® 3d Viewer). All steps of the non-surgical/surgical endodontic management were carried out under varying degrees of magnification (8X–16X) using a dental operating microscope (S2350, Zumax Medical Co. China). The iatrogenic errors at the apical 3mm of the mesial root canals were categorized and managed as follows: The **1st visit**, The working length and width were measured at the level of the coronal extent of the iatrogenic errors at the mesial root and measured at 0.5 mm from the radiographic apex at the distal root by digital periapical radiographs. The canals were instrumented using rotary files system protaper next (Dentsply Maillefer, Switzerland) to a file size # X4 using a brushing motion filling technique accompanied with 5% sodium hypochlorite irrigation. an orthograde MTA (TehnoDent., Russia) was mixed with normal saline and applied using MTA applicator (MAP One, Switzerland) into the mesial canals and compacted using different size pluggers to a level 6 mm. from the radiographic apex. The **2nd visit**, all canals were irrigated, dried and obturated using vertical compaction technique followed by restoration of the teeth using bonded composite restoration (Polofil Nht. Voco. Germany). A surgical stent was virtually designed and fabricated to locate the appropriate osteotomy site, the mesial root apex of the mandibular first molars precisely and the 3 mm apical resection level of the root ends and the lesion area (In case of 1 mm. periapical lesion).

Grouping and Randomization of the patients: the selected patients were divided into four groups (n = 5) according to the type of cutting tools during bony cavity preparation and root end resections in addition to the type of bony cavity filling material. Randomization of the selected patients was done by giving each patient a number from 1 to 20. The patient numbers were submitted in a Research Randomizer software (www.randomizer.org) for blind distribution of the selected patients in each group.

- **Group I:** Piezosurgery assisted cavity preparation and the bony cavity was filled with PRF.
- **Group II:** Piezosurgery assisted cavity preparation and the bony cavity was filled with blood clots.
- **Group III:** Trephine Bur assisted cavity preparation and the bony cavity was filled with PRF.
- **Group IV:** Trephine Bur assisted cavity preparation and the bony cavity was filled with blood clots.

The preoperative pain assessment of selected patients was done by the operator according to a scale modified from the verbal descriptor scale (VDS) described by Mathias Haefli [(12)]. The VDS consist of a scoring system translated into Arabic, which describes a list of adjectives describing the different level of pain from (none) to (Worst pain). The operator marked the adjective which fits the pain intensity according to the patient's own words. The odd numbers represent the intermediate pain intensity among the main pain levels. Patients with a score level (0 - 6)

were included in the study **(Table 1).** The preoperative swelling assessment of selected patients was done by the operator according to a swelling assessment scale. The swelling assessment scale consist of a scoring system describes a list of adjectives describing the different level of swelling from (none) to (severe) **(13)**. Patients with a score level (0) were only included in the study **(Table 2).**

Score	Pain intensity	Description
0	**No pain**	Tooth felt normal
2	**Mild pain**	Low pain intensity + no need for analgesics
4	**Moderate pain**	Higher pain intensity than mild pain level (tolerable) + may need non-steroidal anti-inflammatory drugs (nsaid) analgesics.
6	**Strong pain**	Strong pain intensity that disrupts sleep + need (nsaid) analgesics
8	**Severe pain**	Severe pain intensity that disrupts normal activity (eating, walking, sports activity, etc.) And/or sleep + no effect of (nsaid) administration
10	**Worst pain**	Severe pain that disrupts normal activity and/ or sleep + general symptom manifestation including fever and weakness + need antibiotics and narcotic analgesics.

Table (1): Showing level of pain assessment.

Score	Status	Criteria
Score 0	**None**	**No swilling.**
Score 1	**Mild**	**Intraoral swelling confined to the surgical field.**
Score 2	**Moderate**	**Extraoral swelling confined to the surgical field.**
Score 3	**Severe**	**Extraoral swelling spreading beyond the surgical field.**

Table (2): Showing level of swelling assessment.

Surgical Intervention:

Platelet-rich-fibrin (PRF) preparation was performed for those patients that were included in groups **I** & **III**. Standard inferior alveolar nerve anesthesia technique accompanied by long buccal nerve block anesthesia was performed. Two carpules of local anesthesia solutions lidocaine 4% adrenaline 1:80.000 (Septodent, Lignospan, France) were used through a 27-gauge long needle mounted in a dental syringe. A submarginal flap with one vertical releasing incision was performed using a carbon steel surgical scalpel blade no. 15c (Swann Morton, Sheffield S6 2BJ, England).

A full-thickness flap was reflected, and the surgical guide was fitted in its position, retracting the soft tissue flap and check. The osteotomy and root end resection were performed in an intermittent liner motion till reach the **Depth S**. For Groups **I, II:** A piezosurgery assisted cavity preparation was performed using a **IM4A** Piezosurgery tip mounted in the handpiece of a Piezosurgery device (PIEZOSURGERY® touch, Mectron, Carasco, Italy) at an operating frequency in the range of 24 to 36 kHz with power ratings 55 W. For Groups **III, IV:** A trephine bur assisted cavity preparation was performed using a **TPB-4** trephine bur mounted in 20:1 contra angled handpiece of an implant motor (ImplaNX, Micro-NX, Republic of Korea) at an operating speed of 1200-1500 RPM / Torque 20 N. The resected root end and bone fragments were removed. An apical curettage was performed and the over-extended objects such as separated instruments or Gutta Percha were reached and removed. The osteotomy site was copiously irrigated using normal saline. The PRF clot was placed inside the bone cavity in groups I and III using tissue forceps and packed to the level of the buccal cortical plate of bone. In groups II and IV, the bone cavity was kept for 2 min to allow blood clots to be formed inside the bone cavity to the level of the buccal cortical plate of bone. An interrupted suturing technique was performed using a 4-0 poly-tetra-fluoroethylene coated monofilament suture (PTFE) and 3/8 circle reverse cutting needle (Maxima, Henry Schein, NY, USA).

An immediate post-operative CBCT scans were taken under standard specifications. Post-operative instructions were given as follows; Compression with ice was performed by patients in the surgical zone for the first (4 – 6 hours) postoperatively. The patients were instructed to rinse their mouth twice daily with chlorhexidine 0.2% mouth rinse for 1 week and a soft diet was advised during the postoperative period. The patients returned after 96 hours postoperatively for suture removal. The patients been have prescribed an oral analgesic (ibuprofen 600 mg) as needed and instructed to not take the analgesic before asking/send to the operator and no postoperative antibiotic therapy was prescribed.

Postoperative Evaluation:

1. The primary outcome of this study is the assessment of postoperative pain using the modified verbal descriptor scale (VDS). The postoperative pain assessment was done for five days for each patient every 24, 48, 72, 96, and 120 hours postoperatively. Patients were initially instructed to use the VDS and the description of each level of pain intensity was explained in detail (Score 0-10).

2. Postoperative swelling degree was recorded by the patient for five days every 24, 48, 72, 96 and 120 hours postoperatively using the swelling assessment scale.

Statistical analysis: Data was collected, tabulated, and statistically analyzed. Data management and statistical analysis were performed using the Statistical Package for Social Sciences (SPSS) version. 27. Numerical data were summarized using median and range Data were explored for normality by checking the data distribution and using Kolmogorov-Smirnov and Shapiro-Wilk tests. Comparisons between the 4 groups were done by Kruskal Wallis test followed by Dunn post hoc test. All p-values are two-sided. P-values <0.05 were considered significant

III. Results

1) The postoperative pain assessment score:

A. All the pain scores were comparable between the tested groups in different time points **(Table 3).**

- **At 24 h**, there was no statistically significant difference between the median and range of the pain scores of Groups I, II, III and IV (p= 0.102).
- **At 48 h,** there was no statistically significant difference between the median and range of the pain scores of Groups I, II, III and IV (p= 0.368).
- **At 72 h,** there was no statistically significant difference between the median and range of the pain scores of Groups I, II, III and IV (p= 0.954).
- **At 96 h,** there was no statistically significant difference between the median and range of the pain scores of Groups I, II, III and IV (p= 0.227).
- **At 120 h,** there was no statistically significant difference between the median and range of the pain scores of Groups I, II, III and IV (p= 0.824).

B. Comparing median pain score over time in each single group was statistically significant (p<0.001)

	Group I	Group II	Group III	Group IV	P value
	Median (range)	Median (range)	Median (range)	Median (range)	
Pain					
24 H	0(0-2)	0(0-2)	0(0-2)	2(0-4)	0.102
48 H	2(0-4)	2(2-4)	2(0-4)	4(2-6)	0.368
72 H	4(0-4)	2(0-4)	2(2-4)	2(0-6)	0.945
96 H	0(0-2)	2(0-4)	2(2-2)	0(0-4)	0.227
120 H	0(0-2)	0(0-2)	0(0-2)	0(0-2)	0.824

P<0.05 is statistically significant, analysis done by Kruskal Wallis test

Table (3) : Median and range of pain score at different time points in the tested groups

2) **The swelling assessment scale:** All the swelling scores were comparable between the tested groups in different time points **(Table 4).**

- **At 24 h,** there was no statistically significant difference between the median and range of the swelling scores of Groups I, II, III and IV (p= 0.168).
- **At 48 h,** there was no statistically significant difference between the median and range of the swelling scores of Groups I, II, III and IV (p= 0.053).
- **At 72 h,** there was Statistically significant difference between the median and range of the swelling scores of Groups I and Groups II, III and IV (p= 0.043).
- **At 96 h,** there was no statistically significant difference between the median and range of the swelling scores of Groups I, II, III and IV (p= 0.071).
- **At 120 h,** there was no statistically significant difference between the median and range of the swelling scores of Groups I, II, III and IV (p= 0. 0.367).

	Group I	Group II	Group III	Group IV	P value
	Median(range)	Median(range)	Median(range)	Median(range)	
Swelling					
24 H	0(0-1)	1(0-2)	1(0-1)	1(0-1)	0.168
48 H	0(0-1)	1(1-2)	1(1-2)	1(1-3)	0.053
72 H	0(0-2)[a]	2(1-2)	2(1-2)	2(2-2)[a]	**0.043**
96 H	0(0-1)	1(0-1)	1(0-2)	1(1-1)	0.071
120 H	0(0-1)	0(0-1)	1(0-1)	1(0-1)	0.367

P<0.05 is statistically significant, a: Similar lower case are statistically significant, analysis done by Kruskal Wallis test

Table (4) : Median and range of swelling score at different time points in the tested groups

IV. Discussion

Endodontic microsurgery on mandibular molars remains a great challenge for clinicians. This can be attributed to the difficult accessibility, and the thickness of the buccal bone, in addition to the close relation to anatomical neurovascular structures including the mental foramen, and inferior alveolar nerve which may pose potential risks of complications [(14)]. The concept of guided endodontic microsurgery has been extensively investigated in recent years for minimally invasive, precise, and efficient osteotomy and root end resection [(7,15,16)] using either conventional tools such as surgical cutting burs or/and relatively recently cutting devices such as piezosurgery, trephine bur, and laser [(17)].

This is a randomized clinical trial was done to evaluate the effect of piezosurgery and trephine bur as cutting tools on the post operative clinical outcomes following endodontic microsurgery in addition to their effect on tissue recovery. Regarding patient selection, out of fifty-two healthy male patients, twenty patients were selected to be included in the study. The selected patients have no general medical contraindications for oral surgical procedures (Scores 1–2) as patients with various systemic complications that affect the post operative clinical outcomes and healing [(18)]. The patients were 18 and 45 years old for standardization purposes as the post operative pain is affected by age and healing process and remodeling occur to a lesser degree (the collagen formed is qualitatively different) [(19,20)]. **Van Dijk et al**, concluded that the postoperative pain after endodontic surgeries decreases with increasing age [(21)]. Only males were included in our study for standardization purposes as female patients in the menstruation period have functional impairment of the coagulation system (increased bleeding tendency) and periodic changing levels of serotonin and noradrenaline leading to increased pain prevalence (increase post-operative pain and swelling) [(22,23)]. Other research done in this field has also used healthy male patients with similar patients age range to evaluate bone healing and post operative clinical outcome [(24,25)].

Mandibular first molar teeth were selected in this study because they are the most commonly endodontically treated posterior teeth, and are more susceptible to iatrogenic errors including fracture instruments, ledging, and apical transportation even in the straight canals [(26)]. **Ungerechts et al.** [(27)] investigated the incidence of instrument fracture, they concluded that 39.5% of the separated instruments were in the mesiobuccal canals of the first mandibular molars and 76.5% of these instruments were located apically. **Ali et al.** [(25)] investigated that the post operative pain related to mandibular molars (6%) was significantly higher than maxillary molars (2.2%). The periapical radiolucency was from 0 to 1 mm in all directions for standardization purposes to be managed within the parameter of the osteotomy (4.0 mm in diameter). The CBCT scan was selected as it provides more accurate and imparts more diagnostic information than intra oral periapical radiographs [(28,29)]. The selected patients have signed written informed consent with a detailed explanation of the study and its potential risks because of the sensitivity to vital structures including the inferior alveolar nerve and mental canals. Informed consent is both an ethical and legal obligation to inform well enough to allow them to make a balanced decision and without written informed consent with a detailed explanation of the study is considered malpractice [(30,31)].

All steps of the non-surgical and surgical endodontic management were carried out under magnification for better visibility and accessibility. **Setzer et al.** [(32)] evaluated the effect of DOM, loupes, or no visualization aids on the prognosis of endodontic microsurgery, the success rate of endodontic microsurgeries using DOM was significantly greater than with loupes and without magnification. Up till now, there is no standardized procedure for successful separated instrument removal using ultrasonic [(33)] so far, the management through bypassing the separated instruments and ledges was selected for standardization purposes and to avoid the complications such as excessive loss of dentin, root perforation, and temperature rise on external root surface as a result of ultrasonic use [(34)]. MTA was used as root end filling (orthograde) for its regenerative behavior on periradicular tissues, biocompatibility, excellent sealing ability as well as its mechanical properties as an apical sealing material [(35,36)]. Regarding the technique of application of MTA, the orthograde technique was selected for ease and to avoid the adverse effect of the ultrasonic preparation including cracks and fractures on the root dentin [(37,38)]. **Andelin et al.** [(39)] concluded that there is no discernible leakage in teeth with resected MTA (orthograde MTA) or in those with MTA placed as a retrograde root-end filling material. Based on these results it appears that the resection of set MTA does not affect its sealing ability.

The surgical guide was fabricated to act as a stopper to standard the osteotomy parameter (diameter/depth) and to improve accuracy during the endodontic microsurgery by precise locating the appropriate osteotomy site and performing less sensitive technique to anatomically vital structures such as inferior dental nerve and mental nerve [(40)]. Also, the surgical guide itself acts as a soft tissue retractor, helping to avoid iatrogenic soft tissue damage. **Pinsky et al.** [(41)] confirmed that greater accuracy and consistency were achieved during endodontic surgery with surgical guidance without damaging vital structures. The PRF was used in this study because of its role in decreasing swelling at the surgical site [(42)], in conjunction with angiogenesis promotion (increased vascularity, enhanced fibroblast proliferation, subsequent collagen synthesis, extracellular matrix production, and endothelial cell proliferation) which promotes bone healing [(43,44)].

A submarginal flap with one vertical releasing incision was selected to minimize gingival recession as the soft tissue attachment level and crestal bone is not exposed [(45)] and to minimize edema which is proportional

to time and amount of tissue reflected. Research [46,47] evaluated edema following different types of flaps and concluded that edema was more significant in intrasulcular incisions than the submarginal incisions. The piezosurgery and trephine burs were selected in this study for many reasons. Piezosurgery creates an effective osteotomy with minimal trauma to soft tissue and important structures such as nerves, vessels, and mucosa in contrast to conventional surgical burs [48]. Piezosurgery reduces damage to osteocytes and permits the survival of bony cells during the harvesting of bone (reduces the risk of postoperative necrosis) [49]. Trephine bur is an easy and safe cutting instrument, that creates an effective osteotomy with more accurate (more regular) preparations in comparison with the other techniques [50], available in different diameters and lengths. The research in this field is lacking but the few published papers discussed the trephine burs. Postoperative pain and swelling are the most common complications after endodontic surgery. The magnitude of pain and swelling secondary to any surgical procedure is directly related to the amount of tissue damage [51]. Several studies have shown that factors such as age, sex, tooth type, osteotomy size, flap design, length of procedure, and use of a dental operating microscope can impact levels of pain after endodontic surgery [52].

The present study aimed to evaluate the effect of Piezosurgery and trephine bur on postoperative pain and swelling following endodontic microsurgeries. In the present study, the postoperative pain assessment scores of groups I, II, III and IV were statistically non- significant differences. This can be explained by several causes including, Firstly, that the PRF has no effect on the post operative pain in this study results. These results agreed with several research [53] compared the effect of PRF on the post operative pain assessments and concluded that PRF use had no significant effect on the postoperative pain. Kim et al. [54] reported that the use of PRF had no effect on pain following the surgical removal of impacted mandibular third molars. Secondly, regarding to the cutting tools used for the osteotomy and root end resection, the post operative pain is related to the trauma that resulted from the rotational speed during the drilling and consequence heat generation. Matthews and Hirsch [55] found a directly proportional relationship between drilling speed and heat production when comparing speed ranges from 345 rpm to 2,900 rpm. In this study, the trephine bur was mounted in an implant motor at 1200-1500 RPM / Torque 20 N which considered low speed range [56] which led to less amount of heat was generated. In addition, internal irrigation was used during the osteotomy procedure which have effect to decrease heat generation and decrease the post operative pain. These factors made the trephine bur had similar effect as the piezosurgery that have the least traumatic effect and best post operative pain results. This result is agreed with research compared the post operative pain between piezosurgery and rotary instruments [57].

In the present study, there was statistically significant difference between the swelling scores of group I and Groups II, III and IV. This can be explained by the fact that Piezosurgery creates an effective osteotomy with minimal trauma to soft tissue , nerves, vessels, and mucosa in contrast to surgical burs [48]. In addition to the difficulty during the osteotomy procedure using the contra angle of the implant motor which exerts excusive force for retraction of the check and soft tissue which may be the main cause of edema and swelling.

V. Conclusion

Within the limitations of this study the following conclusions could be drawn: Regarding the post operative pain assessment, there was statistically non-significant differences between groups, however Piezosurgery assisted cavity preparation technique with PRF improve the postoperative swelling.

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