# Pulpotomy with Laser in Primary and Young Permanent Teeth

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**Purpose:** The objective of this study was to evaluate the clinical feasibility and the benefits of using two different wavelengths of laser energy, the Er:YAG laser for treating the caries cavity and the opening of the pulp chamber, and the Nd:YAG laser to achieve the physical sterilization and the superficial coagulation of the remaining pulp tissue in the root canal in primary and young permanent teeth before the placement of three different pulp dressing materials.

**Materials and Methods:** A simple questionnaire was answered by all participating children with reference to their acceptance of the treatment. One hundred eighteen teeth were treated (65 primary and 53 young permanent), using as capping agents: a) a paste of calcium hydroxide $Ca(OH)_2$ and sterile water in 67 teeth, b) a combination of equal parts of $Ca(OH)_2$ and iodoform in 41 teeth, and finally c) glass-ionomer cement in 10 teeth. The treated teeth were evaluated clinically and radiologically during the first year every three months and then annually. Successful treatments were defined as those lacking: spontaneous pain or pain induced by cold, hot, or percussive stimuli; pathological mobility; pathological radiograph; and/or inflammatory aspect of the surrounding soft tissues.

**Results:** Successful treatment resulted in 95.38% of the primary teeth and in 100% of the permanent teeth.

**Conclusion:** The results show this to be a highly effective treatment, the only one which guarantees access and total treatment of the pulp in sterile conditions. Further research is necessary to confirm the histological aspects of the apparent clinical success.

**Keywords:** pulpotomy, pulp therapy, Er:YAG laser, Nd:YAG laser.

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In spite of great progress in the prevention of dental caries and the drastic reduction of its prevalence in many countries around the world, there are still many patients with a high decay index, deep caries, and pulpal pathology, requiring either partial or total pulp treatment to conserve primary or young permanent teeth. These pathologies may be caused by caries, erosions, or trauma, and range from simple and reversible inflammation to necrosis, necessitating the extraction of teeth in the most severe cases.

Pulpotomy is a procedure in which the inflamed or infected but vital coronal pulp is removed, leaving the healthy pulp in the root canal. Different techniques are used for this: Buckley's formocresol 1/5 dilution, glutaraldehyde, calcium hydroxide, ferric sulfate, MTA, electrosurgery, and laser.

The present study was performed with the objective of examining the clinical feasibility and benefits of using two different wavelengths of laser energy, the Er:YAG laser for treating carious lesions and the opening of the pulp chamber, and the Nd:YAG laser to achieve the sterilization and the superficial coagulation of the remaining pulp tissue in the root canal in primary and young permanent teeth. The psychological acceptance

**Table 1 Number and type of treated primary molars**

| Gender | No. treated | 1st maxillary molar | 2nd maxillary molar | 1st mandibular molar | 2nd mandibular molar |
|---|---|---|---|---|---|
| Female | 38 | 11 | 6 | 12 | 9 |
| Male | 27 | 8 | 4 | 10 | 5 |
| Total | 65 | 19 | 10 | 22 | 14 |

**Table 2 Number and type of treated young permanent molars**

| Gender | No. treated | 1st maxillary molar | 1st mandibular molar |
|---|---|---|---|
| Female | 31 | 14 | 17 |
| Male | 22 | 10 | 12 |
| Total | 53 | 24 | 29 |

of the treatment on the part of the pediatric patients was evaluated by means of a simple questionnaire.

## MATERIALS AND METHODS

From 1999 to the end of 2004, 118 laser-assisted pulpotomies were performed in inflamed non-exposed pulps: 65 in primary molars and 53 in young permanent molars (Tables 1 and 2). All the teeth used for this study were diagnosed as having pulpitis, with pain upon thermal stimuli and chewing pressure. The primary molars had at least two-thirds of their root. The permanent molars also had open apices.

A Fotona Twin Light (Ljubljana, Slovenia) device was used, which allows the use of two different types of laser energy, the Er:YAG with a 2940-nm wavelength and the Nd:YAG with 1064 nm. The Er:YAG laser is especially suited to working on the hard tissues, and was used to eliminate caries and remove the roof of the pulp chamber. Energy values of 400 mJ and frequencies between 10 and 15 Hz were used. The Nd:YAG laser is particularly suited for work on soft tissues, and was applied at a power of 2 W, 20 Hz for 10 s at a distance of 2 to 3 mm from the stumps.

In all the treated teeth, we followed exactly the same protocol. The following steps were conducted to perform the laser pulpotomies:

a. Local anesthesia
b. Isolation with rubber-dam
c. Sterile cavity opening with the Er: YAG laser
d. Surgical removal of the coronal pulp with excavators or sharp Black's spoons
e. Coagulation and sterilization of the remaining pulp using Nd:YAG laser
f. Placement of capping material
g. Final restoration

Figure 1 shows a clinical and a radiographic image of a permanent first molar with indication of a pulpotomy. The cavity was opened with the Erbium laser, under water spray cooling and high-power suction (Fig 2). The pulp chamber was opened (Fig 3) and the coronal pulp removed with appropriate Black spoons (Fig 4). Subsequently, the pulp stumps were irradiated with Nd:YAG laser at a power of 2 W, 20 Hz for 10 s at a distance of 2 to 3 mm (Fig 5).

Then the pulp dressings were inserted. The materials used for pulp capping were: $Ca(OH)_2$ (Pro-analisis, Farmadental, Buenos Aires, Argentina); $Ca(OH)_2$ + iodoform (Farmadental); and glass-ionomer cement (GC Fuji I, GC, Tokyo, Japan). The different pulp dressings were randomly assigned to the teeth, as shown in Tables 3 and 4. In 35 primary teeth, the pulp dressing was $Ca(OH)_2$, in 20 a combination of $Ca(OH)_2$ and iodoform, and in 10 glass-ionomer cement was used.

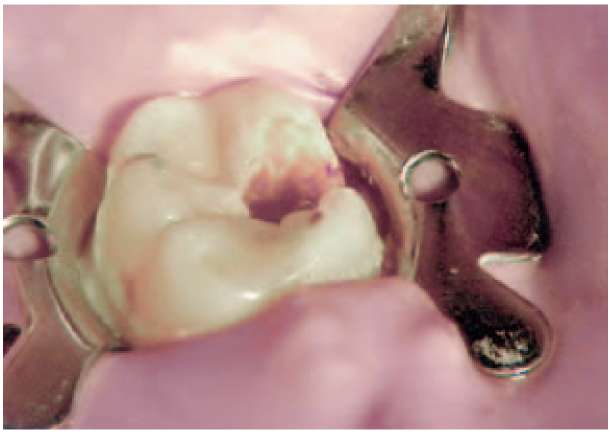

**Fig 1a** First permanent lower molar with deep caries.

**Fig 1b** Preoperative radiograph of the molar.

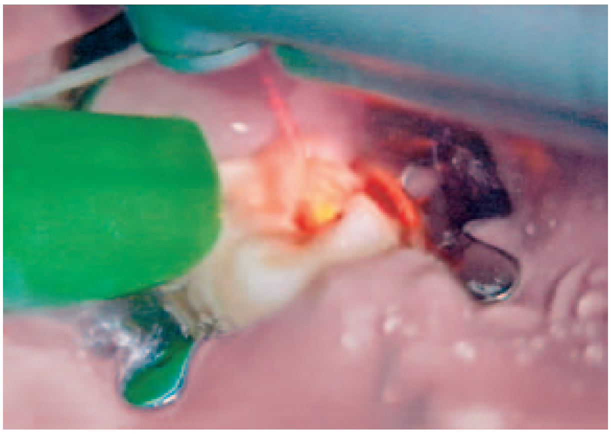

**Fig 2** Opening the cavity.

**Fig 3** Pulp chamber opened.

**Fig 4** Removing the coronal pulp.

**Fig 5** Lasing with Nd:YAG.

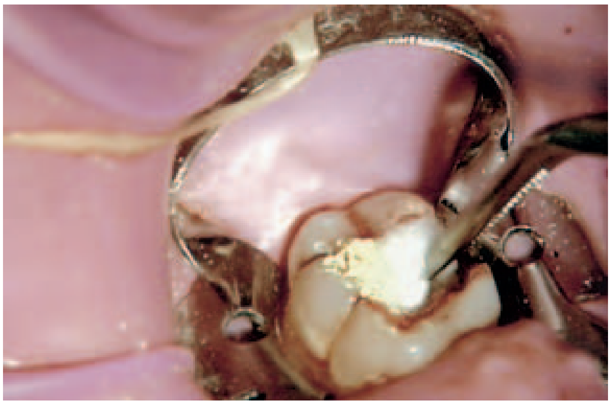

**Fig 6** Applying the pulp dressing.

**Fig 7** Filling with phosphate cement prior to placing the steel crown.

**Fig 8a** Immediate postoperative radiograph.

**Fig 8b** One-year follow-up radiograph.

Thirty-two young permanent molars were treated with calcium hydroxide and 21 with a combination of calcium hydroxide and iodoform. Figure 6 illustrates the technique in a case where the stumps were capped with $Ca(OH)_2$ plus iodoform. Finally, the filling was performed (Fig 7).

Once the treatment was over, the child was asked two questions: 1) if the treatment had caused him/her any pain (yes or no); and 2) if she or he would undergo the same treatment if necessary on any other tooth.

The evaluation criteria by which treatment was considered successful at the follow-up were:

1. No pain, either spontaneous or induced by cold, hot, or percussive stimuli
2. No pathological mobility
3. No pathology radiographically evident in bone or tooth
4. No inflammatory or infectious response of surrounding tissues
5. Apex closure in young permanent molars

During the first year, the treated teeth were clinically and radiologically evaluated every three months, and then annually.

## RESULTS

Of 65 primary teeth treated, 62 (95.38%) were successful according to the evaluation criteria. Three teeth failed. Of these, two pulps were capped with $Ca(OH)_2$ and one with glass-ionomer cement (Table 3). The ma-

**Table 3 Dressing material for primary molars**

| Dressing material | Total treated | Successful treatments | Failures |
|---|---|---|---|
| $Ca(OH)_2$ | 35 | 33 | 2 |
| $Ca(OH)_2$ + iodoform | 20 | 20 | – |
| Glass-ionomer cement | 10 | 9 | 1 |

**Table 4 Dressing material for young permanent molars**

| Dressing material | Total treated | Successful treatments | Failures |
|---|---|---|---|
| $Ca(OH)_2$ | 32 | 32 | – |
| $Ca(OH)_2$ + iodoform | 21 | 21 | – |
| Total | 53 | 53 | – |

jority of these cases (48, or 73.84%) were followed-up for 4 years. All 53 young permanent molars were treated successfully (100%). All of these cases were followed-up for at least 4 years (Table 4).

In response to the questionnaire, none of the children expressed having had pain, and 107 of the 118 said they were sure they would be willing to repeat the experience in the future, if necessary.

## DISCUSSION

Many different techniques have been described to perform a pulpotomy.[1] Formocresol and glutaraldehyde, though with good clinical results, are suspected of having a carcinogenic and/or mutagenic potential,[2,3] as well as of inducing immunological phenomena and periapical inflammatory effects, with the possible formation of dentigerous cysts of the subjacent permanent teeth. Glutaraldehyde also presents hypersensibility phenomena. $Ca(OH)_2$, although it performs well, seems to frequently induce internal resorptions. The other methods, such as MTA,[4] ferric sulfate, and electrosurgery, show promising results, despite other problems.[5,6]

The uses of lasers for pulp treatment have been reviewed elsewhere.[7] Different authors found interesting results concerning bacterial reduction in dental tissues treated with lasers. Mello et al[8] achieved 100% bactericide at a depth of 300 microns and 95% to 98% at 500 microns. Moritz and Gutknecht[9] demonstrated that total sterilization could be obtained in the first 500 microns, and 95% to 97% at 1000 microns of depth.

Matsumoto et al[10] and Ebihara et al[11,12] described the histological characteristics and the reaction of the laser-irradiated pulp. In the positive controls, necrosis of the superficial layer, hyperemia, and inflammatory cells resulting from dentinogenesis were observed. In some specimens, a well-shaped newly formed dentin bridge appeared.

The use of the Er:YAG laser allows opening the cavity in a completely sterile way, an advantage which is not provided by any other means of access to the pulp chamber.

The Nd:YAG laser is especially well suited to work on soft tissues; its properties include cutting, sterilizing, coagulating, and vaporizing.[13] For the treatment performed in this study, its capacity to sterilize and coagulate were particularly relevant. Laser sterilization reinforces the overall sterilizing procedure, and laser coagulation produces a thin necrotic layer over the vital remaining pulp. The vital pulp responds in some cases with the formation of a dentin bridge. The immediate postoperative radiograph (Fig 8a) and the one taken at the 1-year follow-up depict the development of the dentin bridge (Fig. 8b).

The pulp dressings used never came into direct contact with the pulp, but rather with the thin laser-induced necrotic layer. This is the probable explanation for the similarity in the results obtained when using different materials.

As supported by our results, the main advantages of laser-assisted pulpotomies consist in:

1) An absolutely sterile procedure.
2) Formation of a thin laser-induced necrotic layer, which stops the pulp from having direct contact with the covering materials, avoiding or reducing the possible chemical or toxic effects of the materials used.

Finally, we believe that pulpotomies in permanent teeth with an open apex can remain as the final treatment option after apex closure, taking into account the socio-economic conditions of the patients who visit our hospitals or dental schools, where they are treated at no or low cost. These patients would not be able to afford posts and crowns. Helping them to keep their teeth in reasonably good condition until adulthood may give them the chance later, when older and self-sufficient, to have these teeth treated and restored with more conventional and universally accepted treatments, such as pulpectomy with post and crown.

## CONCLUSIONS

It is important to highlight the full acceptance of this treatment by our pediatric patients. This is a highly effective treatment and the only one which guarantees access and total treatment of the pulp under sterile conditions. When we submit a healthy pulp to biological and sterile conditions, it will remain healthy.

Since this was a clinical study in humans, the evaluation criteria were clinical and not histological. The failures obtained, we believe, are due to incorrectly diagnosing a pulp stump as healthy. Further research should focus on examining the histological aspects of the apparent clinical success.

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