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Pulpotomy: An alternative treatment modality to conventional root canal treatment

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ABSTRACT

Introduction

Vital pulp therapy is considered a successful treatment modality in primary and immature permanent teeth. The development of bioactive material has led to vital pulp therapy and pulpotomy treatment becoming a popular treatment modality in permanent teeth. This literature review investigates pulpotomy procedures on permanent teeth as a viable option, as opposed to conventional root canal treatment, as presented in the case report included.

Aim

The aim of this study is to evaluate literature on the reported success of pulpotomy treatment in mature permanent teeth. For this reason, the study specifically reviewed literature detailing the use of pulpotomies including the materials required for the procedure.

Method

The literature review is focused on studies using MTA and bioactive alternatives as pulpotomy material. An electronic search was done on EBSCOhost to source 58 articles published from 1979 to 2022.

Results

Literature investigated reports that pulpotomy treatment with bioactive materials shows promising results and therefore the possibility exists of it being a suitable treatment option or alternative to conventional root canal treatment.

Keywords

Apexification, dental pulp, root canal therapy, partial pulpotomy, vital pulp therapy.

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Conflict of interest

The authors have no conflict of interest to declare.

INTRODUCTION

Vital pulp therapy (VPT), as a possible therapeutic intervention in the treatment of both primary and permanent teeth, is well documented.[1,2] The long-term health of the dental pulp is reliant on the correct diagnosis and subsequent treatment.[3] VPT is a viable treatment option in permanent teeth with normal/healthy pulps or pulpitis (for example: apexogenesis, indirect pulp capping, direct pulp capping, partial pulpotomy and complete pulpotomy).[2] The standard treatment options in permanent teeth with irreversible pulpitis or necrotic pulp are regenerative endodontics, conventional root canal treatment and apexification.[4,5] It is advised that clinicians familiarise themselves with these pulp therapies, taking into consideration the restorability of the tooth as well as alternative VPT treatment therapies.[5]

The American Academy of Paediatric Dentistry (AAPD) guidelines define when pulpotomy procedures can be performed: "A pulpotomy is performed in a tooth with extensive caries without evidence of radicular pathology when caries removal results in a carious or mechanical pulp exposure."[6]

Pulpotomy treatment is indicated in primary teeth with exposed vital pulps or reversible coronal pulpitis. Pulpotomies can also be considered in immature permanent teeth with pulpal exposure due to caries or trauma. This can also be performed as an emergency procedure in permanent mature teeth until such time as root canal treatment can be performed.[7] Coronal pulpotomy in comparison to conventional RCT procedures are less costly and not considered as technically demanding and time consuming.

VPT aims to maintain tooth functionality and vitality.[8] In the past, VPT has predominantly been used in primary and immature permanent teeth; however, with the development of bioactive materials, the use of these materials in permanent teeth with mature root apices is gaining popularity. Performing a coronal pulpotomy on permanent teeth, which implies the amputation of pulp tissue down to the cervical line with bioactive material, has been suggested as an alternative to a traditional RCT.[9]

According to the AAPD guidelines, a partial pulpotomy is the treatment of choice following traumatic or carious pulp exposure in immature permanent teeth, whereas coronal pulpotomy is the treatment of choice in immature teeth with pulpal inflammation. The primary objective of performing a pulpotomy is to preserve radicular pulpal tissues that may help to complete apexogenesis in immature permanent teeth.[7]

www.sada.co.za / SADJ Vol. 78 No.6
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Coronal pulpotomy differs from partial pulpotomies whereby only partial removal of coronal pulp is performed. A pulpotomy procedure is performed when the coronal pulp is either inflamed and/or infected and subsequently amputated.[10] The remaining radicular dental pulp is then covered with the appropriate material to protect the pulp from further injury and to facilitate healing.[7,11]

Clinical decision-making and correct diagnosis in considering coronal pulpotomy treatment as an alternative treatment modality over conventional RCT in mature permanent teeth with irreversible pulpitis is paramount.[9]

Review of literature

Conventional RCT, indicated in permanent mature teeth with pulpal and periradicular diseases, consists of the complete removal of pulp tissue from the root canals of the tooth, the disinfection of canals and final restoration/prosthesis. Root canal treatments are considered to have high overall success rates estimated at 86.02%.[12] Results of 86% at 2-3 years, 93% at 4-5 years and 87% at 8-10 years survival rates of endodontically treated teeth have been reported.[13] However, considerable loss of tooth structure is one of the negative outcomes of performing RCT. The most common denominator in the failure after root canal treatment is tooth fracture and loss due to compromised remaining tooth structure.[8,14,15] Coronal pulpotomy treatment is a more conservative therapy and aids in preserving tooth structure in a minimally invasive manner.[9] Pulpotomy treatments are also less technically challenging and demanding than standard root canal treatments.[7]

Various studies have reported high rates of poor quality of obturation (25-62%) and apical periodontitis (45%) associated with root filled teeth.[16,17,18] Healthy pulps are still the best option to fill a root canal with and it should not be assumed that just because the pulp is damaged that it will need to be removed completely.[19] However, RCT in teeth with pulpal and/or peri-radicular diseases is still considered the standard care.[20, 21] Unfortunately, survival rates of these teeth are significantly reduced after root canal treatment compared to vital teeth.[14] Plausible causes might include the lack of a proprioceptive mechanism, loss of dental hard tissue and the loss of a damping effect.[22,23]

Advances in bioactive materials have recently provided an alternative treatment option in teeth with irreversibly inflamed pulps. Most bioactive materials are calcium silicate-based material (ProRoot MTA (Dentsply Sirona, Switzerland), Biodentine (Septodont, Saint-Maur-des-Fossés, France) and calcium-enriched mixture (CEM) (Yekta Zist Dandan Company, Tehran, Iran). Both these materials are biocompatible and capable of inducing cementogenesis, dentinogenesis and osteogenesis.[24,25]

Due to the biocompatibility and superior sealing ability, mineral trioxide aggregate (MTA) and CEM have been found to produce better success rates than calcium hydroxide.[9] Dentine bridge formation and pulpal health were more predictable and successful after MTA pulpotomy treatments.[26,27]

Since its introduction, MTA has attracted a fair amount of attention from the endodontic field due to many of its advantages compared to traditional endodontic material. This includes its sealing ability, biocompatibility and the ability to form dentine bridges due to the induction and proliferation of pulp cells. Many studies show that MTA is the material of choice for vital pulp therapy, while other studies found no significant differences when comparing MTA to similar material.[28-34] Conflicting results exist as to MTA being the material of choice for vital pulp therapy in primary and young permanent teeth.[28-34]

The use of bioactive material has created a new awareness of pulp regeneration and vascularisation as well as leading to many scholars focusing on alternative treatment options, for example coronal pulpotomy treatment in permanent teeth with reversible pulpitis. Several studies have shown success rates comparable to traditional RCT.[35] Studies conducted on coronal pulpotomies also show success rates comparable to traditional root canal treatment in teeth with pulpal disease.[36,37,38]

A concern with coronal pulpotomies in permanent teeth is the uncertainty of the pulpal status before commencing treatment, as well the unpredictability and lack of long-term scientific evidence regarding success rates of treatment.[39] Teeth in which full pulpotomy treatment is considered are generally nonresponsive to sensibility tests.[43] The radicular pulp should therefore be considered healthy in the absence of contradicting clinical or radiographic signs.
Eghbal *et al*.[40] reported that upon histologic examination, there was no inflammation on pulpal tissue after direct placement of MTA on vital pulp tissue. Additionally, Asgary *et al*.[41] showed similar results in their multicentre trial, comparing coronal pulpotomies using CEM, with RCT in permanent teeth with closed apices and irreversible pulpitis. No differences in success rates were reported between pulpotomies and standard RCT in either 6- or 12-month follow-ups. However, pulpotomies performed better radiographically compared to the RCT group.[37] A study done by Alqaderi *et al.*[42], which performed pulpotomies with MTA on permanent teeth in children, indicated for traditional root canal treatment, presented a success rate as high as 90%.[43,44] Taha *et al*.[43] reported success rates of 100% at one year and 92.7% success at a period of three years follow-up. Similarly, studies by Simon *et al*.[45] as well as Taha *et al.*[44] reported high clinical and radiographic success in their prospective study in permanent teeth with mature apices and irreversible pulpitis performed by using Biodentine during complete coronal pulpotomy.

Asgary *et al*.[41] illustrated a case in which a molar tooth with irreversible pulpitis and condensing osteitis was treated with a coronal pulpotomy using CEM cement. The tooth was clinically asymptomatic, and complete healing of periradicular tissue had taken place at a two-year follow-up investigation. Root canal calcifications were not evident in contrast to calcifications frequently seen in clinical practice using calcium hydroxide pulpotomy.[41]
Asgary *et al*.[37] compared root canal treatments with coronal pulpotomies (CEM pulpotomy) and showed no significant difference in the success rates during a five-year follow-up between these two treatment modalities. Linsuwanont *et al*.[46] reported a clinical success rate of 87.3% in their study on MTA pulpotomy treatment in 66 carious exposed permanent teeth at a 62-months follow-up evaluation.

Alqaderi *et al*.[42] evaluated the success rate of cervical pulpotomy treatment in mature permanent irreversibly inflamed teeth. Success rates were reported as high as 94% in year one and 92% in year two. Pulpotomies performed using Bioactive materials resulted in higher success rates

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than those performed using calcium hydroxide. The author of this systematic review proposed coronal pulpotomy as a viable treatment option in irreversibly inflamed permanent teeth.[26]

Baranwal *et al*.[47] conducted a pulpotomy study and found contradicting results compared to the study done by Asgary[41], using Biodentine instead of MTA in the treatment of human permanent molar with irreversible pulpitis. After the first year an overall success rate of 87% was reported using Biodentine. This might be due to its adequate sealing ability, compressive strength and biocompatibility. The additional calcium release of ions in Biodentine compared to MTA and calcium hydroxide-based materials was also evident in this study. When Biodentine is used as a capping material, pulp mesenchymal stem cells develop to odontoblast-like cells, due to the TGF-b1 growth factor release, resulting in tertiary dentine formation. Both partial and complete pulpotomies developed a degree of dentine bridge formation, running the risk of developing root canal calcifications which is less apparent in partial pulpotomies.

A review done by Cushley *et al*.[48] evaluated the clinical success rate of pulpotomies in permanent teeth presenting with symptomatic irreversible pulpitis. The success rate of coronal pulpotomy was found to be 97.4% clinically and 95.4% radiographically at the 12-month follow-up.[48]

Li et al.[49] systematically reviewed the comparison between MTA pulpotomies and calcium hydroxide pulpotomies. Pulpotomies performed using MTA revealed to have a higher clinical and radiographic success rate at one year follow-up than that of calcium hydroxide pulpotomy.

Positive outcomes at two- to three-year follow-up periods have been reported in cases of mature teeth with irreversible pulpitis treated by means of pulpotomy procedures. Defective restorations causing microleakage was reported as the main reason for coronal pulpotomy failures[50]. Hence, it is crucial for the success of the VPT that there is coronal restoration and satisfactory sealing with bioactive material. Regular evaluations and recalls of restorations are of great importance to ensure marginal integrity and longevity[9].

In a study by Kunert *et al*.[51] pulpotomies were performed on 273 teeth using different restorative options. The best results in terms of coronal seal were achieved by using a prosthetic crown, followed by amalgam, while the use of composite yielded poor results.[51]

Endodontic treatment can be complex and is influenced by various factors such as unusual canal shapes, dilacerations, unusual number of canals as well as root canal calcifications.[52] It would be of great advantage to be able to practice a less expensive, and less technically demanding, alternative technique.[53] Vital pulp therapy would be such an alternative, as suggested by a recent systematic review.[54]

The overall success of VPT in caries exposed teeth depends on the technique employed, the extend of pulp tissue inflammation and the period of observation.[28] The possibility of failure of vital pulp is far less in younger patients compared to older patients opening new possibilities in endodontics, as observed by Bjorndal *et al.*[55]

Case report

An 11-year-old male patient reported with a history of irreversible pulpitis before his previous dentist removed the inflamed coronal pulp tissue from the pulp chamber on his right, maxillary first molar. The tooth was temporarily restored with a polycarboxylate restoration (Figure 1).

A high resolution CBCT scan revealed patent root canal systems in the mesiobuccal, distobuccal and palatal root canal systems with immature apices (Figure 2).

After access cavity preparation it was noted that there was vital bleeding pulp tissue at the canal orifices of the root canal systems (Figure 3a). It was decided to do partial pulpotomy using MTA. A 3.5% sodium hypochlorite solution was used to disinfect the exposed pulp tissue and to control the bleeding from the exposed pulp tissue.[56-58] MTA Flow (Ultradent) was mixed and preloaded in a syringe according to the manufacturer's instructions. A 3-4mm layer of the MTA material was dispensed onto the pulp floor, over the exposed pulp tissue at orifice level (Figure 3b).

The MTA material was covered with a thick layer of Vitrebond (3M/ESPE) light-cured glass-ionomer cement (Figure 4a) before the rest of the temporary restorative material was removed. A class II composite resin restoration was placed as a definitive restoration (Figure 4b). Figure 4c shows the

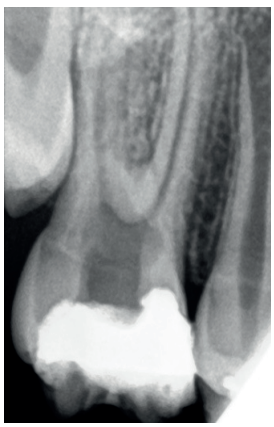

Figure 1. Preoperative periapical radiograph of a right, maxillary first molar after removal of inflamed pulp tissue in the pulp chamber.

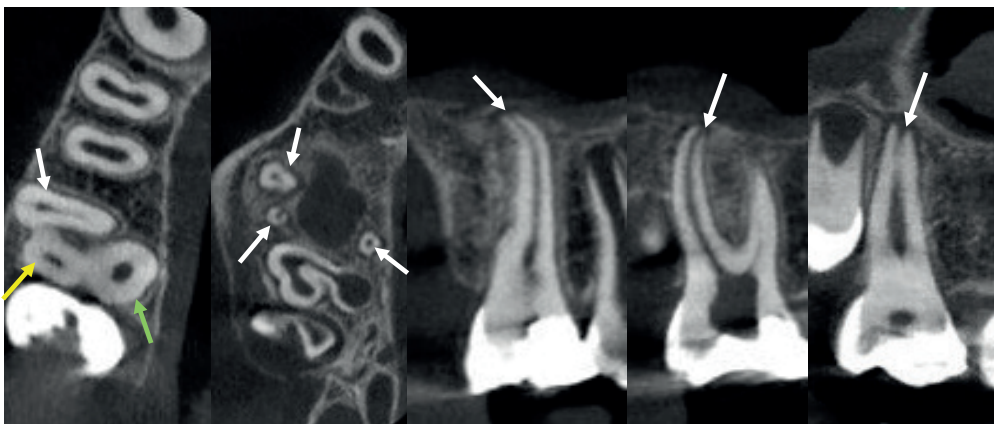

Figure 2. High resolution CBCT images of the right, maxillary first molar depicting the preoperative root canal anatomy: (a) Axial view at the level of the coronal third of the roots showing a very oval shaped mesiobuccal root (white arrow) and round distobuccal (green arrow) and palatal (yellow arrow) roots with patent root canal systems; (b) Axial view at level 0.5-1mm from the apex of the roots showing mesiobuccal, distobuccal and palatal roots with two immature apices (white arrows); (c) Coronal view of the mesiobuccal root canal system ending in an open apex (arrow); (d) Coronal view of the distobuccal root canal system ending in an open apex (arrow); (e) Coronal view of the palatal root canal system ending in an open apex (arrow). Note that all three root canal systems are patent without any calcifications present.

www.sada.co.za / SADJ Vol. 78 No.6
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immediate postoperative periapical radiograph. A periapical radiograph (Figure 5) and CBCT scan (Figure 6) at a five-year follow-up revealed pulp calcification in the root canal systems with mature apices.

In conclusion, with the use of MTA and other bioactive materials such as Biodentine and CEM, pulpotomies could be a viable alternative to conventional RCT in the management of symptomatic, caries exposed, mature permanent teeth, keeping in mind careful case selection.[28]

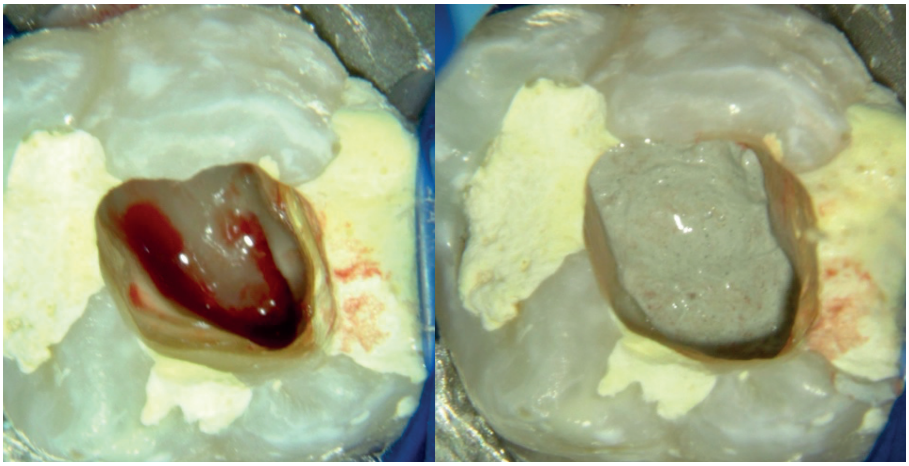

Figure 3. (a) Vital bleeding pulp tissue at the canal orifices of the root canal systems visible after access cavity preparation; (b) A 3-4mm layer of MTA Flow (Ultradent) material dispensed onto the pulp floor, over the exposed pulp tissue at orifice level.

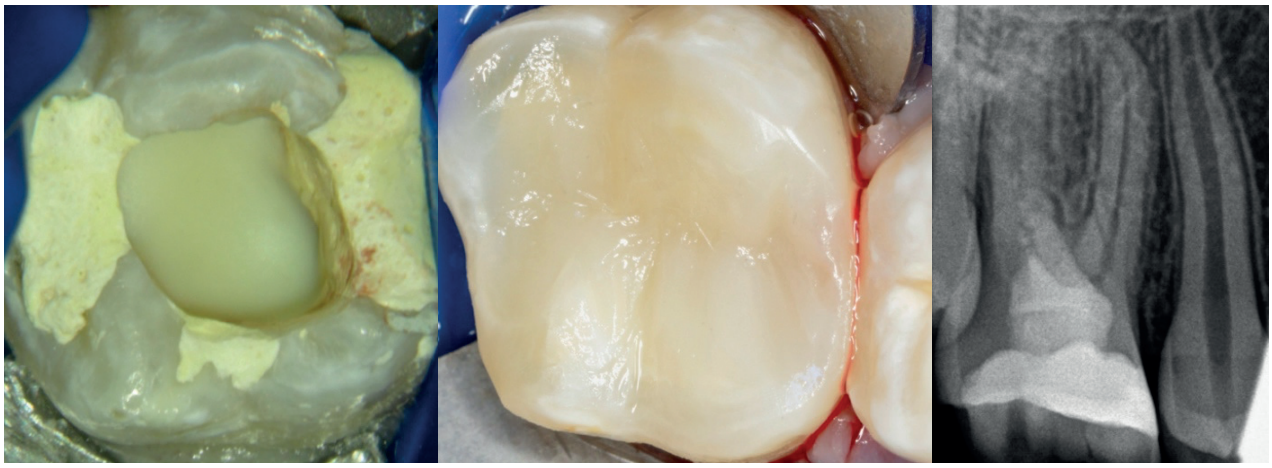

Figure 4. (a) The MTA material was covered with a thick layer of Vitrebond (3M/ESPE); (b) Class II composite resin restoration was placed as a definitive restoration; (c) Immediate postoperative periapical radiograph.

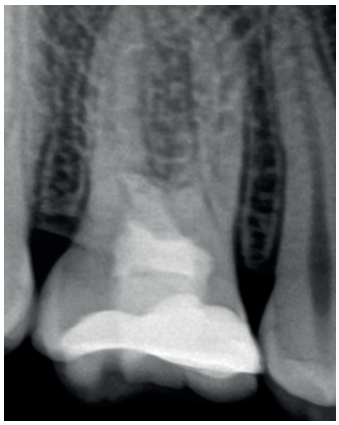

Figure 5. Periapical radiograph after 5 years. Note the evidence of root canal calcification.

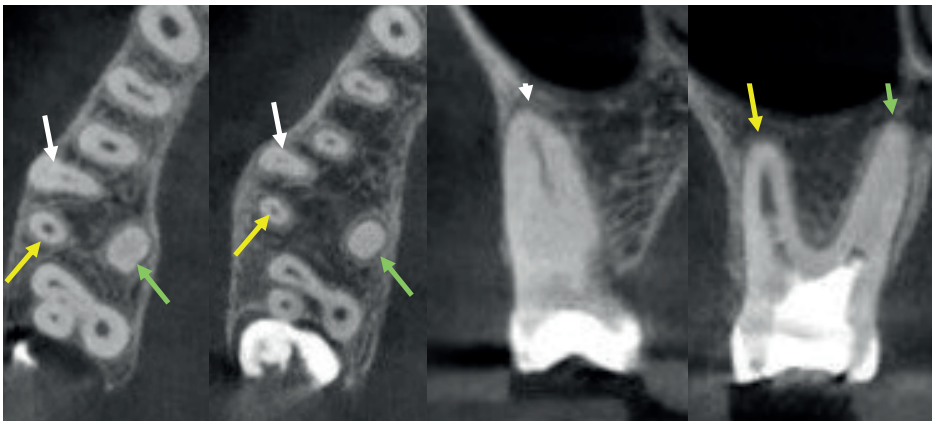

Figure 6. High resolution CBCT images at a 5-year follow-up visit depicting the new root canal anatomy: (a) Axial view at the level of the coronal third of the roots showing a partially obliterated mesiobuccal root canal (white arrow), completely obliterated palatal root canal (green arrow) and patent distobuccal root canal system (yellow arrow); (b) Axial view at the level of the apical third of the roots also showing a partially obliterated mesiobuccal root canal (white arrow), completely obliterated palatal root canal (green arrow) and patent distobuccal root canal system (yellow arrow); (c) Coronal view of the mesiobuccal root showing partially with a closed apex (white arrow). Note the coronal calcification of the root canal system with only some canal system visible towards the apical third of the root; (d) Coronal view of the distobuccal (yellow arrow) and palatal (green arrow) roots with closed apices. Note the patent distobuccal root canal system with evidence of pulp calcification in the midroot area of the canal. The entire palatal root canal system was calcified.

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