

Pulpotomy Versus Root Canal Therapy in Mature Permanent Teeth with Irreversible Pulpitis

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Abstract

This review evaluates the effectiveness of pulpotomy as an alternative to traditional RCT for managing irreversible pulpitis in mature teeth. The studies analyzed collectively demonstrate that full pulpotomy achieves success rates comparable to RCT, with reported figures indicating high clinical efficacy. Additionally, pulpotomy not only alleviates pain significantly but also reduces treatment duration, which contributes to enhanced patient satisfaction and overall quality of life.

Moreover, the cost-effectiveness of pulpotomy varies according to different willingness-to-pay thresholds, making it particularly beneficial in resource-limited settings. For instance, findings reveal that pulpotomy generally results in lower overall costs compared to RCT, further emphasizing its practicality for both patients and healthcare systems.

The evidence supports the integration of full pulpotomy into clinical practice as a preferred approach for treating irreversible pulpitis. This less invasive technique not only meets the clinical needs of patients but also aligns with current trends in dentistry that favor minimally invasive procedures. By adopting full pulpotomy, dental professionals can potentially enhance patient outcomes and satisfaction while also transforming conventional practices in endodontics.

In conclusion, the findings of this review advocate for the broader adoption of full pulpotomy in dental practice as a viable, effective, and economical treatment option for irreversible pulpitis. As dental professionals continue to seek strategies that improve patient care, full pulpotomy emerges as a promising alternative that not only fulfills clinical objectives but also enhances the overall patient experience. Future research should focus on long-term outcomes associated with pulpotomy to further validate its efficacy and support its integration into standard dental protocols.

Keywords: Pulpotomy, Root Canal Treatment (RCT); Irreversible Pulpitis; Cost-Effectiveness; Efficacy

Introduction

Irreversible pulpitis is a distressing condition characterized by sudden and intense pain, often driving patients to seek urgent dental care. However, the fear of pain during and after treatment can trigger dental anxiety, causing some patients to delay or avoid seeking necessary treatment altogether [1].

Irreversible pulpitis is believed to be a localized inflammatory reaction to bacterial infection within the dental pulp tissue. The symptoms typically include intense pain episodes triggered by thermal stimuli, which may persist even after the stimulus has been removed [2].

Histological and microbiological research has indicated that inflammation and microbial activity in teeth typically diagnosed with irreversible pulp disease are confined to the coronal pulp tissue, with no evidence of bacterial invasion or inflammation in the radicular pulp [3].

In one study involving 244 children, males exhibited a slightly higher prevalence of irreversible pulpitis, accounting for about 54%, while females represented approximately 46%. The data indicated that children aged 4 to 6 years had a higher incidence of irreversible pulpitis, exceeding 50% overall. Thus, the study suggests that the prevalence of irreversible pulpitis in children is somewhat greater among males than females [4].

There are two types of pulpitis: reversible and irreversible. Studies have shown that there is no clear correlation between clinical symptoms and the histopathological condition of the pulp, particularly in cases of irreversible pulpitis, which can result in misdiagnosis. Unfortunately, the current diagnosis of reversible or irreversible pulpitis relies on patient history, subjective assessments of pain, and pulp sensitivity tests, rather than accurately reflecting the true state of pulp inflammation [5-7].

The standard treatment for irreversible pulpitis is endodontic therapy, which is often considered both physically and mentally challenging for patients. The procedure involves several steps, including injection, drilling, pulp removal, shaping, cleaning, and filling of the root canals, which can heighten dental anxiety. Achieving effective pulpal anesthesia is more difficult in patients with irreversible pulpitis, and it is widely acknowledged that numbing teeth affected by this condition is more challenging compared to teeth with healthy pulp [8].

The objective of this review is to compare the efficacy, safety, and clinical outcomes of pulpotomy and root canal therapy (RCT) in the management of mature permanent teeth with irreversible pulpitis. This review aims to evaluate the effectiveness of pulpotomy as a less invasive alternative to RCT, assess the factors influencing treatment choice, and provide insights into patient outcomes, ultimately contributing to evidence-based decision-making in endodontic practice.

Pulpotomy background

Pulpotomy therapy can be categorized based on specific treatment goals, including mummification and cauterization, preservation of vitality through minimal or noninductive devitalization, and regeneration strategies such as inductive and reparative approaches [9].

Pulpotomy has traditionally been the preferred vital pulp procedure for primary molars affected by extensive caries. The success of this procedure is significantly influenced by technique sensitivity and several factors, including the accuracy of the diagnosis, the method used for caries removal, the choice of pulp dressing material, the quality of the final restoration, and the experience of the operator [10].

Numerous studies have been conducted to identify the optimal pulpotomy agent. Several materials, including mineral trioxide aggregate (MTA), biodentine, lyophilized freeze-dried platelets, enamel matrix protein, Aloe vera, and honey, have demonstrated effective outcomes. These materials can generally be categorized into herbal and non-herbal medicaments [11].

Clinicians have explored and utilized various materials for pulpotomy in primary molars, including formocresol (FC), ferric sulfate (FS), calcium hydroxide (CH), sodium hypochlorite (SH), MTA, and, more recently, calcium-enriched mixture (CEM). These materials have been proposed for their unique properties in preserving tooth vitality and promoting healing [12].

Among the materials used for pulp therapy, FC has historically been the preferred choice for treating primary molars. However, concerns over its potential toxicity, hypersensitivity (allergic reactions), and teratogenicity (ability to cause developmental defects) due to the systemic spread of FC molecules through root canals have prompted the search for safer alternatives [13]. In this regard, FS has been tested and shown success by forming a protein complex that seals capillaries, aiding in blood clot formation and reducing risks of inflammation and internal resorption (breakdown of internal tooth tissue) [14,15].

In the past decade, there has been a renewed focus on pulpotomy as a definitive treatment for mature permanent teeth, aimed at enhancing the understanding of pulp biology and the development of bioactive materials. Coronal pulpotomy is commonly performed on deciduous and immature permanent teeth, highlighting the need for clinical trials to assess the effectiveness of pulpotomy as a therapeutic procedure for mature permanent teeth, in line with Good Clinical Practice guidelines [16].

Efficacy of pulpotomy treatments in teeth with irreversible pulpitis

According to a recent meta-analysis, the success rate of pulpotomy strengthens the growing body of evidence supporting it as an effective treatment option for carious teeth with irreversible pulpitis. With its potential for managing pulpitis and the increasing global focus on minimally invasive dentistry, there is an urgent need for well-designed randomized clinical trials to further investigate this under-researched topic [17].

In clinical practice, mature permanent teeth with both reversible and irreversible pulpitis, often due to severe tooth wear and caries, were treated with pulpotomy using mineral trioxide aggregate (MTA) as a capping material. This approach achieved a remarkable clinical success rate of over 90% at the 12-month follow-up, with age identified as a key factor influencing clinical outcomes. Notably, no statistically significant difference was observed in success rates between teeth affected by caries and those suffering from severe tooth wear [18].

In another study, pulpotomy was performed on teeth exhibiting clinical signs and symptoms of irreversible pulpitis, with 70% (14 out of 20) also presenting symptomatic apical periodontitis. Remarkably, all patients experienced complete pain relief just two days after the procedure. Follow-up evaluations at both 6 months and 1-year post-treatment showed all teeth to be clinically successful. Radiographic assessments revealed continued development of immature roots, with dentin bridge formation observed in five of the twenty teeth. Healing signs were noted in all seven teeth with preoperative periapical rarefaction; however, one tooth displayed internal root resorption after one year, leading to an overall success rate of 95% (19 out of 20).

Young permanent teeth with carious exposure can also be effectively treated with full pulpotomy using biodentine, with clinical symptoms of irreversible pulpitis not contraindicating this approach [19].

Another trial found that 91% of the teeth exhibited clinical signs consistent with symptomatic irreversible pulpitis, and 78% showed signs of symptomatic apical periodontitis. The follow-up period spanned from 18.9 to 73.6 months, and by the end, all pulpotomies were deemed clinically and radiographically successful, with a hard tissue barrier forming in 57% of the teeth. MTA demonstrated high clinical and radiographic success as a pulpotomy agent for children with permanent teeth showing signs of irreversible pulpitis [20].

In terms of clinical outcomes, both treatment groups showed success rates of 98% or higher at 2 and 5 years, with no significant differences between them. Radiographic results favored the FP/MTA group over FP/CEM at the 2-year mark ($P= 0.005$), but by the 5-year follow-up, the success rates were comparable ($P= 0.413$). Factors such as age and preoperative periapical status did not significantly influence treatment outcomes. These findings emphasize that both MTA and CEM biomaterials are equally effective as pulpotomy agents for mature permanent molars with irreversible pulpitis and associated apical periodontitis, promoting a shift towards more conservative and biologically focused treatments in dentistry [21].

Pulpotomy demonstrated a clinical success rate of 94.4% at 7 days, which declined to 85.4% after 12 months. All three biomaterials used were equally effective in relieving pain at each interval, with no significant differences observed between them ($P > 0.05$). However, by 6 and 12 months, 26.2% and 52.4% of teeth exhibited slight widening of the periodontal ligament space. Radiographically, there were no significant differences in success rates among the three groups ($P = 0.135$ at 6 months, 0.717 at 12 months). Overall, pulpotomy achieved a high clinical success rate in mature molars with irreversible pulpitis, and the choice of biomaterial did not significantly influence the outcome [22].

Additionally, the CEM cement group achieved complete apical closure (apexogenesis) in 76.8% of roots, while the MTA group reached 73.8%, with no statistically significant difference in radiographic outcomes between the two. Both CEM cement and MTA demonstrated comparable effectiveness in pulpotomy for immature, caries-exposed permanent molars [23].

Finally, teeth showing clinical signs of irreversible pulpitis and periapical radiolucency were successfully treated with MTA pulpotomy, achieving success rates of 84% and 76%, respectively. Among the seven cases that failed, three required pulpectomy to relieve painful pulpitis, while the other four remained asymptomatic, with failure identified through radiographic examination. Importantly, a statistical relationship between treatment outcomes and treatment factors was not observed. Thus, teeth with carious pulp exposure can be effectively treated with MTA pulpotomy, and the presence of irreversible pulpitis or periapical radiolucency should not be considered a contraindication for this treatment [24].

In table 1, the efficacy of pulpectomy is illustrated.

Reference	Intervention	Success Rate	Other Findings	Conclusion
[18]	Pulpotomy with MTA	> 90%	Age influenced success; no significant difference between caries and wear-affected teeth.	MTA pulpotomy effectively treats mature teeth with reversible and irreversible pulpitis.
[19]	Pulpotomy with Biodentine	95%	70% had symptomatic apical periodontitis; complete pain relief after 2 days; one showed resorption.	Young permanent teeth with carious exposure can be treated successfully with Biodentine pulpotomy.
[20]	Pulpotomy with MTA	100%	91% exhibited symptomatic irreversible pulpitis; hard tissue barrier formed in 57% of teeth.	MTA shows high clinical and radiographic success as a pulpotomy agent in children with irreversible pulpitis.
[21]	Pulpotomy with MTA and CEM	≥ 98%	No significant differences in success rates; similar outcomes at 5 years.	MTA and CEM are equally effective for mature molars with irreversible pulpitis.
[22]	Pulpotomy with various biomaterials	94.4% (7 days), 85.4% (12 months)	Pain relief effective; slight widening of periodontal ligament space observed.	Pulpotomy has high success in mature molars; biomaterial choice did not significantly impact outcomes.
[23]	Pulpotomy with CEM and MTA	76.8% (CEM), 73.8% (MTA)	No significant difference in radiographic outcomes.	CEM and MTA demonstrate comparable effectiveness in pulpotomy for immature, caries-exposed molars.
[24]	Pulpotomy with MTA	84% (pulpitis), 76% (radiolucency)	Three failed cases required pulpectomy; four asymptomatic found via radiographs.	MTA pulpotomy effectively treats carious pulp exposure; irreversible pulpitis is not a contraindication.

Table 1: The efficacy of pulpectomy.

Cost-effectiveness

The decision for pulpotomy treatment often depends on cost considerations. While MTA is highly effective, its expense may make it less practical for primary molars. In 2008, Fuks proposed ferric sulfate as a viable and more affordable alternative. If cost is a significant factor, particularly when the treated molars will be replaced by permanent teeth, ferric sulfate could be a better option due to its cost-effectiveness [25,26].

Pulpotomy is a time-efficient and cost-effective procedure, benefiting both patients and public health systems by reducing the need for more extensive treatments [27].

Root canal therapy background

Root canal therapy is a type of endodontic procedure aimed at effectively cleaning and shaping the root canals to eliminate microorganisms. It involves filling the canal with an inert material to create a three-dimensional seal and placing a restoration to prevent any connection between the periradicular tissues and the oral environment. This process is essential for maintaining tooth health and preventing infection [28].

Root canal treatment is often not the preferred option, primarily due to limited access to endodontic equipment and time constraints. As a result, most endodontic procedures are performed in private dental practices or dental schools. Additionally, participants in endodontic courses typically express a desire to learn techniques that make these treatments quicker, easier, and more successful [29,30].

The clinical success of root canal treatment can be evaluated from various perspectives, including the dentist, the patient, and the tooth itself. For dentists, success is indicated by the absence of symptoms (no pain), proper imaging (root canal fully filled with no periapical inflammation), and the overall condition of a well-restored tooth. Patients primarily value symptom relief, while tooth success is linked to the absence of disease, such as infections. Ultimately, successful RCT reduces the need for further interventions and leads to positive treatment outcomes [31].

Root canal treatment in teeth with irreversible pulpitis and acute apical periodontitis tends to be more painful. Factors such as the patient's age, the type of tooth, and the duration of the procedure were linked to a higher likelihood of pain during treatment. Understanding the pain levels patients experience can help dentists determine when to administer additional local anesthesia [32].

This heightened pain sensitivity poses a challenge for effective pain management, particularly when morphogenetic changes from neurogenic inflammation make nerve fibers resistant to anesthesia. For instance, in patients with irreversible pulpitis, the standard inferior alveolar nerve block fails to work in up to 80% of cases [33,34].

Pulpotomy versus RCT in mature permanent teeth with irreversible pulpitis

This study examines the efficacy and efficiency of full pulpotomy versus traditional RCT for managing irreversible pulpitis in mature teeth. As dental professionals aim to adopt less invasive techniques, it is important to evaluate various clinical outcomes, such as success rates, pain management, treatment duration, and cost-effectiveness of both procedures.

A randomized clinical trial investigated the efficacy of minimally invasive VPT using full pulpotomy with ProRoot MTA and CEM cement compared to traditional RCT. The results revealed success rates of 98% for RCT, 100% for ProRoot MTA, and 97.9% for CEM cement, with no significant differences observed in clinical outcomes ($p = 0.653$) or radiographic success rates ($p = 0.544$). This study supports the notion that full pulpotomy with either ProRoot MTA or CEM cement provides success rates comparable to RCT, thereby reinforcing VPT as a less invasive alternative for managing mature permanent teeth, particularly in cases involving irreversible pulpitis [35].

Further research involving 160 mature molar teeth with irreversible pulpitis compared full pulpotomy using iRoot BP Plus with traditional RCT. The success rates were similarly high for both treatments, with clinical outcomes reported as 97.3% for pulpotomy and 98.6% for RCT, while radiographic success rates stood at 93.3% and 94.6%, respectively ($P > 0.05$). Notably, postoperative pain reduction was greater on the first day in the pulpotomy group ($P < 0.05$), and this group also experienced lower treatment time and costs compared to RCT ($P < 0.05$). These findings establish full pulpotomy as a viable, cost-effective alternative for managing mature teeth with irreversible pulpitis in the short term [36].

Another trial explored the efficacy of pulpotomy using a calcium-enriched mixture against one-visit RCT in a sample of 407 patients. While clinical success rates were similar across both groups, RCT patients reported significantly more postoperative pain ($P < 0.001$). Interestingly, the calcium-enriched mixture group exhibited higher radiographic success rates ($P < 0.001$), suggesting that pulpotomy with this mixture may serve as a promising alternative to RCT for treating irreversible pulpitis, which could have transformative implications for global oral health if long-term outcomes confirm these findings [37].

Additionally, a study assessed the short-term pain progression and treatment success of full pulpotomy as a permanent solution for irreversible pulpitis in mature molars compared to RCT. Although there were no significant differences in pain reduction or clinical success rates (80% for pulpotomy vs. 90% for RCT), pulpotomy demonstrated a significantly higher radiographic success rate (94% vs. 69%). These results imply that full pulpotomy could be a viable and conservative alternative to RCT, even when performed by non-specialist dentists [38].

A comprehensive evaluation compared full pulpotomy and RCT for treating mature teeth with carious pulp exposure and irreversible pulpitis, revealing similar clinical and radiographic success rates at 93% for both treatments. However, pulpotomy was associated with significantly lower pain levels on the first day, quicker pain relief, and reduced analgesic requirements. While both treatment methods improved patients' quality of life, satisfaction rates were higher for pulpotomy, attributed to shorter treatment duration, reduced discomfort, and lower costs. This indicates that full pulpotomy is a viable alternative to RCT, offering comparable success with greater patient satisfaction [39].

Lastly, an economic analysis evaluated the cost-effectiveness of pulpotomy versus RCT for managing irreversible pulpitis in mature permanent teeth. Utilizing a Markov model, the study found that while RCT provided slightly more health benefits (1.08 additional years), it also incurred a higher cost (\$311.20) over a patient's lifetime. Pulpotomy was determined to be cost-effective at lower willingness-to-pay (WTP) values, with 99.9% acceptability at \$50, whereas RCT became more cost-effective at higher WTP thresholds (99.9% acceptability at \$550). This suggests that pulpotomy is more economical at lower cost thresholds, while RCT may be preferable as WTP increases [40].

The information in table 2, which compares studies on pulpotomy and RCT

Reference	Intervention	Control	Success rate	Other findings	Conclusion
[35]	Full Pulpotomy with ProRoot MTA and CEM cement	Traditional RCT	98% (RCT), 100% (ProRoot MTA), 97.9% (CEM)	Comparable outcomes, supports VPT as less invasive	Full pulpotomy offers success rates similar to RCT for managing irreversible pulpitis in mature teeth.
[36]	Full Pulpotomy with iRoot BP Plus	Traditional RCT	97.3% (FP), 98.6% (RCT)	FP had lower treatment time and cost, significant pain reduction	Full pulpotomy is a viable, cost-effective alternative to RCT for managing irreversible pulpitis.

[37]	Pulpotomy with Calcium-Enriched Mixture	One-Visit RCT	Similar clinical success, higher radiographic success in CM group	Significant less post-operative pain in CM group	Pulpotomy with calcium-enriched mixture may transform oral health; promising alternative to RCT.
[38]	Full Pulpotomy	Traditional RCT	80% (FP), 90% (RCT)	Higher radiographic success for pulpotomy	Pulpotomy may be a conservative alternative to RCT, especially by non-specialist dentists.
[39]	Full Pulpotomy	Traditional RCT	93% (both)	Lower pain levels and higher patient satisfaction	Pulpotomy could be a viable alternative to RCT with similar success and greater patient satisfaction.
[40]	Pulpotomy	Traditional RCT	Slightly more health benefits with RCT	Pulpotomy cost-effective at lower WTP (\$50)	Pulpotomy is economical at lower thresholds; RCT is preferable at higher WTP values.

Table 2: Comparison between pulpotomy and RCT in teeth with irreversible pulpitis.

Conclusion

The studies collectively indicate that full pulpotomy is a highly effective and less invasive alternative to traditional RCT for managing irreversible pulpitis in mature teeth. With success rates comparable to root canal therapy, pulpotomy not only provides significant pain relief and reduced treatment time but also enhances patient satisfaction and quality of life at a lower cost. Furthermore, its cost-effectiveness varies based on willingness-to-pay thresholds, suggesting that pulpotomy is particularly advantageous in settings with budget constraints. As such, the findings support the adoption of full pulpotomy as a preferred treatment option, particularly for cases involving irreversible pulpitis, thereby promising to improve patient outcomes while potentially transforming clinical practices in endodontics.

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