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Postoperative pain after total pulpotomy and root canal treatment in mature molars according to the new and traditional classifications of pulpitis: a prospective, randomized controlled trial

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Abstract

Background The aim of this study was to compare postoperative pain following total pulpotomy (TP) and root canal treatment (RCT) in mature molar teeth with irreversible pulpitis. To compare the traditional pulpitis classification system with the Wolters system in evaluating postoperative pain.

Methods Eighty mandibular molars with irreversible pulpitis were included and classified according to the Wolters (moderate/severe pulpitis). The teeth were randomly assigned to two groups (RCT or TP). RCT was performed following standardized protocols. TP was performed to the level of the canal orifices, and hemostasis was achieved with 2.5% sodium hypochlorite. A 3 mm layer of MTA was placed as the pulpotomy material. The teeth were restored with glass ionomer cement followed by composite. Pain scores were recorded preoperatively and, at 6, 12, 24, 48, and 72 h and 7 days after the interventions. The data were statistically analyzed using the Mann-Whitney U test, the Friedman test, the Wilcoxon signed-rank test, and the Spearman's correlation test. The significance level was set at 0.05.

Results Sixty-four patients were analyzed at the one-week follow-up and all were diagnosed as irreversible pulpitis according to the AAE; 22 teeth were classified as moderate and 42 teeth were classified as severe pulpitis according to Wolters. There was no significant difference between TP and RCT in pain scores in moderate pulpitis patients ($p > 0.05$). There was a significant difference between TP and RCT at 24 and 72 h of severe pulpitis; higher pain scores were observed in the RCT ($p < 0.05$).

Conclusions In patients with moderate pulpitis, the TP procedure allowed symptom relief more quickly than RCT. In patients with severe pulpitis, TP provided for significantly lower pain scores compared to RCT at both 24 and 72 h.

Clinical trial registration The study was retrospectively registered with ClinicalTrials.gov (NCT05923619). Date of Registration: 06/16/23.

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Keywords Irreversible pulpitis, Mature molars, Mineral trioxide aggregate, Post-operative pain, Pulpotomy

Introduction

Pulpitis is traditionally classified as reversible and irreversible pulpitis, based on the relationship between clinical symptoms and treatment. In reversible pulpitis, the pulp can potentially heal after the elimination of etiological factors. Vital pulp therapy (VTP) involves pulp capping and partial pulpotomy (PP) or total pulpotomy (TP) procedures. VPT, which is indicated for reversible pulpitis in noncarious pulp exposures, is an efficient approach to eliminate etiological factors while preserving the vitality of the remaining pulp tissue when there are no periapical pathologies [1]. In contrast, irreversible pulpitis is characterized by a severe degenerative process that leads to pulp necrosis and eventually apical periodontitis, necessitating root canal treatment. (RCT) [2]. Despite the high success rate of RCT at 89% [3], procedural errors such as transportation, zip formation, file fracture during mechanical preparation, incomplete detection of all canals, and issues like inadequate or excessive root filling can contribute to treatment failure. Unlike RCT, which involves removing the entire pulp tissue, VPT preserves the pulp's immune defense mechanism and regenerative potential [4, 5] allowing continued root development in immature teeth [6].

The conventional classification, which primarily categorizes the severity of inflammation in the pulp, fails to capture the complex nature of pulpitis and adequately explain the success of VPTs in patients diagnosed with irreversible pulpitis [7]. Histological studies on teeth with symptoms of irreversible pulpitis have shown that inflammation is often confined to the superficial pulp beneath the exposure site [8]. It has been reported that dental pulp responds to microorganisms and their toxic products in a segmented manner, allowing the coronal pulp, distant from the caries, to remain histologically healthy [9, 10]. Therefore, Wolters et al. proposed a new classification that more accurately reflects the extent of pulp injury and suggests treatment options for each stage [11].

Wolters classification [11]

Initial pulpitis There is an increased response to the cold stimuli; nonetheless, there is no percussion or spontaneous pain.

Mild Pulpitis There is an increased reaction to cold, warm, and sweet stimuli lasting up to 20 s. Painkillers are effective against percussion or spontaneous pain.

Moderate pulpitis Symptoms are more significant, and there is a strong and prolonged reaction to cold stimuli. Painkillers are moderately effective against percussion or spontaneous pain.

Severe pulpitis There is significant pain reaction against warm stimuli. Painkillers do not provide much relief, and the patient cannot sleep at night due to severe pain. Percussion pain is observed.

Clinicians have been encouraged to use VPT instead of RCT in suitable patients because of a better understanding of the molecular and cellular events that occur during inflammation, the ability to repair inflammation induced by caries in the dentin-pulp complex [12], advancements in technical and biological aspects of wound debridement [13, 14], and the introduction of hydrophilic calcium silicate cements (CSCs) [15].

Irreversible pulpitis, which causes spontaneous and severe pain, is one of the most common reasons patients seek dental treatment and referral to a clinic. Although RCT provides long-term pain relief and functional retention of the tooth, postoperative pain due to various factors is one of the most common complications, with an incidence ranging from 3–58% [16]. The most essential criterion in the evaluating treatment success is ensuring the functional survival of the tooth; however, the pain reported by the patient after the procedure, the need for analgesics, and the duration of sensitivity are also important variables to consider in assessing reatment success [17]. Studies have evaluated the outcomes of TP and RCT procedures in mature molar teeth with symptomatic irreversible pulpitis. Asgary et al. [18]. reported that TP with Calcium-enriched mixture (CEM) has better pain-reducing effects compared to RCT in cases of irreversible pulpitis. Nevertheless, to the best of our knowledge, this is the first study to assess postoperative pain following TP and RCT procedures using both a traditional and a more detailed novel pulpitis classification system. Therefore, this study aimed to evaluate postoperative pain following TP and RCT in mature molar teeth; to compare the traditional pulpitis classification system with the Wolters system in evaluating postoperative pain; and to analyze the effect of hemostasis time on the pain scores.

The null hypothesis was that there would be no difference between the two treatment procedures in terms of post-operative pain levels.

Materials and methods

After ethics committee approval, the study was designed as a double-arm, prospective, randomized controlled trial with parallel experimental groups. The study was registered with ClinicalTrials.gov (NCT05923619).

Sample size calculation

According to Galani et al. [19], the sample size was calculated using the G*Power v.3.1.9.2 (Heinrich Heine, Dusseldorf University, Dusseldorf, Germany) with a power of 80%, an α error of 5%, and an effect size of 0.5. The minimum sample size was calculated as 28. Considering the loss of patients, 80 patients were included in this study ($n=40$).

Inclusion criteria

Patients aged between 18 and 50 years with no systemic disease who were referred to our clinic were screened for the study from January 2023 to October 2023. Mandibular first and second molars with complete root development, no periodontal issues (probing pocket depth ≤ 3 mm and mobility within the normal limit), and deep/extremely deep caries detected on periapical radiography were included in the study. These teeth were diagnosed with moderate or severe pulpitis according to the Wolters classification. All had vital pulp and responded to the cold test (Endo Ice; Coltene, Altstatten, Switzerland). Preoperative pain levels were determined according to the visual analog scale (VAS), which consists of a 10 mm long horizontal line where numerical values are divided into visual categories. The patient was included if the preoperative pain level was above 4 mm.

Exclusion criteria

Patients who had received antibiotic therapy in the last three months or used nonsteroidal anti-inflammatory drugs within the last twelve hours, patients with diabetes, immunosuppressive disease or pregnancy, and teeth that could not be restored or required a post-core, had devital pulp, did not respond to the cold test, and had no exposed pulp after nonselective caries cleaning were excluded from the study.

After a patient was considered potentially eligible for the study, the patient was informed, and written consent was obtained after they agreed to participate in the study.

Patient evaluation

As a result of clinical and radiographic examinations, the teeth were classified both according to the American Association of Endodontists (AAE) [20] and as proposed by Wolters [11]. Patients were instructed to score their pain with a value on the VAS. The presence or absence of pain was classified into 4 categories:

Level 1 No pain (0 mm).

Level 2 Mild pain (1–3 mm).

Level 3 Moderate pain (4–6 mm).

Level 4 Severe pain (7–10 mm).

Randomization and blinding

The patients were assigned to the TP or RCT group. Randomization was performed via online software (www.randomizer.org) with a four-block size block randomization technique to ensure even distribution between the groups (1:1 ratio). A coinvestigator managed the allocation, and reported the allocated treatment procedure to the operator. The operator could not be blinded because of the different stages of the two treatment procedures.

All the endodontic procedures were performed by a single operator. After inferior alveolar nerve block anesthesia was performed with local anesthetics (adrenaline 4% Articaine, 1:100,000) (Ultracain D-S; Sanofi, Paris, France), the tooth was isolated with a rubber dam. The isolated area was cleaned using a cotton pellet damped in 3% hydrogen peroxide followed by 2% chlorhexidine. The entire caries was removed nonselectively using a high-speed sterile diamond bur #801 (Meisinger, Dusseldorf, Germany) under water coolant followed by a sterile round bur in a slow speed handpiece.

Total pulpotomy procedures

After the access cavity was prepared, pulp vitality was visually confirmed. The coronal pulp tissue was completely removed with a high speed sterile diamond bur #801G (Meisinger) under an abundant water coolant. The exposed pulp tissue was rinsed with 5 ml of 2.5% sodium hypochlorite (NaOCl; Wizard, RehberKimya, Istanbul, Turkey). A cotton pellet moistened with 2.5% NaOCl was used to achieve hemostasis and bleeding was checked every minute. The time taken to achieve hemostasis in the pulp tissue was noted.

Following the achievement of hemostasis, MTA Angelus (Angelus; Londrina, PR, Brazil) was used to cover the root canal orifices and pulp chamber. A moist cotton pellet was applied over the MTA for 10 min to set the material. A thin layer of flowable glass ionomer cement (Glass Liner; Willmann Pein, Barmstedt, Germany) was then placed over the MTA, and the cavity was restored with a resin composite (Estelıte Sıgma Quıck; Tokuyama, Tokyo, Japan).

After the coronal pulp tissue was removed, RCT was performed on the teeth whose hemostasis could not be achieved within eight minutes, considering that the residual pulp tissue was irreversibly inflamed, and those patients were excluded from the study.

Root canal treatment procedures

After the access cavity was prepared pulp vitality was visually confirmed. After localizing the canal orifices, the working length (WL) was determined using a 10 K file (VDW, Munich, Germany) and apex locator (Morita

Root ZX, Tokyo, Japan) and checked by radiography. The chemomechanical preparation was completed using the Reciproc (Reciproc, VDW) files at the WL. During the chemomechanical preparation, the root canals were irrigated with 2.5% NaOCl after every three pecking motions. The total volume of NaOCl was 20 ml for each root canal during enstrumentation. The final irrigation sequence was as follows: 5 ml of 17% ethylene diamine tetra-acetic acid (EDTA; Coltene) for 1 min; 5 ml of distilled water; 5 ml of 2.5% NaOCl, retained in the canal for 1 min; 5 ml of distilled water to neutralize the NaOCl.

After completing the final irrigation, the root canals were dried with sterile paper points (VDW) and filled in a single visit using the lateral condensation technique with an epoxy-resin-based sealer (AH Plus; Dentsply DeTrey GmbH, Konstanz, Germany). All teeth were restored with resin composite (Estelıte Sıgma Quıck).

Patients in both groups were prescribed 400 mg of ibuprofen following treatment and instructed to use it as needed. They were advised to consult the endodontist if severe post-operative pain was not relieved by analgesics. An investigator (S.C.) who was blinded to the study conducted preoperative and postoperative pain observations. All participants were administered a questionnaire form based on the VAS, which assesses their pain at 6 h, 12 h, 24 h, 48 h, 72 h, and one week post-treatment. Patients were contacted by S.C. at these intervals to assess their pain levels. Patients were invited for a clinical examination one week after treatment, with follow-up appointments were scheduled for three months, six months, and one year.

Statistical analyses

The collected data were analyzed using IBM SPSS Statistics software (SPSS Inc., Chicago, IL, USA; Version 22.0). Chi-square test was used to assess the gender distribution of participants among the study groups. Intergroup comparisons of the mean age of the participants were performed using the Independent *t*-test. The pain scores data were nonnormally distributed according to the the Shapiro–Wilk test. Therefore, nonparametric tests were performed. The Mann Whitney U test was performed for intergroup comparisons of pain scores at different follow-up time points. The Friedman's test followed by the Wilcoxon signed rank test for pairwise comparisons were used for intra-group comparison of pain scores. The Mann-Whitney U test was used to determine whether there was a difference in hemostasis time among teeth with different diagnoses (moderate-severe pulpitis). The Spearman's correlation test was used to evaluate the associations between preoperative pain scores and the time taken to achieve hemostasis. Statistical significance level was set at 0.05.

Results

Demographics of participants

The study involved 82 patients. Two patients declined to participate and excluded from the study. The remaining 80 patients were randomized into two groups, TP and RCT, with equal numbers in each group. In the TP group, eight patients were excluded due to the inability to achieve hemostasis within the specified time in six cases and partial necrosis detected in two cases. In the RCT group, eight patients were excluded due to partial necrosis (Fig. 1).

The demographic data for the 64 patients who were included in the study are presented in Table 1. All 64 teeth were classified as having irreversible pulpitis according to the AAE criteria. Additionally, 22 teeth were classified as having moderate pulpitis, and 42 were classified as having severe pulpitis according to the Wolters system. In the TP group, there were 17 female and 15 male patients, while the RCT group comprised 16 female and 16 male patients. The mean ages of the patients in the TP and RCT groups were 24.63 ± 7.38 years and 28.6 ± 8.55 years, respectively. The age and gender distributions were similar between the groups ($p > 0.05$).

Intergroup comparisons of pain scores

Pain scores were assessed using the VAS scale and presented in Table 2. The preoperative pain scores were similar and there was no statistically significant difference between the TP and RCT groups ($p > 0.05$). For patients with moderate pulpitis, no significant difference was found between TP and RCT at any time point evaluated with respect to the postoperative scores ($p > 0.05$). However, for patients with severe pulpitis, the postoperative scores were significantly different between the TP and RCT at the 24th and 72nd hours ($p < 0.05$); however, there was no significant difference at the other time points ($p > 0.05$). Higher scores were detected in the RCT group at the 24th and 72nd hours.

Pain scores of both treatment modalities across the different follow up periods

Pain scores decreased significantly in both the moderate and severe pulpitis groups after both TP and RCT ($p < 0.05$). Compared to the preoperative period the pain scores for patients with moderate pulpitis decreased significantly at the 12th hour after TP and at the 24th hour after RCT. For patients with severe pulpitis, pain scores were significantly lower at the 6th hour after both TP and RCT compared to the preoperative period.

By the 72nd hour, no patients in the moderate pulpitis group reported moderate or severe pain (Fig. 2). In the severe pulpitis group, 10% of patients who underwent TP reported moderate pain, while 54.5% of patients who underwent RCT reported mild pain and 9.1% reported

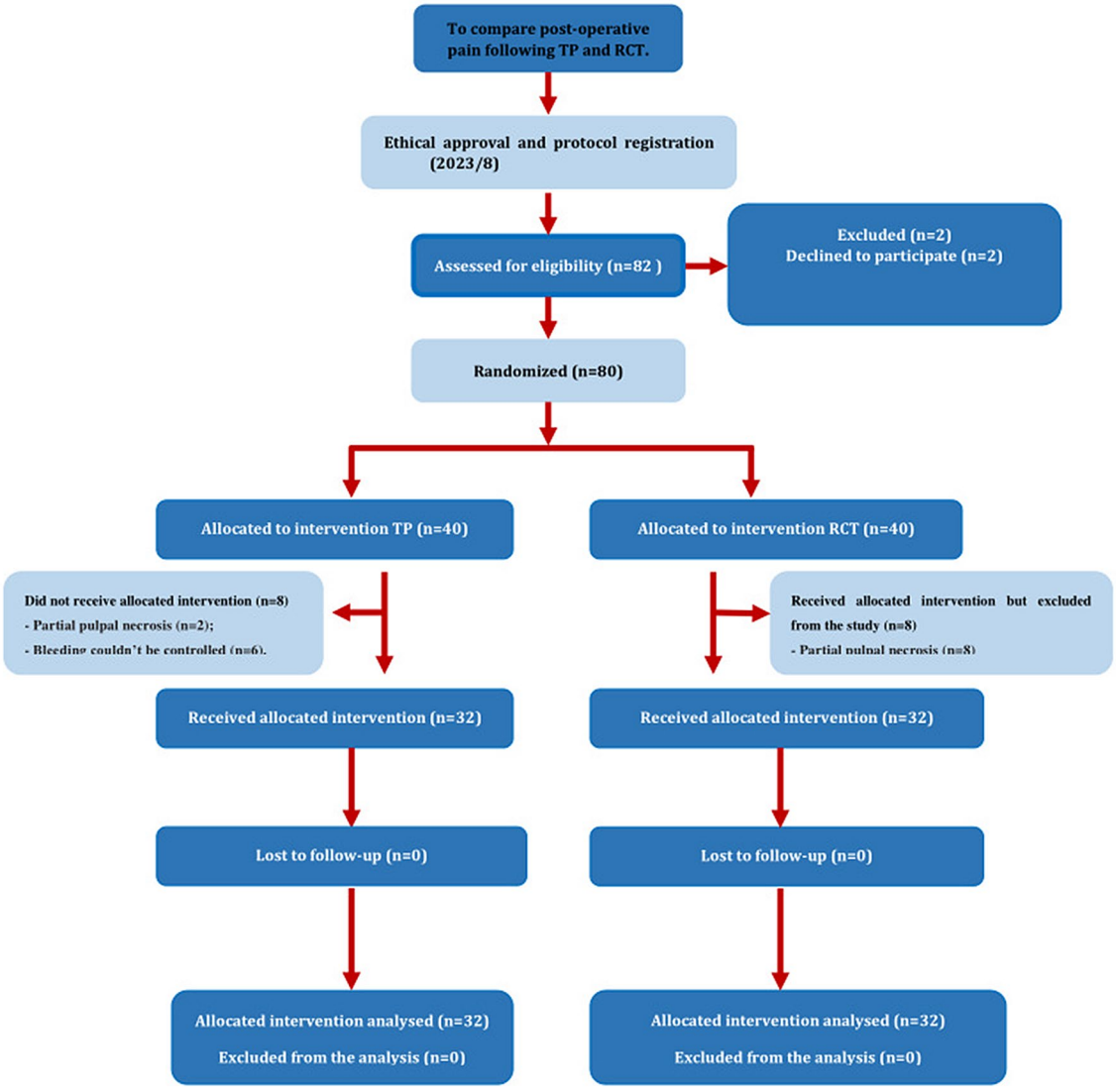

Fig. 1 PRIRATE 2020 flowchart of participants throughout the trial

	Gender		Age		Clinical Diagnosis	
	Female	Male	Mean± Standard Deviation	Range	Moderate	Severe
Total Pulpotomy	17	15	24.63 ± 7.38	18-43	12	20
Root Canal Treatment	16	16	28.56 ± 8.55	18-47	10	22
Total	33	31			22	42

Table 1 Demographics of the patients included to the present study

	Time period	Mean ± Standard Deviation		p
		Total Pulpotomy	Root Canal Treatment	
Moderate P.	Pre-op	5.43 ± 0.54 [A]	6.40 ± 2.07 [A]	0.416
	Post-op 6th hour	4.29 ± 2.30 [A]	3.40 ± 1.34 [A]	0.368
	Post-op 12th hour	1.71 ± 0.95 [B]	3.20 ± 1.30 [A]	0.054
	Post-op 24th hour	1.65 ± 2.87 [B]	1.60 ± 1.82 [B]	0.799
	Post-op 48th hour	1.61 ± 2.36 [B]	0.80 ± 1.30 [B]	0.650
	Post-op 72nd hour	1.14 ± 1.46 [B]	0.20 ± 0.45 [B]	0.287
	Post-op 1st week	0.14 ± 0.38 [B]	.00 ± .00 [B]	0.398
Severe P.	Pre-op	8.48 ± 1.49 [A]	7.73 ± 1.74 [A]	0.433
	Post-op 6th hour	4.75 ± 2.60 [B]	4.55 ± 1.86 [B]	0.755
	Post-op 12th hour	2.83 ± 2.62 [B]	4.73 ± 1.95 [B]	0.062
	Post-op 24th hour	1.58 ± 1.78 [C]	3.36 ± 1.80 [C]	0.027*
	Post-op 48th hour	1.08 ± 2.07 [C]	1.73 ± 1.56 [D]	0.135
	Post-op 72nd hour	0.42 ± 1.44 [C]	0.91 ± 1.14 [D]	0.016*
	Post-op 1st week	0.08 ± 0.29 [C]	0.18 ± 0.41 [D]	0.493

*Mann Whitney U test indicates statistically significant difference in the same row. Different superscript capital letters indicate statistically significant differences in the same column ($p<0.05$).

Table 2 Preoperative and postoperative pain scores of the patients according to the groups

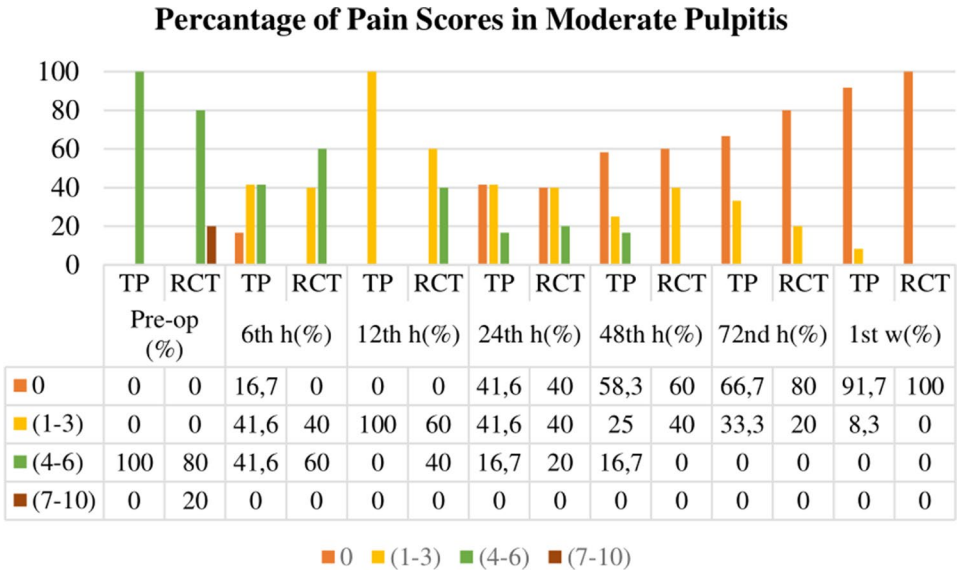

Fig. 2 Percentage of pain scores in moderate pulpitis for both treatment modalities over 7 days

moderate pain. No patients reported severe pain. None of the patients reported moderate or severe pain at the end of the first week (Fig. 3). Additionally, three patients who underwent TP (one with moderate pulpitis and two with severe pulpitis) developed severe symptoms after treatment, leading to the need for RCT.

Hemostasis time

The mean hemostasis times for teeth with moderate and severe pulpitis were 4.29±1.70 and 5.17±1.27 min, respectively, with no significant difference between the groups ($p>0.05$) (Table 3). There was a significant correlation between the preoperative pain scores and the time taken to achieve hemostasis (Correlation coefficient: 0.564; sig: 0.012).

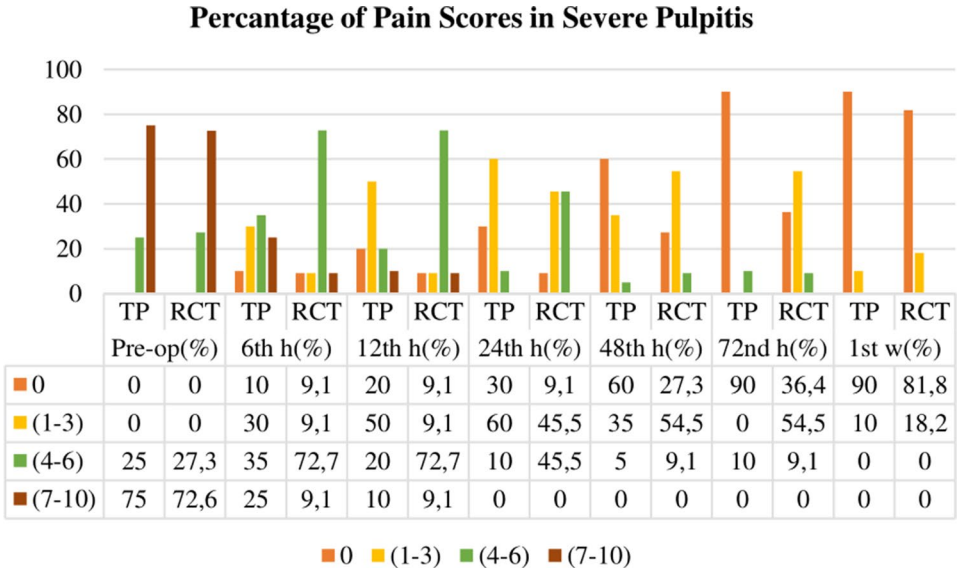

Fig. 3 Percentage of pain scores in severe pulpitis for both treatment modalities over 7 days

Hemostasis	N	Mean	Standard Deviation	Minimum	Maximum
Moderate Pulpitis	12	4,29	1,70	3	8
Severe Pulpitis	20	5,17	1,27	4	8

Table 3 Hemostasis duration of the cases according to the groups

Discussion

Treatment decisions for mature teeth with a vital pulp are typically based on clinical symptoms because of the difficulty in determining the degree of inflammation. While irreversible changes are often confined to the area adjacent to the exposure site in the pulp exposed to caries, the deep pulp may not be significantly affected by inflammatory changes [21]. Therefore, VPT can be considered an alternative to RCT in suitable patients. Santos et al. reported that the success rate of VPT for mature molars with symptomatic irreversible pulpitis ranges between 81% and 90% [22]. According to the literature, few studies have evaluated the success rates of VPT and RCT in mature teeth with irreversible pulpitis [19, 23], but no study has assessed postoperative pain following TP and RCT procedures using both a traditional classification system and Wolter's classification system.

Under clinical conditions, determining the degree of inflammation in the pulp tissue and predicting the prognosis of VPT can be challenging [24].The medical history, clinical and radiographic findings are useful in making treatment decisions. Evaluation of hemostasis time in the pulp is another method as hypervascularization is an indicator of inflammation. If hemostasis cannot be achieved, it can be assumed that the tissue is irreversibly inflamed and more pulp should be removed to reach healthy tissue [14]. Literature suggests that pulpectomy is indicated if hemostasis cannot be achieved within 5–10 min [25]. In this study, if hemostasis was not achieved within eight minutes after coronal pulp removal, it was assumed that the radicular pulp tissue was infected, leading to the decision to perform RCT. The mean hemostasis times were 4.29 min for moderate pulpitis and 5.17 min for severe pulpitis. The difference was not statistically significant.

A moderate correlation was found between preoperative pain and hemostasis time. Increasing pulp inflammation is likely to lead to an increase in pain-like symptoms. However, due to the subjective nature of pain, this finding should be interpreted with caution. There is no study available for direct comparison of the results. Evaluating the relationship between preoperative symptoms and hemostasis time in greater populations would be beneficial. A 28-month follow-up study investigating factors affecting the success of pulpotomy in permanent teeth found no significant difference in failure rates between teeth with hemostasis times of one minute or less, between 2 and 5 min, or between 5 and 10 min [26]. While imaging of vital tissue and achieving hemostasis are crucial for deciding on VPT, there is no evidence to suggest that the duration of hemostasis significantly affects the prognosis of VPT [27].

In a clinical study on teeth with symptomatic irreversible pulpitis, TP was found to be more successful than PP, although the difference was not statistically significant. This study also reported lower pain scores following TP [28]. In the present study, TP was preferred over PP due to the difficulty of clinically determining the depth of inflammation and ensuring thorough removal of pathological pulp tissue.

In this study, MTA Angelus was chosen as a TP material. Since the capping material used in VPT directly contacts the pulp tissue, it is crucial to ensure that it is biocompatible and provides a hermetic seal. MTA is known for its biocompatibility and its ability to induce hard tissue formation due to its alkaline pH [29]. Despite its disadvantages, such as long setting times and potential discoloration, MTA has demonstrated high success rates in VPTs [30]. Asgary et al. found similar success rates for TP using MTA and CEM [31]. Taha et al. reported that at the 1-year follow-up, success rates for symptomatic permanent teeth treated with TP were 91.8% for MTA, 93.3% for Biodentine, and 91.6% for TotalFill, with no statistically significant difference among them [4].

There is no reliable and clinically objective method for evaluating the degree of pulp inflammation. A study analyzing the usefulness of diagnostic tests commonly used in endodontics found that while these tests accurately detect healthy pulp, teeth diagnosed with irreversible pulpitis often showed no signs of the disease upon histological examination [32]. This suggests that VPT might be effective in healing many teeth diagnosed with irreversible pulpitis based on subjective patient complaints and radiographic findings [11]. Consequently, a new diagnostic system and associated treatment options appear clinically necessary. In our study, 64 teeth diagnosed with irreversible pulpitis were evaluated using the system recommended by Wolters et al., with 22 classified as moderate pulpitis and 42 as severe pulpitis. Careddu et al. explored the suitability of this new diagnostic system for managing VPTs and reported that moderate and severe pulpitis could be effectively categorized as subgroups of irreversible pulpitis [7].

Postoperative pain is commonly experienced even when a RCT is performed according to clinical standards. A systematic review found that the frequency of reporting pain after RCT range from 3–58% [16]. In a prospective study involving 415 patients, 40.2% reported pain 48 h after RTC; though, only 12% reported severe pain [33]. Another systematic review on pain frequency and severity after RCT found that the prevalence of severe pain present before treatment (81%) significantly decreased within 24–48 h after treatment, dropping to minimal levels after one week (40% at 24 h, decreasing to 11% after one week). The severity of preoperative pain was 54 on a 100 mm scale, which decreased to 24 after 24 h and to 5 after one week [34]. In the present study, a significant decrease in pain intensity was observed at 24 h in RCT group. By the end of one week, pain had resolved in all patients with moderate pulpitis and in 81.8% of patients with severe pulpitis, consistent with the literature.

In our study, which included patients with preoperative pain scores above four, statistically significant results were found for teeth with severe pulpitis at the 24th and 72nd hours. Higher postoperative pain scores were generally observed in the RCT group compared to the TP group, and the null hypothesis was rejected. Galani et al. compared the pain scores after TP and RCT in mandibular molars exposed to caries and reported higher scores for RCT during the first week following treatment [19]. This discrepancy might be attributed to their inclusion of patients with preoperative pain scores ranging from 0 to 6, using a 10 mm VAS scale.

In the moderate pulpitis group, the percentages of patients reporting pain were 58.3% at 24 h, 41.7% at 48 h, and 33.3% at 72 h after TP, and 60% at 24 h, 40% at 48 h, and 20% at 72 h after RCT. In the severe pulpitis group, the percentages of patients reporting pain were 70% at 24 h, 40% at 48 h, and 10% at 72 h after TP, and 91% at 24 h, 72% at 48 h, and 63.6% at 72 h after RCT. Although pain scores decreased in both groups compared to the preoperative period, symptoms were relieved faster in the TP group. These results align with findings from a previous study that included patients with symptoms indicative of irreversible pulpitis [18]. However, in the TP group, severe symptoms developed in three patients after treatment. Although these patients initially experienced symptom relief within the first week, they returned with complaints of severe pain 13, 17, and 20 days after treatment, respectively.

Eghbal et al. [35] reported that none of the 14 patients, aged between 16 and 28 years, diagnosed with irreversible pulpitis experienced pain 24 h after TP with MTA. The study was conducted on maxillary and mandibular molar teeth that exhibited spontaneous and referred pain; however, preoperative scores were not reported. Taha et al. [4] reported that one week after TP was performed to maxillary and mandibular molar teeth clinically diagnosed with either reversible or irreversible pulpitis, 96.9% of the patients experienced no pain or only mild pain. In a subsequent study by the same authors, where only molar teeth with irreversible pulpitis were treated, symptoms disappeared in 93% of patients two days after TP [23].

This study includes a one-week follow-up of patients after TP and RCT, comparing these procedures in terms of postoperative pain severity. However, a six-month follow-up is generally recommended for teeth treated with pulpotomy [5], and a longer follow-up is advised to identify potential late-term failures [23]. Therefore, while TP

appears effective in alleviating symptoms, it cannot yet be considered a definitive alternative to RCT. Additionally, although all endodontic procedures were performed by a single operator following a strict protocol, a limitation of this study is that the operator could not be blinded to the treatment procedures due to the different processes involved in each treatment modality.

Conclusion

In patients with moderate pulpitis, the TP procedure allowed symptom relief more quickly than RCT. In patients with severe pulpitis, TP provided for significantly lower pain scores compared to RCT at both 24 and 72 h. Within the limitations of this study, it can be argued that TP performed with MTA Angelus provides rapid relief of symptoms in teeth with irreversible pulpitis.

Abbreviations

VPT	Vital Pulp Therapy
PP	Partial Pulpotomy
TP	Total Pulpotomy
RCT	Root Canal Treatment
CSC	Calcium Silicate Cements
AAE	American Association of Endodontists
VAS	Visual Analog Scale
WL	Working Length
NaOCl	Sodium Hypochlorite
EDTA	Ethylene Diamine TetraAcetic Acid
CEM	Calcium-Enriched Mixture

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Author contributions

K.Y and T.O made substantial contributions to the conception of the work.M.S carried out the study.M.S and K.Y analyzed and interpreted the data.M.S wrote the main manuscript text. K.Y prepared the figures and tables.K.Y and T.O have revised the work.All authors reviewed the manuscript.

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Data availability

All data generated or analysed during this study are included in this published article.

Declarations

Ethics approval and consent to participate

This study was approved by the Hatay Mustafa Kemal University Clinical Research Ethics Committee (Protocol Number: 2023/8). The authors certify that the study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments (as revised in Brazil 2013). Written informed consent to participate was obtained from the all individual participants included in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Disclosure statement

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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