

EVALUATION OF POSTOPERATIVE PAIN AFTER PARTIAL PULPOTOMY VERSUS FULL ROOT CANAL TREATMENT IN MANAGING YOUNG PERMANENT MOLARS WITH SYMPTOMATIC IRREVERSIBLE PULPITIS: A RANDOMIZED CONTROLLED TRIAL

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#### ABSTRACT

**Background:** Recent studies suggest that partial pulpotomy results in less postoperative pain than conventional root canal treatment.

**Methods:** A randomized controlled trial was conducted among young patients with age ranged between nine to fourteen years old to compare postoperative pain intensity after treatment of young permanent molars diagnosed with symptomatic irreversible pulpitis that was treated by either partial pulpotomy using putty MTA or traditional endodontic therapy. Statistical analysis was done by Chi-square test to compare between tested groups. The significance level was set at  $P \le 0.05$ .

**Results:** Compared to the root canal treatment group, the partial pulpotomy group showed lower mean pain score levels at 24, 48, and 72 hours with a statistically significant difference at 48 hours only.

**Conclusions:** Partial pulpotomy using bioceramics proved to have reduced postoperative pain than cases treated with full RCT when managing young permanent teeth with symptomatic irreversible pulpitis. **Trial registration:** The trial was registered with ClinicalTrials.gov on July 7, 2023, and given the identification number NCT05956613.

**KEYWORDS:** Partial pulpotomy, Root canal treatment, Bioceramics, Post-operative pain, Visual analogue scale, Neoputty MTA, Molar incisor hypomineralization.

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# INTRODUCTION

Globally, nearly 15% of children experience severe enamel abnormalities and dental caries, such as molar incisor hypomineralization (MIH), while around 48% suffer from early childhood caries.<sup>1,2</sup>

Most dental emergencies are caused by irreversible pulpitis that is symptomatic (SIP), meaning its description is based only on the degree of spontaneity of its onset with the persistence of pain, provoked by mild temperature changes.<sup>3</sup> SIP signifies that the inflammation in the pulp has exceeded a point where the damage cannot heal without definitive treatment, such as root canal therapy, tooth extraction, or pulpotomy. SIP significantly impacts the patient's quality of life and pain perception.<sup>4</sup> Effective management of pain necessitates the removal of inflamed pulpal tissues.<sup>5</sup>

Historically, pulpectomy has been the conventional therapy, even with full instrumentation, and remains in practice today.<sup>3</sup> Pulpectomy procedures primarily aim to completely remove the pulp, facilitate effective irrigation, and render canal filling easier.<sup>6</sup> Though full root canal treatment is considered the gold standard for treating symptomatic irreversible pulpitis (SIP) because of its long-term effectiveness, partial and full pulpotomy were introduced as alternatives with reports suggesting improvements in patient's quality of life.7 However, despite significant advances in endodontics, 58% of patients report post-endodontic discomfort.8

To preserve affected teeth for as long as possible, it is essential to employ minimally invasive and conservative treatments.<sup>9</sup> Partial pulpotomy appears to be a promising approach, especially for cases involving extensive tooth damage from developmental enamel defects, dental trauma, or symptomatic deep dentin caries. In these situations, where there is significant tooth damage, partial pulpotomy may be an effective option to consider.<sup>10</sup> Experts generally advocate retaining a substantial portion of the pulp rich in coronal cells to enhance the potential for natural dentin deposition and healing. Haemostasis should ideally occur within 4–10 minutes in the presence of a healthy pulp, although variations have been documented.<sup>11,12</sup> With advancements in materials and techniques, partial pulpotomy can now be performed more effectively and with less uncertainty.<sup>13</sup>

The pain-relief effectiveness of Calcium Enriched Mixture (CEM) and Mineral Trioxide Aggregate (MTA) pulpotomies was found to be significantly higher than RCT mature permanent teeth with extensive deep carious lesions and irreversible pulpits compared to RCT.<sup>14</sup>

Recently, premixed bioceramics like Neoputty MTA® have emerged, offering advantages such as wasteless production, consistent uniformity, excellent handling qualities, and non-staining properties.<sup>15</sup>

Given these material advancements, this study aimed to contrast the postoperative pain severity following partial pulpotomy using Neoputty MTA with traditional root canal therapy in symptomatic irreversible pulpitis cases among young patients.

#### **METHODS**

#### Sample size:

The number of participants needed for this study (the sample size) was determined based on a previous similar study,<sup>16</sup> which demonstrated a 100% probability of pain alleviation among controls. Assuming an anticipated likelihood of pain relief of 60% in the other group, it was calculated that 16 cases would need to be included in each treatment group in order to have a power of 0.8. The alpha level (type I error probability) for testing the null hypothesis was set at 0.05, and the chi-squared test was employed to assess this null hypothesis. To account for potential dropouts, the total number of subjects needed for each group was increased to 20.

# Study setting

This study utilized a superiority framework, parallel-group, double-blind (clinician and statistician), randomized controlled trial design with equal numbers of participants (1:1 allocation ratio) in each treatment group. The study was conducted from July 2023 to October 2023 at the endodontic clinic of Faculty of Dentistry, October 6 University. The October 6 University Faculty of Dentistry's Ethics Committee approved the study protocol, which was assigned permission number RECO6U27/2023. Before each treatment session, informed consent forms were signed by the patients' parents or guardians, and the participants were fully informed about the details of the study and any potential risks. The trial was registered with ClinicalTrials.gov on July 7, 2023, and given the identification number NCT05956613.

This article adheres to the CONSORT Checklist 2010 guidelines.

50 patients consented to participate in the study then referred to the Endodontic clinic with pain due to symptomatic irreversible pulpitis (SIP) from carious mandibular first molar teeth requiring endodontic treatment and were assessed as potential candidates for this study. Eligible subjects, aged 9 to 14, without systemic disorders were included. Each patient reported moderate to severe pain (according to VAS), which could be radiating or throbbing, occurring either at night or spontaneously. All teeth included in the trial showed significant pain or response to cold pulp testing (using Endo-Frost), indicating pulpitis. The response could be lingering pain or not.

Additionally, upon entry into the pulp chamber, noticeable pulp bleeding was observed. Another inclusion criterion was the absence of periapical bone abnormalities on preoperative periapical radiographs, which were obtained using film holders (Dentsply Rinn, Elgin, IL) and the paralleling technique (only 40 patients met these criteria). Subjects were then randomized into two treatment groups based on the treatment protocol.

Block randomization was utilized to allocate patients into two groups (n=20/group), using computer generated randomization (*www.random.org*). The two treatment groups were as follows: Group 1 received partial pulpotomy using Neoputty MTA (n = 20), while Group 2 underwent conventional root canal treatment (n = 20).

## Outcomes

The primary outcome, post-operative pain intensity, was assessed using the Visual Analogue Scale (VAS) with an ordinal measurement unit. Success was defined across all pain categories.

#### **Experimental procedures**

Before receiving any kind of care, each patient's preoperative pain was measured using a visual analogue scale (VAS) chart. The VAS pain scale had a range of 0 to 10, and it was represented by a 100 mm horizontal ruler with no number markings other than a 0 at one end and a 10 at the other end. It was directed to the patients to indicate on the ruler the point at which they felt the least degree of pain. The following categories of postoperative pain levels were used to assess pain at 24, 48, and 72 hours: no pain (0), mild pain (1-3), moderate pain (4–7), or severe pain (8–10).

#### Group 1: Partial pulpotomy using Neoputty MTA

Prior to the treatment, a 2% lidocaine with 1:100,000 epinephrine combination was used to provide local anaesthesia \*

Throughout the procedure, a rubber dam was used to isolate each tooth. The tooth surface was disinfected with cotton soaked in 5.25 percent sodium hypochlorite before caries excavation

<sup>&</sup>lt;sup>k</sup> (Carpule lidocaine, Alexandria Company for Pharmaceuticals and Chemical Industries, Egypt, #1423).

#### (1750) E.D.J. Vol. 71, No. 2

(NaOCl). After caries removal, the cavity was prepared with a large slow-speed round bur and a sterile high-speed fissure bur with water coolant. A sterile round bur in a high-speed handpiece was then used to extract exposed pulpal tissue down to a depth of two to three millimetres. 2.5 percent NaOCl was used to flush the pulp wound. If necessary, an additional 2.5 percent NaOCl was soaked in cotton pellets to cover the pulpal wound for an additional two to three minutes to prevent bleeding (Figure 1). If haemostasis was not established, root canal therapy was started.



Fig. (1) Partially amputated pulpal tissue

Neoputty MTA was carefully placed to a thickness of 3 mm over the newly created pulp wound, according to the manufacturer's recommendations (Figure 2). A wet cotton pellet was applied to guarantee that Neoputty MTA set, this was followed by a thin layer of a glass ionomer liner. The tooth was then permanently restored with resin composite in the same visit\*. In cases with multi-surface destruction of the crown, stainless steel crowns were fitted as the final restoration after 72 hours postoperative. A periapical radiograph was obtained postoperatively (Figure 3). In the pain chart, the post-operative pain levels were recorded after 24, 48, and 72 hours. After three days, patients came back to the clinician for an assessment of their pain charts.



Fig. (2) Placement of Neoputty MTA



Fig. (3) Postoperative periapical radiograph

#### Group 2: Conventional root canal treatment

Before starting the endodontic treatment technique, a 2% lidocaine with 1:100,000 epinephrine combination was used to provide local anaesthesia<sup>\*\*</sup>. Every tooth was isolated with the use of a rubber dam during the procedure.

Using an E-connect Pro endomotor rotary device (Changzhou Eighteenth Medical Technology Co., Ltd, China) and a Root ZX Mini Apex Locator (J Morita, Japan) for guidance, root canal preparation was conducted following the manufacturer's instructions with ProTaper Next instruments (PTN,

<sup>\* (3</sup>M Filtek Z250 XT, Universal, St Paul, USA)

<sup>\*\* (</sup>Carpule lidocaine, Alexandria Company for Pharmaceuticals and Chemical Industries, Egypt, #142)

Dentsply Maillefer, Switzerland). Using a standard syringe and a 24-gauge beveled needle, the root canal was initially irrigated after creating a glide path with an apical size of up to 20 or 25-size K-file (Dispovan, India). In order to promote irrigant flow, the needle was gently pressed into the canal as far apically as feasible without binding. After completion of the root canal preparation, apical patency was checked using a size 10 K-file (Mani Co., Tokyo, Japan).

After that, 2.5 ml of NaOCl 2.6 percent was utilized to irrigate the root canal prior to the insertion of each file used for canal preparation. Following instrumentation, 5 ml of NaOCl 2.6 percent was used for a final flush of every root canal, and 30 seconds of ultrasonic activation were then added (IRR20-21, Satelec, Acteon, France). For the last flush, EDTA 17 percent<sup>\*</sup> and NaCl 0.9 percent were utilized.

The obturation process employed the modified single-cone technique. Auxiliary gutta-percha cones size 25<sup>\*\*</sup>, Ceraseal bioceramic sealer<sup>\*\*\*</sup>, and ProTaper Next gutta-percha points were utilized. Following completion, a cotton pellet was inserted into the pulp chamber, and the access cavity was permanently restored with resin composite<sup>\*\*\*\*</sup> in the same visit (Stainless steel crown placement was scheduled after 72 hours). An intraoral periapical radiograph was taken to confirm proper canal filling to the working length and ensure no extrusion of filling material into the periapical tissues (Figure 4).

In the pain chart, the post-operative pain levels were recorded after 24, 48, and 72 hours. After three days, patients came back to the clinician for an assessment of their pain charts.

- \* (META BIOMED Co, Chungbuk, Korea)
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- \*\*\*\* (3M Filtek Z250 XT, Universal, St Paul, USA)

Fig. (4) Postoperative periapical radiograph

### Harms

At the conclusion of the trial, any observed harm in participants, regardless of their group assignment, was carefully documented and reported. The following actions were taken based on the nature of the harm.

- Pain: Anti-inflammatory analgesics were administered as needed (e.g., one 600 mg tablet of Brufen).
- In cases of fever or lymphadenopathy, antibiotics were prescribed (e.g., Augmentin 625 mg capsule every 8 hours for 5 days), along with hot fomentation and mouth rinses using warm, salted water until symptoms resolved.

#### **Statistical analysis**

When applicable, data were presented as means and standard deviations (SD), and their normality was assessed using the D'Agostino-Pearson test. The age ranges of the tested groups were compared using an independent t-test. Differences in the sex distribution frequencies and percentages, and VAS scores were evaluated between the tested groups using the Chi-square test. The significance level was established at  $P \le 0.05$  ( $\alpha$ =0.05). In order to account for patient loss over the follow-up period, intentionto-treat analysis was used. With IBM® SPSS®, statistical analysis was carried out (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.).

## RESULTS

## **Baseline data:**

The age minimum, maximum, mean, and standard deviation for each group were shown in Table 1 and Figure 5. After comparing the groups using an independent t-test, there was no significant difference (P=0.63).

The frequency and percentages of sex distribution in both groups were shown in Table 2 and Figure 6. When the groups were compared using the Chisquare test, there was no significant difference found regarding sex (P=0.52).

# **Evaluation of pain:**

Frequency and percentages of different levels of pain in both groups preoperatively, and postoperatively after 24, 48, and 72 hours were presented in Table (3) and figure (7).

# Intergroup comparison (comparison between both groups to evaluate the effect of used material):

Preoperatively, the groups showed no significant difference (P=0.104). After 24 hours, there was a significant difference between both groups (P=0.04). In the partial pulpotomy group with bioceramic putty, 70% reported no pain, 20% mild pain, and 10% severe pain, while in the root canal therapy group, 40% reported no pain, 10% mild pain, 30% moderate pain, and 20% severe pain. At 48 hours, there was no significant difference (P=0.104). How-

 TABLE (1) Minimum, maximum, mean and standard deviation of age in both groups and comparison between them using Independent t test:

						Comparison between both groups					
Age		Min	Max	М	SD	MD	CED	95% CI		10	<b>D</b> I
							SED	L	U	- df	P value
Partial pulpotomy using Bioceramic putty		9	14	12	2	0.300	0.618	-0.95	1.55	38.00	0.630 ns
Conventional root canal treatment		9	14	11	2						
Min: minimum Max: maximum			M: mean SD: standard deviation								
MD: mean difference	SED: standard error difference				CI: confidence interval						
L: lower arm U: upper arm Df: degree of freedom				n	ns: non-significant difference as P>0.05.						

TABLE (2) Frequency and percentages of sex in both groups and comparison between them using Chisquare test:

		Partial pulpotomy using Bioceramic putty		Convention trea	nal root canal itment	Chi-square test			
		Ν	%	Ν	%	Chi-square	df	P value	
Sex	Male	12	60.0%	10	50.0%	0.404	1.000	0.525	
	Female	8	40.0%	10	50.0%	0.404		0.525 ns	

N: frequency %: percentages

Df: degree of freedom

ns: non-significant difference as P>0.05.





Fig. (5) Bar chart showing mean age in both groups.



# TABLE (3) Frequency and percentages of pain preoperatively, after 24, 48 and 72 hours in both groups and comparison between them using Chi-square test:

Pain		Partial pul Biocera	potomy using mic putty	Conventio tre	onal root canal atment	Chi-square test			
		Ν	%	Ν	%	Chi-square	df	P value	
Preoperative pain	No	0	0.0%	4	20.0%	6.154	3.000	0.104	
	Mild	2	10.0%	0	0.0%				
	Moderate	4	20.0%	4	20.0%				
	Severe	14	70.0%	12	60.0%				
Postoperative pain (24 hr)	No	14	70.0%	8	40.0%	8.303	3.000	0.040*	
	Mild	4	20.0%	2	10.0%				
	Moderate	2	10.0%	6	30.0%				
	Severe	0	0.0%	4	20.0%				
Postoperative pain (48 hr)	No	16	80.0%	10	50.0%	7.385	3.000	0.061	
	Mild	4	20.0%	4	20.0%				
	Moderate	0	0.0%	4	20.0%				
	Severe	0	0.0%	2	10.0%				
Postoperative pain (72hr)	No	20	100.0%	14	70.0%	7.059	2.000	0.029*	
	Mild	0	0.0%	4	20.0%				
	Moderate	0	0.0%	2	10.0%				
	Severe	0	0.0%	0	0.0%				
P value		0.0	001**	0.0	0001**				

N: frequency

%: percentages Df: degree of freedom

\*Significant difference as P<0.05.



Fig. (7) Bar chart showing percentages of pain at different follow-up visits

ever, at 72 hours, a significant difference appeared (P=0.02). In the root canal therapy group, 70% reported no pain, 20% mild discomfort, and 10% moderate pain, while in the partial pulpotomy group with bioceramic putty, 100% reported no pain.

# Intragroup comparison (comparison between different intervals within each group to evaluate the effect of time):

In the context of partial pulpotomy using bioceramic putty, there was а significant improvement in pain over time (P<0.0001). The percentage of cases reporting no pain increased from 0% to 70% after 24 hours, further to 80% after 48 hours, and ultimately reached 100% after 72 hours. Conversely, within 24 hours postoperatively, the proportion of cases experiencing severe discomfort dropped from 70% preoperatively to 0%. In contrast, for conventional root canal therapy, the percentage of cases reporting no pain increased from 20% to 40% after 24 hours, followed by 50% after 48 hours, and eventually reaching 70% after 72 hours. This reflects a significant improvement in pain alleviation over time (P<0.0001). Similarly, the proportion of cases experiencing severe pain decreased from 60% pre-operatively to 20% after 24 hours, 10% after 48 hours, and ultimately 0% after 72 hours.

#### DISCUSSION

Children and adolescents often develop deep caries, requiring early intervention for young permanent molars.<sup>17,18</sup> Previously, regardless of symptoms, root canal therapy (RCT) was typically recommended for teeth with caries-induced pulp exposure due to concerns about permanent pulp damage. In vital pulp therapy, however, less invasive techniques such as partial or total pulpotomy are becoming more popular. Young teeth with symptoms of permanent pulpitis have responded well to partial pulpotomy, indicating that maintaining pulp vitality is more feasible than previously thought.<sup>19,20</sup>

The term "partial pulpotomy" was first used in literature by Cvek (1978), who also reported a 96 percent success rate for teeth with crown fractures in which 2-3 mm of inflamed pulp tissue were surgically removed.<sup>21</sup>

RCT-related pain is a significant cause of anxiety for both patients and dentists, especially when there are preoperative symptoms.<sup>19</sup> The pulpotomy procedure is more appealing to patients and operators due to its shorter duration as compared to single-visit RCT. It can be described as being relaible, with complete pain alleviation, and with a lower cost. Postoperative pain is common after endodontic procedures and is associated with various risk factors, including gender, age, type of intracanal medication, preoperative pain, pulp and periradicular diagnoses, and debris extrusion.<sup>22,23</sup> In this study, we recorded preoperative pain in all patients to assess its potential impact on postoperative pain.<sup>24,25</sup> This is consistent with earlier research that found that in teeth with preoperative symptoms, there was a 57% chance of postoperative pain recurrence.<sup>26</sup> It is difficult to compare the incidence of postoperative pain among studies since different pain assessment techniques and pulp health assessments are used.

This study aimed to assess the level of postoperative pain following standard root canal therapy and partial pulpotomy utilizing Neoputty MTA. The frequency and intensity of postoperative pain were noted at 24, 48, and 72 hours.

Both groups exhibited similar clinical conditions before treatment, and previous research<sup>23</sup> found no correlation between age, gender, or tooth type and flare-up occurrence. However, preoperative pain, tooth type, age, and gender can influence postoperative discomfort.<sup>24,26</sup>

In this study, lower molar teeth were chosen as they were reported to have a higher incidence of postoperative pain and greater preoperative pain severity, most likely because of larger canals or foramina and thicker cortical plates.<sup>4,26</sup>

The current results showed a significant decrease in the levels of postoperative pain during the followup period, in both groups. This conclusion is in line with the findings of Pak et al. (2011),<sup>19</sup> which showed that pain significantly decreased between 24 and 48 hours after therapy and then continued to decline until it reached very low levels after 7 days.

While the partial pulpotomy group showed lower mean pain scores at 24 and 72 hours compared to the root canal therapy group, there was no statistically significant difference in mean pain scores. However, a significant difference emerged at 48 hours, with the partial pulpotomy group exhibiting substantially lower mean pain scores. This difference might be attributed to the bioactive properties of the sealing material, which promote cellular differentiation and enhance reparative and healing abilities when applied to an infection-free, viable pulp. The fact that partial pulpotomy is a less traumatic and shorter procedure, may also account for the lower levels of postoperative pain.

Composite was used as a final restoration, as a proper coronal seal is an important determinant of success.<sup>27</sup> However many of these multi-surface affected molars require full coverage as a final restoration,<sup>28</sup> but because of the anticipated initial gingival irritation or occlusal discrepancies that may occur after crown fitting and cementation, this final restoration was postponed to be done after 72 hours postoperative, not to interfere with the recorded VAS scores.<sup>29</sup> We can conclude that partial pulpotomy using bioceramics appears to reduce postoperative pain in young permanent molars with symptomatic irreversible pulpitis and could be considered an alternative to RCT in vital cases.

## REFERENCES

- Uribe SE, Innes N, Maldupa I. The global prevalence of early childhood caries: A systematic review with metaanalysis using the WHO diagnostic criteria. Int J Paediatr Dent. 2021, (6):817-30.
- Zhao D, Dong B, Yu D, Ren Q, Sun Y. The prevalence of molar incisor hypomineralization: evidence from 70 studies. Int J Paediatr Dent. 2018, (2):170-9.
- Abbott PV, Yu C. A clinical classification of the status of the pulp and the root canal system. Aust Dent J. 2007; 52(1 Suppl): S17-31.
- Segura-Egea JJ, Cisneros-Cabello R, Llamas-Carreras JM, Velasco-Ortega E. Pain associated with root canal treatment. Int Endod J. 2009; 42(7):614-20.
- AAE. American Association of Endodontists Colleagues of Excellence: Management of Endodontic Emergencies: Pulpotomy Versus Pulpectomy. Colleagues Excell 2017, 2017, 1–8.

- Hulsmann, M.; Peters, O.A.; Dummer, P.M. Mechanical preparation of root canals: Shaping goals, techniques and means. Endod. Top. 2005, 10, 30–76
- Prati C, Pirani C, Zamparini F, Gatto MR, Gandolfi MG. A 20-year historical prospective cohort study of root canal treatments. A Multilevel analysis. Int Endod J. 2018; 51(9):955-68.
- Sathorn C, Parashos P, Messer H. The prevalence of postoperative pain and flare-up in single- and multiplevisit endodontic treatment: a systematic review. Int Endod J. 2008; 41(2):91-9.
- Leong DJX, Yap AU. Vital pulp therapy in carious pulpexposed permanent teeth: an umbrella review. Clin Oral Investig. 2021; 25(12):6743-56.
- Alqaderi HE, Al-Mutawa SA, Qudeimat MA. MTA pulpotomy as an alternative to root canal treatment in children's permanent teeth in a dental public health setting. J Dent. 2014; 42(11):1390-5.
- Tong HJ, Seremidi K, Stratigaki E, Kloukos D, Duggal M, Gizani S. Deep dentine caries management of immature permanent posterior teeth with vital pulp: A systematic review and meta-analysis. J Dent. 2022; 124:104214.
- Ghoddusi J, Forghani M, Parisay I. New approaches in vital pulp therapy in permanent teeth. Iran Endod J. 2014; 9(1):15-22.
- Kaur M, Singh H, Dhillon JS, Batra M, Saini M. MTA versus Biodentine: Review of Literature with a Comparative Analysis. J Clin Diagn Res. 2017; 11(8):ZG01-ZG05.
- Asgary S, Eghbal MJ. The effect of pulpotomy using a calcium-enriched mixture cement versus one-visit root canal therapy on postoperative pain relief in irreversible pulpitis: a randomized clinical trial. Odontology. 2010;98(2):126-33.
- Lozano-Guillén A, López-García S, Rodríguez-Lozano FJ, Sanz JL, Lozano A, Llena C, et al. Comparative cytocompatibility of the new calcium silicate-based cement NeoPutty versus NeoMTA Plus and MTA on human dental pulp cells: an in vitro study. Clin Oral Investig [Internet]. 2022.
- Taha NA, Abdulkhader SZ. Full Pulpotomy with Biodentine in Symptomatic Young Permanent Teeth with Carious Exposure. J Endod. 2018; 44(6):932-7.
- Ghanim AM, Manton DJ, Morgan MV, Mariño RJ, Bailey DL. Trends of oral health care and dental treatment need in relation to molar incisor hypomineralisation defects: a

study amongst a group of Iraqi schoolchildren. Eur Arch Paediatr Dent. 2012; 13(4):171-8.

- Ridell K, Olsson H, Mej\_are I. Unrestored dentin caries and deep dentin restorations in Swedish adolescents. Caries Res 2008; 42:164–70.
- Pak JG, White SN. Pain prevalence and severity before, during, and after root canal treatment: a systematic review. J Endod 2011; 37: 429–38.
- Aguilar P, Linsuwanont P. Vital pulp therapy in vital permanent teeth with cariously exposed pulp: a systematic review. J Endod 2011; 37:581–7.
- 21. Chailertvanitkul P, Paphangkorakit J, Sooksantisakoonchai N, Pumas N, Pairojamornyoot W, Leela-Apiradee N, Abbott PV. Randomized control trial comparing calcium hydroxide and mineral trioxide aggregate for partial pulpotomies in cariously exposed pulps of permanent molars. Int Endod J. 2014; 47(9):835-42.
- 22. Pamboo J, Hans MK, Kumaraswamy BN, et al. Incidence and factors associated with flare-ups in a post-graduate program in the Indian population. J Clin Exp Dent. 2014; 6(5): e514–9.
- Onay EO, Ungor M, Yazici AC. The evaluation of endodontic flare-ups and their relationship to various risk factors. BMC Oral Health. 2015; 15(1): 142.
- Sadaf D, Ahmad MZ. Factors associated with postoperative pain in endodontic therapy. Int J Biomed Sci. 2014; 10(4): 243–7.
- AlRahabi MK. Predictors, prevention, and management of postoperative pain associated with nonsurgical root canal treatment: A systematic review. J Taibah Univ Med Sci. 2017; 12(5): 376–84.
- 26. Arias A, de la Macorra JC, Hidalgo JJ, Azabal M. Predictive models of pain following root canal treatment: a prospective clinical study. Int Endod J 2013; 46: 784–93.
- 27. Shetty K, Habib VA, Shetty SV, Khed JN, Prabhu VD. An assessment of coronal leakage of permanent filling materials in endodontically treated teeth: An in vitro study. J Pharm Bioallied Sci. 2015; 7(Suppl 2):S607-11.
- Guo YB, Bai W, Liang YH. Fracture resistance of endodontically treated teeth with cervical defects using different restorative treatments. J Dent Sci. 2022; 17(2):842-7.
- Staman NM, Townsend JA, Hagan JL. Observational study: discomfort following dental procedures for children. Pediatr Dent. 2013; 35(1):52-4.