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# Outcome of Vital Pulp Therapy Using MTA and Biodentine in Permanent First Molars with or without Pulpitis in Pediatric Patients

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## Abstract

**Purpose:** This study evaluated the outcome of vital pulp therapy (VPT) in permanent first molar teeth using Biodentine (Septodont, Saint Maur des Fosses, France) or ProRoot MTA (Dentsply Tulsa Dental Specialties, Johnson City, Tenn.) in pediatric patients.

**Methods:** Permanent first molar teeth with or without a history of pulpitis from patients aged 7 to 14 years old were treated at the Graduate Endodontic Clinic from September 2007 to August 2022. A retrospective cohort clinical trial was conducted. VPT was performed on a total of 22 teeth. There were 13 teeth in the Biodentine (BD) group and nine teeth in the ProRoot MTA (MTA) group. All teeth were examined clinically and radiographically to determine the health status of the pulp and periapical tissues.

**Results:** Of the 22 teeth, 16 teeth were present in the mouth, five teeth have been extracted, and one tooth had only root tips. The Biodentine group had 69.2% of teeth that were vital. The ProRoot MTA group had 55.6% of teeth that were vital. The average follow-up period was 62.3 months for the Biodentine group and 91.2 months for ProRoot MTA group. Teeth with immature permanent roots showed continued or complete root development radiographically at follow-up examination.

**Conclusions:** VPT in permanent first molar teeth using either Biodentine or ProRoot MTA in pediatric patients has a successful outcome and can be considered as a reliable treatment modality for maintaining pulp vitality and observing continued root development.

**Keywords:** pulp capping; endodontics; silicate cement; vital pulp therapy; capping agents; dental caries; pediatric dental; mineral trioxide aggregate; Biodentine

The dental pulp plays an important role in the tooth's structure, function, and root development. Trauma, caries, or restorative procedures can initiate inflammatory and immune response, causing pulpitis. When pulpitis is not resolved, the pulp may degenerate, resulting in necrosis.<sup>1</sup>

Vital pulp therapy (VPT) is aimed to preserve the pulp's vitality and its function when affected by trauma, caries, or restorative procedures.<sup>2</sup> Traditionally, VPT consisted of indirect or direct pulp capping, and partial or complete pulpotomy on asymptomatic teeth.<sup>3</sup> By preserving pulp vitality in immature permanent teeth, VPT can allow apexogenesis to occur. With more understanding of pulp biology today, and the advancement of the current biomaterial properties, VPT procedures can be performed even in teeth diagnosed with symptomatic irreversible pulpitis.<sup>4-9</sup> Ricucci et al. 2014 and 2019 showed histological evidence that reversible or irreversible pulpitis is a part of a pulpal condition and not representative of the entire pulp tissue.<sup>10,11</sup> By removing the diseased pulpal tissue, vitality of the pulp can be maintained with VPT. Mineral trioxide aggregate (MTA) and other calcium silicate cements (CSCs) are used for VPT procedures in permanent teeth with symptomatic or asymptomatic irreversible pulpitis, success rates range from 85-100% at 1-2 years.<sup>2</sup>

Biomaterials such as mineral trioxide aggregate and Biodentine (BD) are used more often in VPT procedures.<sup>5,12-14</sup> The main properties of MTA include superior sealing ability, biocompatibility, antimicrobial effect, and the ability to set in moist environments.<sup>15</sup> Disadvantages of using MTA are the long setting time, difficult handling properties, and discoloration of the tooth.<sup>16</sup> Both gray and white MTA have been shown to stain teeth due to the presence of iron in gray MTA and bismuth oxide interaction with dentin collagen.<sup>17</sup> In this study, a tooth treated with MTA presented with grayish blue color. The zirconia used as radioopacifier in BD has shown to have a non-staining property.<sup>18,19</sup> BD has great sealing ability and promotes hard tissue healing comparable to MTA.<sup>17,20</sup> Biodentine promotes pulp healing by activating transforming growth factor-beta 1 and stimulating odontoblasts during

early mineralization. Silicon ions play an important role in the formation of a dentinal bridge.<sup>21,22</sup> Multiple studies have shown that when these biomaterials are used for VPT in immature permanent teeth with a history of pulpitis, the success rates range from 87% to 100% after one to two years.<sup>7,8,23,24</sup> More studies are still needed to evaluate VPT over an extended follow-up period comparing the use of MTA to Biodentine.

Cushley et al. found in a systematic review and meta-analysis that MTA and Biodentine have equally high success rates with direct pulp-capping procedures. Both materials had higher success rates than calcium hydroxide.<sup>25</sup>

They have calcium and silicate in their composition, and multiple studies have shown successful outcomes in VPT procedures.<sup>8,23,24,26</sup> Biomaterial ideally should be biocompatible, antibacterial, have higher sealing qualities, improved compressive strength, should be radiopaque, and not soluble or resorbed with the surrounding tissues.<sup>16,21</sup> Mente evaluated the long-term treatment outcome of vital pulp therapy using MTA and calcium hydroxide. There was significantly improved treatment outcome with direct pulp capping with MTA (80.5%) compared to calcium hydroxide (59%).<sup>27</sup> Tzanetakakis et al. evaluated the outcome of

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Table 1 — Categorical Data Summary of 20 Participants

Participant #	Sex	First Molar Type	BD or MTA	VPT Type	Present in Mouth	Age at Treatment (years)	Follup up Period (months)	Code Test Response	EPT Response	Percussion Pain	Palpation Pain	Bite Test Pain	Mobility	Lowest	Highest	Pulpal Diagnosis	Apical Diagnosis	Restoration	
														Probing Depth (mm)	Probing Depth (mm)			Functional Type	In Mouth
1	M	Mn	BD	TP	Yes	8	6	Yes	NA	No	No	No	0	3	5	NP	NAT	Crown	Yes
2	M	Mn	MTA	TP	Yes	7	108	Yes	NA	No	No	No	0	3	4	NP	NAT	Crown	Yes
3	M	Mn	BD	TP	Yes	9	44	Yes	NA	No	No	No	0	2	3	NP	NAT	Crown	Yes
4	F	Mn	BD	DPC	Yes	9	60	Yes	Yes	No	No	No	0	1	3	NP	NAT	Composite	Yes
5	M	Mn	MTA	TP	Yes	11	108	No	No	No	No	No	0	1	2	NP	NAT	Amalgam	Yes
6	M	Mn	BD	TP	No	8	52	NA	NA	NA	NA	NA	NA	NA	NA	SIP	SAP	NA	NA
7	F	Mx	BD	DPC	Yes	12	115	Yes	NA	No	No	No	0	2	3	NP	NAT	Crown	Yes
8	M	Mx	MTA	TP	No	9	77	NA	NA	NA	NA	NA	NA	NA	NA	RP	NAT	NA	NA
9	F	Mn	MTA	TP	Yes	14	141	Yes	Yes	No	No	No	1	2	2	SIP	AAP	Amalgam	Yes
10	M	Mx	BD	TP	Yes	11	89	Yes	Yes	No	No	No	0	1	2	RP	NAT	Composite	Yes
11	M	Mn	MTA	TP	Yes	8	11	No	NA	No	No	No	0	3	4	NP	NAT	Crown	Yes
12	M	Mx	MTA	TP	Yes	10	108	No	NA	No	No	No	0	1	2	PT	NAT	Crown	Yes
13	F	Mx	BD	TP	Yes	9	47	NA	NA	NA	NA	NA	NA	NA	NA	AIP	NAT	RR	No
14	M	Mn	MTA	TP	Yes	8	136	No	NA	No	No	No	0	1	2	NP	NAT	Crown	Yes
15	F	Mn	MTA	TP	No	9	170	NA	NA	NA	NA	NA	NA	NA	NA	SIP	NAT	NA	NA
16	F	Mx	MTA	TP	No	7	97	NA	NA	NA	NA	NA	NA	NA	NA	AIP	NAT	NA	NA
17	M	Mn	BD	TP	Yes	8	79	No	Yes	No	No	No	0	1	2	NP	NAT	Composite	Yes
17	M	Mn	BD	TP	Yes	9	70	No	No	No	No	No	0	1	2	PT	AAP	Composite	Yes
18	M	Mx	BD	TP	Yes	12	59	Yes	Yes	No	No	No	0	2	3	NP	NAT	Composite	Yes
19	M	Mx	BD	TP	No	8	59	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
19	M	Mn	BD	TP	Yes	8	59	Yes	No	Yes	Yes	No	0	2	3	NP	NAT	Composite	Yes
20	F	Mn	BD	TP	Yes	11	17	No	Yes	No	No	No	0	1	2	AIP	NAT	Missing	Yes

TP — therapeutic pulpotomy; DPC — direct pulp capping; BD — Biodentine; NP — normal pulp; PT — previously treated; SIP — symptomatic irreversible pulpitis; RP — reversible pulpitis; NAT — normal apical tissues; AAP — asymptomatic apical periodontitis; Mn — mandibular; Mx — maxillary; RR — retained root.

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partial pulpotomy using ProRoot MTA in 33 immature permanent teeth with symptomatic irreversible pulpitis. Results showed normal apical tissue radiographically in all cases median 2.4 years. They concluded that partial pulpotomy is a highly efficient treatment option.<sup>28</sup>

The aim of this study was to determine if VPT in permanent first molar teeth with or without a history of pulpitis using either Biodentine or ProRoot MTA, in pediatric patients is a predictable treatment option for maintaining pulp vitality.

### Materials and methods

This study was approved by the University Institutional Review Board, Detroit, Michigan, United States, and registered (IRB-#22-23-19). Records of pediatric patients who received VPT in the form of direct pulp cap or therapeutic pulpotomy at University Clinic were selected in this study. Partial and complete pulpotomy were grouped together under the therapeutic pulpotomy procedure code. A total of 140 patient records were identified. All patients included in this study received VPT on permanent first molar teeth between September 2007 to August 2022. A total of 20 patients with 22 teeth were able to be recalled for follow-up evaluation. In accordance with the AAE Vital Pulp Therapy Position Statement all cases were treated under magnification. Eighteen treatments were performed by endodontic residents with the use of a surgical microscope and two cases by dental students using loupes as magnification. Rubber dam isolation was used in all cases, with complete caries removal, control of hemostasis, placement of the calcium silicate material and placement of a temporary filling.<sup>2</sup>

Patients were advised to follow up

as soon as possible with their primary dental provider to have a permanent restoration placed. Follow-up appointments, which included clinical and radiographic evaluation, were carried out by one second-year endodontic resident. Patients and the parents and/or guardians of the patients were informed of the aim of the study. Informed consent was obtained from all participating adult subjects, and parents or legal guardians of minors.

Inclusion criteria consisted of patients aged 7 to 14 years with permanent first molar teeth with or without history of pulpitis, who received a single visit VPT using either Biodentine (BD) group or ProRoot MTA (MTA) group. The mean age was 9.38 years for the BD group and 9.78 years for the MTA group. Patients' treatment history and radiographs were collected from their electronic dental record. Exclusion criteria consisted of fully developed teeth in adults, missing preoperative bitewing and/or periapical radiographs, procedures taking two visits, presence of a sinus tract, history of swelling, and teeth with periapical lesion present.

Follow-up appointments were made for 20 patients with 22 teeth who had VPT completed at least six months prior. Clinical and radiographic examination was done to determine the health status of the treated tooth. Radiographic evaluation was done by taking bitewing and periapical radiographs. The following diagnostic tests were performed: pulp sensibility test consisting of cold test with Frisco-Spray (Ad-arztbedarf GmbH, Frechen, Germany) and electric pulp test (EPT) (Vitality Scanner, SybronEndo, Boston, MA); percussion and palpation test; bite test using the Tooth Slooth® (Professional Results, Laguna Niguel, Calif.); mobility test; and periodontal probing. Data was also collected regarding the type of definitive restoration received on the teeth. The t-test and z-test were used for statistical

analysis to determine the difference between the BD and MTA groups. The data on the pre-operative pulpal and periapical diagnoses was collected and the post-operative pulpal and periapical diagnoses were determined using the American Association of Endodontists' diagnostic terminology.<sup>29</sup> A chi square test was used to evaluate the relationship of the outcome to the preoperative pulpal and periapical diagnosis. Evidence of root development was determined by observing the current root length and dentin thickness compared to immediate post-operative radiographs from initial treatment.

### Results

Overall data summary of 22 teeth are shown in Table 1 (see Page 55). A total of 22 teeth in 20 patients were recalled for follow-up examination. There were 17 out of 22 teeth present in the mouth, and five were extracted between the time of initial treatment to follow-up examination. There was no statistically significant difference in the functional teeth status between BD and MTA groups. In the BD group, there was one non-functional tooth that was present as retained roots, resulting in 76.9% that were functional. In the MTA group, 66.7% were functional. Each group had one tooth that received RCT, resulting in 69.2% success in the BD group compared to 55.6% success in the MTA group. This finding was statistically not significant. Prior to VPT, 50% of total teeth evaluated had radiographically evident immature permanent roots. During follow-up examination, all of these roots showed continued or complete root development.

There were 13 males and 7 females in this study. Of the 22 teeth evaluated, 14 were mandibular molars and eight were maxillary molars. There were three different types of restoration observed in the treated teeth, composite, amalgam, and full coverage crown shown in Table 2. Teeth

restored with composite were only seen in the BD group, while teeth restored with amalgam were only seen in MTA group. There were 66.7% of teeth restored with full coverage crown in the MTA group compared to only 30% in the BD group. Even though there was variation in the type of restorations placed, there was no difference in the outcome between the MTA and BD groups.

Four numerical/quantitative variables including the patient's age, lowest and highest probing depth, and follow-up period were statistically evaluated using t-tests. Means and standard deviations were calculated. The p-value showed none of these variables were statistically significant ( $p>0.05$ ) between the MTA and BD groups. In the BD group, the mean age was  $9.70\pm1.64$  years old. In the MTA group, the mean age was  $10.5\pm2.35$  years. The mean follow-up period in the BD group was  $62.3\pm33.1$  months. The mean follow-up period in the MTA group was  $91.2\pm52.6$  months.

Table 3 shows the proportion of responses by patients to the eight tested clinical parameters between both groups. Bite test and functional status of the tooth were classified as either 0% (negative) or 100% (positive). Since there was no variation, there was no difference, thus z-test could not be calculated. Pulp sensibility test, percussion test, palpation test, mobility, and restoration type were evaluated for both groups using the z-test. In the BD group, cold response was detected in 70% of teeth while only 33.3% of teeth in the MTA group. In the BD group, EPT response was detected in 50% of teeth while 20% did not respond, and 30% were not determined. In the MTA group, EPT response was detected in 16.7% of teeth while 16.7% did not respond, and 66.7% were not determined due to teeth having full coverage restorations and not having natural tooth surface to elicit an EPT response, and data was recorded as not applicable (NA). The results showed there was no statistically significant difference ( $p>0.05$ ) in any of these parameters between the two groups.

The post-operative pulpal outcome was compared to the pre-operative diagnosis. Two groups of pre-operative diagnoses were considered. One group consisted of pre-

**Table 2 — Restoration type between Biodentine and ProRoot MTA groups**

Restoration Type	Biodentine	ProRoot MTA
Amalgam	0.0%	33.3%
Composite	60.0%	0.0%
Crown	30.0%	66.7%
No restoration	10.0%	0.0%
Total	100.0%	100.0%

operative pulpal diagnosis of reversible pulpitis and normal pulp (RP/NP) and a second group consisted of pre-operative diagnosis of symptomatic irreversible pulpitis and asymptomatic irreversible pulpitis (SIP/AIP). These two groups were compared with two post-operative outcomes; a 1) desirable outcome of reversible or normal pulp and normal apical tissue or 2) undesirable outcome of symptomatic irreversible pulpitis and/or asymptomatic apical periodontitis.

A chi square test was done and the results between the two pulpal diagnosis groups and desirable outcome were found to be not significant. At the postoperative follow-up, the tooth was present in the mouth for 6/7 teeth (85.7%) of RP/NP and 11/15 teeth (73.3%) of SIP/AIP cases. The outcome of related to pre-operative pulpal diagnosis was evaluated. Of the cases present in the mouth with pre-operative NP/RP, 5/6 teeth (83.3%) had NP at post-operative evaluation. Of the cases present in the mouth with pre-operative SIP/AIP 9/10 teeth (90%) had NP at post-operative evaluation. The outcome related to pre-operative periapical diagnosis was also evaluated. No statistical difference was found between pre-operative periapical diagnosis and outcome.

At the postoperative follow-up, the tooth was present in the mouth for 6/7 teeth (85.7%) of normal apical tissue teeth (NAT) and 11/15 teeth (73.3%) of SAP/AAP cases. *(Continued on Page 58)*

**Table 3 — Proportion of responses by participants to the 8 tested clinical parameters**

	Cold Test Response	EPT Response	Percussion Pain	Palpation Pain	Bite Test Pain	Mobility	Restoration	Functional
Biodentine	70.0%	50.0%	10.0%	10.0%	0%	0%	90.0%	100%
ProRoot MTA	33.3%	16.7%	0%	0%	0%	16.7%	100%	100%

EPT — electric pulp test



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the cases present in the mouth with pre-operative SAP/AAP, 100% had NAT at post-operative evaluation. Of the cases present in the mouth with pre-operative NAT, 80% had NAT at post-operative evaluation. These findings demonstrate the favorable treatment outcome was not influenced by pre-operative pulpal or periapical diagnosis.

### Discussion

Multiple studies have shown that VPT using bioceramic materials in permanent molars is a successful treatment modality at one- to two-year follow-up examination.<sup>5,7,23,24,30</sup> A long-term study by Mente comparing MTA to calcium hydroxide had an extended outcome with a median recall of 42 months.<sup>27</sup> However, more long-term follow-up studies are needed to evaluate the outcome of VPT using currently available calcium silicate materials. This particular study evaluated whether or not VPT in pediatric patients using MTA or BD in permanent first molars maintained pulp vitality and root development, and maintain the tooth func-

tional over an extended period of time.

The current study found that the combined success rate of VPT between the two groups was 63.6% with a follow-up period of  $62.3 \pm 33.1$  months for BD group and  $91.2 \pm 52.6$  months for the MTA group. This finding is in agreement with Asgary et al., a five-year follow-up study, in which the success rate of VPT was 78.1%.<sup>9</sup> Comparing our results to Uesrichai et al. using MTA and BD, their clinical success for MTA was 92% and for the BD group was 87% with a follow-up period averaging 32 months.<sup>7</sup> Even though our success rate was lower, our follow-up period was two to three times longer, which may introduce failures not derived from the VPT procedure itself. The lower success rate could be attributed to delay in definitive restoration placement and failure to maintain a good quality seal of the existing restoration.

The long-term prognosis of VPT is correlated with the amount of remaining tooth structure and the clinician's ability to restore the tooth.<sup>17</sup> A determining factor in the longevity of pulp vitality and functioning tooth after VPT is the quality of the definitive restoration.<sup>8,31</sup> Due to the longer follow-up examination, some patients had difficulty remembering when the

definitive restorations were placed after VPT. Delay in definitive restorations can play a role in teeth lost to extraction. VPT treated with BD showed a higher percentage of tooth retention, possibly due to a shorter follow-up period compared to the MTA group. In Figure 1, BD was used to perform complete pulpotomy on tooth #19. At a nine-year follow-up examination, there is no radiographic evidence of periapical pathology.

When comparing the two groups, BD resulted in more functional teeth in the mouth at 76.9% than MTA at 66.7%. However, this difference was not statistically significant. MTA was first commercially available in 1999 as MTA, while BD was first commercially available in 2009. This could be one reason for the longer follow-up period in the MTA group. A tooth from the BD group was missing a restoration and BD was exposed at the roof level of pulp. The tooth showed no evidence of marginal breakdown at the interface of BD and dentin. It showed positive response to EPT and no signs or symptoms of periapical pathology radiographically. This demonstrated the great sealing ability and prevention of micro-leakage of bacteria, further supporting the use of BD.

Figure 1



Radiographs of an 11-year-old who presents with reversible pulpitis with normal apical tissues. (A) Preoperative radiograph of tooth #19. (B) Radiograph immediately after Biodentine pulpotomy. (C) 9-year postoperative radiograph demonstrating normal periapical tissues.

Determining the vitality of teeth with VPT can be challenging. When VPT is performed, especially in full pulpotomy, a significant amount of pulpal tissue is removed. A decrease in temperature conductivity can be explained by pulp recession or calcification in response to a direct pulp cap procedure or reduced pulpal tissue in a pulpotomy procedure. In two treated teeth that did not respond to the cold test, EPT was able to verify pulp vitality. Another tooth responded to the cold, but did not respond to the EPT. This could have been a false-negative result. EPT has been shown to be a good supplemental test to confirm pulp vitality.<sup>32</sup> Most of the teeth with MTA full pulpotomy in permanent teeth showed no cold response, but a majority of these teeth responded to EPT.<sup>33</sup> This finding is in

agreement with similar studies.<sup>8,24</sup> In Figure 2, complete root maturation is evident from preoperative radiograph to a nine-year follow-up radiograph. Pulp tissue in immature permanent teeth has natural defenses and abundant blood supply resulting in a higher chance of resisting bacterial infection and promoting healing.<sup>8</sup>

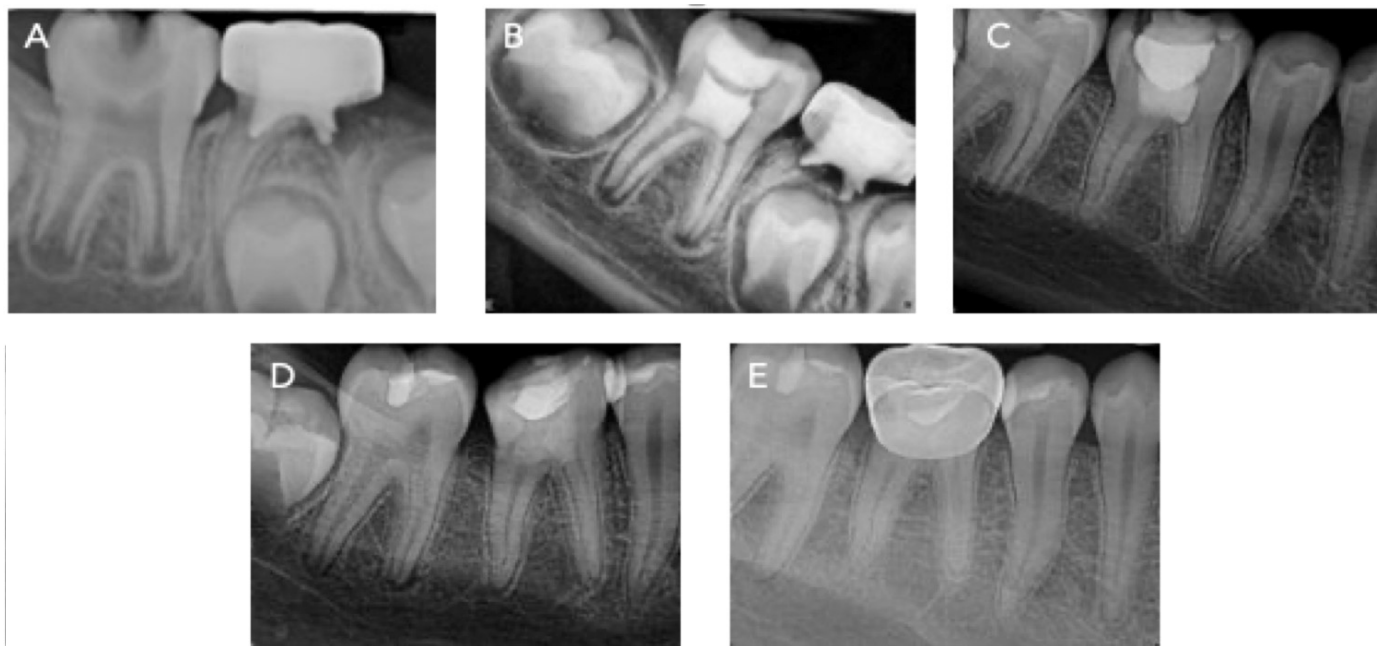
Factors associated with a successful outcome of VPT include maintaining pulp vitality, minimizing pulpal inflammatory reactions, reparative dentin formation, and continuous root development of immature teeth.<sup>12,16,27,34</sup> Preservation of pulp vitality is crucial in maintaining blood supply and nutrients to the tooth during development. Root canal therapy for a child can be challenging for both the clinician and the child. The procedure may consist of long appoint-

ments and multiple visits when treating posterior teeth. In pediatric patients, VPT procedure allows for shorter appointment time, is usually completed in one visit, and is therefore more cost-effective.<sup>35</sup> This treatment option can be very beneficial when treating a child, not only for behavioral and time management, but also to keep the permanent tooth vital.<sup>35</sup> If the tooth becomes symptomatic or necrotic, the child may be more mature at a later point to tolerate endodontic treatment.

Clinically, the outcome of the treated tooth should have no signs and symptoms of thermal pain, apical periodontitis, swelling, or no radiographic signs of root resorption or periapical radiolucency.<sup>17</sup> Figure 3 profiles a treated case of a successful

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**Figure 2**



Radiographs of a 6-year-old patient who presented with reversible pulpitis with symptomatic apical periodontitis. (A) Preoperative radiograph of tooth #30 with gross caries and immature root development. (B) Radiograph after MTA pulpotomy. (C) 3.5-year postoperative radiograph with distal marginal ridge fracture. (D) Existing MTA replaced with Biodentine and tooth temporized. (E) 9-year postoperative radiograph demonstrating complete root development and normal periapical tissues.

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outcome. In the preoperative radiograph of tooth #30 there is gross caries in close proximity to the pulp. Pulpotomy was performed using Biodentine. At the 3.5-year follow-up examination, the radiograph showed no evidence of periapical pathology, and clinical examination showed evidence of pulp vitality. This is in agreement with findings from Tzanetakis.<sup>28</sup>

Some calcification was noted in the coronal aspect of the distal canal. Vital pulp therapy can cause dystrophic calcification to occur, preventing or creating challenging endodontic treatments in the future. Calcification can cause a decrease in blood circulation resulting in necrosis of the pulp.<sup>17</sup> Outcomes of vital pulp therapy in permanent teeth with different medicaments based on review of the literature. However, by the time the pulp becomes necrotic, apexogenesis may be complete.<sup>19</sup> At that time, endodontic therapy can be performed predictably.

Out of 140 patients who were reached out for follow-up appointment, the overall recall rate was only

14.3%. Having a larger sample size could have possibly had an impact on the overall success rate. In this study, the greatest challenge was the ability to recall the patients who received VPT. A similar observation was noted by Asgary et al.<sup>16</sup> One of the barriers in recalling patients was phone numbers that had been changed, with no alternative means of contacting patients. One reason for the number change was relocation. Some patients with the same phone number had transportation issues, which prevented them from returning for follow-up examination. Many treated patients are minors, which meant that either a parent or guardian needed to be present at follow-up appointments. Patients lacking signs and symptoms were not motivated to return. The extended time period for evaluation from initial treatment in this clinical study also made it more challenging to recall patients for follow-up examination. Future multicenter research is suggested in an attempt to increase the pool of data in similarly designed long-term clinical studies of VPT outcome.

## Conclusions

Within the limitations of this retro-

spective clinical study, VPT using Biodentine and ProRoot MTA is a viable and successful treatment modality for permanent first molars in pediatric patients with reversible or irreversible pulpitis. A single-visit VPT procedure is cost-effective, and is able to maintain pulp vitality for continued root development and prolonged tooth functionality in pediatric patients. In the current study, preoperative pulpal and periapical diagnosis did not affect treatment outcome. VPT should be considered as a treatment modality on immature permanent teeth. ●

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Figure 3



Radiographs of a 9-year-old patient who presented with asymptomatic irreversible pulpitis with normal apical tissues. (A) Preoperative radiograph of tooth #30 with gross caries. (B) Radiograph immediately after Biodentine pulpotomy. (C) 3.5-year postoperative radiograph demonstrating normal periapical tissues.



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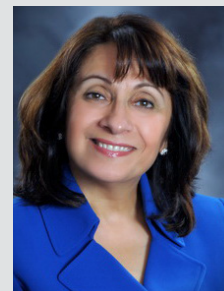
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