

## Clinical and radiographic evaluation of partial pulpotomy in carious exposure of permanent molars

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### Introduction

General agreement is that pulp exposure of an immature tooth with partially developed roots requires a vital technique to enable continued normal root development. It also is universally accepted that the vitality of exposed pulps of young permanent teeth should be preserved, even when roots are completed. In all teeth, with or without closed apices, apposition of dentin along the canal walls and pulp chamber is a continuing physiological process. Root canal treatment would stop this dentin apposition, leaving the tooth with thin dental walls, and making it more prone to fracture.<sup>1</sup>

Direct pulp capping and vital pulpotomy are two accepted clinical modalities to preserve tooth vitality in cases of pulp exposure in young permanent teeth.

According to Seltzer and Bender<sup>2</sup> and Baume and Holz,<sup>3</sup> direct pulp capping is indicated mainly for mechanical small exposures in young permanent teeth with extensive vascular supply and should be discouraged for carious pulp exposures. In teeth with immature roots and open apices, vital pulpotomy is indicated as a temporary treatment to maintain the vitality of the underlying pulp until roots develop.

Pulp curettage has been described as an alternative approach for treating carious pulp exposure.<sup>4</sup> In a review of pulp curettage, Massler<sup>5</sup> suggested the name partial pulpotomy (PP) and described it as the surgical removal of only part of the pulp tissue. The procedure includes partially removing the most superficial inflamed pulp tissue and covering the wound with a calcium hydroxide dressing.

The purpose of this study was to assess, clinically and radiographically, the long-term outcome of partial pulpotomy as a treatment modality in a large number of permanent molars with carious pulp exposure.

### Methods and materials

The study sample consisted of 35 first and second permanent molars with very deep carious lesions in 35 young patients aged 7.5–25 years (mean 12.5 years). Table 1 shows the distribution of the teeth according to the patients' ages. Fifteen of these teeth were described in an earlier report.<sup>6</sup> PP was performed in all teeth upon exposure of the pulp while the surrounding dentin was still soft, and evaluated clinically as cariously affected. The PP indications included:

1. No/or recent pain complaint of short duration that subsided with analgesics
2. No reaction to percussion, no vestibular swelling and no mobility
3. No internal or external resorption and no pathological changes in PDL or surrounding bone in the radiographic examination
4. Pulp exposure during caries removal not exceeding 1–2 mm in diameter, with bleeding that stopped within 1–2 min.

All teeth were isolated by rubber dam following local anesthesia. After removing the carious dentin, the exposed pulp tissue was removed to a depth of 2–3 mm, using a high-speed abrasive diamond bur under a rich water spray. The surface of the excised pulp was irrigated with saline until bleeding stopped. A calcium hydroxide preparation (Calxyl™—Otto & Co., Dirmstein, Germany) was placed over the wound, covered by a soft, quick setting zinc oxide eugenol preparation (IRM™—The LD Caulk Co. Milford, DE). The rest of the exposed dentin then was covered with quick-setting calcium hydroxide base (Dycal™ Caulk—Dentsply Ltd., Weybridge, Surrey, England) and the tooth was restored, either by amalgam (29 teeth) or by a preformed stainless steel crown (6 teeth).

**Table 1. Distribution of permanent molars treated by partial pulpotomy according to patient's age**

Tooth	Age (Years)				25	Total
	7–9	9–12	12–15	15–18		
M <sup>1</sup>	1*	3	5	1	1	11
M <sup>2</sup>			1*			1
M <sub>1</sub>	4*	8	5	3		20
M <sub>2</sub>			3*			3
Total	5	11	14	4	1	35

\* Immature; M<sup>1</sup> — Maxillary first molar; M<sup>2</sup> — Maxillary second molar; M<sub>1</sub> — Mandibular first molar; M<sub>2</sub> — Mandibular second molar.

Routine follow-up examination was carried out by both authors every 3 months in the first year and every 6 months thereafter. The follow-up examination included vitality tests using sensitivity response to cold, percussion, and mobility tests. Periapical radiographs were performed every 3 to 6 months in the first year and once every 1 to 2 years thereafter.<sup>6</sup> The evaluation was not blinded since both examiners were those who performed the treatment.

Treatment was considered successful when the following criteria were observed:

1. Absence of clinical symptoms (pain, tenderness to percussion, swelling)
2. No interradicular, periapical, or intrapulpal pathology could be detected radiographically
3. Normal vital activity of the pulp, i.e., continued root development in immature teeth, occasional presence of dentin bridge, and physiological narrowing of the pulp chamber and the root canals.

## Results

Table 2 summarizes the distribution of the 35 teeth treated by PP, according to patients' ages and the follow-up period. Of the 35 teeth, no pathological changes were observed in 32 (91.4%) and three underwent pulp necrosis: one upper first molar (age of treatment 14 years) after 20 days<sup>6</sup> and two lower first molars, one (age of treatment 14 years) after 17 months and one (age of treatment 9 years) after 27 months. No correlation was found between the final restoration and the treatment outcome.

## Discussion

Several factors influence a clinician's decisions when encountering a carious pulp exposure in a permanent molar.

The first and most important factor is to evaluate the degree of pulp inflammation and to distinguish between reversible and irreversible pulpitis. It is well established that clinical evaluation correlates poorly with the histological state of the pulp. Therefore, careful interpretation of multiple tests is the most reliable.<sup>7,8</sup> The histological condition of a cariously exposed pulp often shows a

microabscess beneath the penetrating caries, yet evidence of continued defense efforts against the decalcifying and bacterial aggression were noticed.<sup>9</sup> Baume and Holz<sup>3</sup> advocated not capping directly with calcium hydroxide in cases of pulp exposure from penetrating caries. Direct pulp capping is not tantamount to PP, because the infected and inflamed superficial part of the pulp is supposed to be surgically removed in PP.

In this study, the clinical evaluation of the teeth was based on multiple clinical tests, yet the ultimate diagnosis was made immediately after exposure. However, three teeth failed, two after relatively long periods, indicating that the state of the pulp in those teeth was estimated incorrectly. Moreover, longer follow-up periods may reveal more failures. Recording subjective information such as pain history, reaction to pulp tests and percussion is limited and inconsistent in children. At most, when the information is absolutely positive, it can indicate a need to perform more radical treatment.

The second consideration is the size of the exposure. Animal studies showed that the state of the pulp and the degree of bacterial contamination penetrating the pulp, rather than the size of the exposure, largely determine the prognosis of direct pulp capping.<sup>10,11</sup> Nevertheless, teeth with exposures larger than 2 mm in diameter were excluded from our study. In this respect, the criteria for PP should not be different from those for direct pulp capping.

The patient's age is another disputable factor. It has been shown that age makes no difference in the success rate of direct pulp capping.<sup>3,12</sup> Yet, Horsted et al. demonstrated a slightly lower tooth survival rate in the older age group over longer observation periods.<sup>13</sup> Our sample was limited to children, teenagers, and one young adult treated in a pediatric dental clinic. Indeed, in older patients, the histological state of the pulp may affect its ability to overcome an insult<sup>2,13</sup> and therefore, we suggest that PP be limited to children or young adults.

The choice of a capping material in case of a pulp exposure is still a calcium hydroxide paste, which accelerates the deposition of dentin bridge and possesses antibacterial properties.<sup>14</sup> It is well established that an inflamed pulp does not react favorably to calcium hydroxide.<sup>15</sup> However, in pulp exposure of moderately carious teeth, 45–84% of direct pulp capping techniques were reported successful.<sup>3,13</sup> In this study, direct pulp capping was not indicated, since the pulps were exposed while the surrounding dentin was still soft and wet, giving the clinical impression of infected dentin and inflamed pulps. A traditional vital pulpotomy often results in complete obliteration of the root canals, which should be considered an unacceptable outcome. Obliteration results in diminished blood supply, which could lead to pulp necrosis. Root canal treatment is too radical and technically difficult to be performed in very young permanent molars with blunderbuss apices.<sup>1</sup> In those teeth with fully formed apices, although technically possible, it is reasonable to give the young pulp a chance to regenerate. PP is, therefore, a

**Table 2. Distribution and followup of cariously exposed first and second permanent molars treated by partial pulpotomy**

Follow up	Age		Total No.
	< 13 Years Range (7.6 – 12)	> 13 Years (13–25)	
12–24 months	5	6	11
24–48 months	7	8	15
More than 48 months	4	2	6
Failures	1*	2†	3
Total number	17	18	35

\* After 27 months; † One after 20 days and one after 17 months.

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reasonable alternative, providing all mechanical and biological aspects are carefully considered.

It is important to control bacterial contamination of the pulp, especially after treatment, due to microleakage at the tooth restoration interface.<sup>10, 16, 17</sup> Partial pulpotomy improves pulp sealing by creating a microrestoration of calcium hydroxide and ZOE at the exposure site.

Previous reports of PP in permanent molars presented either no information on the success rate<sup>4</sup> or 100% success rate in 26 cases with 8- to 36-month followup.<sup>18</sup> In a previous article,<sup>6</sup> 1 of 15 cases failed, with 12- to 99-month followup. With all mentioned variables, the success rate (91.4%) in this study justifies using partial pulpotomy as a treatment alternative in young permanent molars with carious pulp exposure.

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