Use of the Nd:YAG laser in the treatment of Early Childhood Caries

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ABSTRACT. Aim This was to demonstrate that traditional therapy of Early Childhood Caries (ECC) can be improved with the use of the Nd:YAG laser. Methods This investigation was conducted on three 3 year-old children in which the four maxillary primary incisors were affected by ECC. The teeth were treated with the Nd:YAG laser and one unrestorable tooth for each child was extracted for investigation by scanning electron microscopy. Results The laser therapy provided several clinical advantages (reduction of dentine permeability and hypersensitivity, sterilization of the lased surface, and fluoride penetration within the tooth). Good patient compliance was also achieved due to the type of appliance and materials used, absence of noise and vibration, a lack of need for local analgesia, and the reduced number of brief appointments. Conclusion This approach to treatment of ECC permits teeth to be retained in the dental arch and delays the use of traditional methods to a later time when the child has reached an age sufficient for cooperation with the practitioner.


Introduction

Early Childhood Caries (ECC) is one of the paediatric dental pathologies most difficult to deal with due to its early onset, complex treatment and probable lack of cooperation of very young children. ECC usually appears at the age of 1-2 years and progresses rapidly, characteristically involving the maxillary primary incisors. It later diffuses to the other teeth following a typical pattern [Thakib et al., 1997]. Epidemiological studies carried out in Europe show that among 1-3 year olds ECC has a prevalence of between 4.5 to 43% and percentages of 6.4 to 35% have been found in North America [Tang et al., 1997; Strohmenger and Ferro, 2003]. However, these studies report that prevalence studies on children below 3 years of age rarely show signs of treatment.

Clinical aspects. Initially, white spots representing decalcified enamel appear on the involved teeth and eventually spread to cover larger areas [Van Waes and Stockli, 2001]. These areas of decalcification become progressively darker in colour, tending towards brown and black. Often, the child’s parents underestimate or do not notice the first signs of decalcification. The surfaces most frequently involved are the facial aspects of the maxillary primary incisors, followed by the surfaces of the maxillary primary molars, the mandibular molars and lastly the mandibular incisors [De Grauwe et al., 2004].

Treatment. This classically consists of restoration and when necessary, pulp therapy of the involved teeth in order to retain the elements in the dental arch till natural exfoliation occurs. However, when teeth are irretrievably compromised, extraction is mandatory and may be followed by the placement of a removable prosthetic appliance which can be modified to accommodate the eruption of the corresponding permanent teeth. In some cases, sedation may be necessary because treatment is often complex, given the usual number of teeth involved and the reduced collaboration offered by the small child [Matthewsons et al., 1987; Roberts, 1991; Mc Donald and Avery, 1994].

Effect of laser irradiation on carious dentine and enamel

Antibacterial action. Lasing has an antibacterial action on dentine and enamel through the vaporization of cariogenic bacteria both on the surface and in the deeper structure [Caprioglio et al., 2003].

Decrease in dentine and enamel permeability. In-vitro studies have shown that Nd:YAG radiation of a dentine or enamel surface reduces its permeability. There are various theories on the possible mechanisms responsible for this effect. Some authors hypothesize that there is modification of the mineral composition of these tissues...
while others believe that structural alteration occurs originating from hydroxyapatite reorganization and loss of the superficial structure because the dentinal tubules and enamel rods ‘melt’ and then resolidify becoming amorphous [Tagomori, 1995; Iaria and Frati, 2001a].

**Fluoride uptake.** Nd:YAG radiation increases fluoride (F) uptake [Zhang et al., 1996, 2001].

**Benefits, arrest of decay.** The decrease in permeability increases the resistance of decayed dental surfaces to acid attack from cariogenic bacteria. The increase in F uptake during exposure to Nd:YAG radiation further improves resistance to acid attack [Zhang et al., 1996]. Less surfaces at caries risk and under antibacterial action permit dental decay to be arrested.

**Benefits, decrease in hypersensitivity.** Lasing has an antalgic effect on tooth surfaces [Caprioglio et al., 2003] because the reduction in permeability seals the open dentinal tubules and therefore blocks the sodium-potassium pump which inhibits the transmission of pain stimuli [Hondeghem and Miller, 1992; Goodis et al., 1997]. In fact, the Nd:YAG laser has been used to reduce hypersensitivity in permanent teeth and vital abutments and may be used for reducing the pain response due to thermal and chemical stimuli in teeth affected by ECC.

**Compliance.** It is important to remember that ECC is a rapidly destructive pathology and therapy has success only if it is early and timely. In the preschool age group, active cooperation can only be obtained by building a rapport over a longer period of time. This obstacle may be overcome with laser treatment. Good compliance levels on behalf of children and their parents are due to:
- the type of object and materials used (F gel);
- absence of local analgesia;
- the need for only 1 or 2 short appointments.

Compliance with treatment is further augmented by the presence of the optical fibre which is bright and colourful and easily recalls images of play. The acoustic levels and vibration produced by dental instrumentation are often sources of anxiety which render any treatment in the young patient more difficult. Treatment with the Nd:YAG laser does not produce the noise and vibration usually present in conventional therapy.

The extreme brevity of the laser pulse does not permit the peripheral nerve endings, which are responsible for the pain reaction, to be stimulated. Consequently, treatment with the Nd:YAG laser can be carried out in the absence of anaesthesia [Iaria and Frati, 2001b].

**Investigation.** In this investigation the use of the Nd:YAG (Neodymium: Yttrium Aluminium Garnet) laser for the treatment of ECC was investigated, not as a full alternative to traditional methods but for preparation of the hard tissues when very young patients (2-4 year olds) or non-cooperative children require treatment.

**Materials and methods**

**Case reports.** Three 3 years old children, with DMFT ranging from 7 to 10 were selected for this study. All 3 children presented with the 4 maxillary primary incisors affected by ECC (Fig. 1) and a decision was made to treat them with lasers, after obtaining an informed consent from the parents.

**The Nd:YAG laser.** The following parameters must be set in order to apply the Nd:YAG laser (Fidelis Plus Er-Nd V.S.P., Fotona, Ljubljana, Slovenia):
- pulse frequency (10-200 Hz);
- beam power (max 6 W);
- contact mode (all powers) or no-contact mode (maximum power 1 W);
- optical fibre size (diameters: 200-320-400 μm).

The duration of the single pulse however is fixed at 100 microseconds and cannot be regulated. The energy levels used are shown in Table 1.

<table>
<thead>
<tr>
<th>Energy Level</th>
<th>Frequency</th>
<th>Power</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st application</td>
<td>20 mJ</td>
<td>10 Hz</td>
<td>0.2 W</td>
</tr>
<tr>
<td>2nd application</td>
<td>30 mJ</td>
<td>10 Hz</td>
<td>0.3 W</td>
</tr>
<tr>
<td>3rd application</td>
<td>40 mJ</td>
<td>10 Hz</td>
<td>0.4 W</td>
</tr>
<tr>
<td>4th application</td>
<td>60 mJ</td>
<td>10 Hz</td>
<td>0.6 W</td>
</tr>
<tr>
<td>5th application</td>
<td>80 mJ</td>
<td>10 Hz</td>
<td>0.8 W</td>
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**TABLE 1** - Protocol adopted for the clinical use of the Nd:YAG laser in the treatment of ECC in very young children.
Protocol. Two treatment sessions were needed. At the first appointment, once each patient, dental practitioner and assistant were given eyewear to protect against the laser light. The surfaces of the 4 primary teeth were lasered after covering them with a thick layer of F gel (GELF 149, Ogna: 0.149% fluoride ion, sodium monofluorophosphate) applied with a cotton roll before each application. The tip of the optical fibre was kept immersed in F during lasing of the tooth (Fig. 2). During laser irradiation, ‘contact’ was constantly maintained between the optical fibre and the tooth surface. Laser contact was defined as keeping the tip of the optical fibre 2 mm from the surface of the tooth being treated but always immersed in F [Benazzato and Stefani, 2002]. The tip of the optical fibre was moved in a hatched design in order to act as uniformly as possible on the entire surface to be treated. Local analgesia was not used. Treatment took only a few minutes and was not traumatic for the child. For each child, extraction was scheduled for one of the 4 affected teeth because of excessive coronal breakdown.

There were no postoperative complications. The parents reported regression and, in some cases, the complete disappearance of hypersensitivity to cold. Figure 3 shows one of the cases after laser treatment.

At the second appointment, the unrestorable tooth was extracted and its surface was observed by scanning electron microscopy in order to evaluate the effect of laser vitrification on compromised enamel and dentine. All other carious teeth were treated with traditional methods.

Results

Desensitization. In the cases presented, sensitivity to cold was tested before and after treatment using a blast of air from a dental syringe, for a few seconds. The reaction of the young patients to this stimulus, present before treatment, appeared to be diminished or absent.

Reduction of dentine permeability. Initial SEM pictures of a tooth before treatment shows the typical disorganization of the dentine structure (Fig. 4). In the SEM analysis after laser treatment sealed dentinal tubules can be observed (Fig. 5). The image of the
glazed surface resembled lava flow.

**Aesthetics.** Laser treatment did not significantly influence the aesthetics of the tooth. Appearance of the teeth treated in this study remained unchanged even after a 12 months period (the longest interval before therapeutic completion which resulted in restoration for some teeth and extraction for others). None of the parents requested any further need to improve dental aesthetics. They also said they were satisfied with the reduction in dentinal hypersensitivity which would commonly manifest itself during the child’s meals.

**Discussion**

There appears to be no other reports in the literature on the use of laser treatment for ECC. Because of the difficulty of treating very young children with ECC in the normal dental office, alternatives such as the use of lasers may be promising. The alternatives of the use of general anaesthetics are much more expensive and carry additional risks.

**Long-term treatment and future prospects for laser use.** Laser therapy permits even the most difficult children to be reinserted in classic treatment protocols. In this study the authors verified the advantages of laser treatment for advanced caries in the 3 year age group, on which little documentation exists today. The possibility of use in the 2 year age group in which less advanced lesions are to be expected will be examined.

**Behavioural advantages.** Therefore, the advantages given by integrating traditional therapy with laser therapy are essentially two: good compliance and good clinical advantages in the early management of ECC. Good compliance is due to:

- the type of instruments and materials used;
- the absence of noise and vibration;
- the absence of the need for local analgesia;
- the need for only brief appointments which are reduced in number (1 or 2 maximum).

The clinical advantages in the treatment of ECC are:

- arrest of the carious process through glazing of the tooth’s surface which is at the same time sterilized;
- fluoride penetration into the enamel and dentine which increases resistance towards future attack from cariogenic bacteria;
- dentine desensitization which reduces discomfort caused by thermal and chemical stimuli.

Therefore, this type of treatment permits teeth to be retained in the dental arch and delays the use of traditional methods to a later period when the child reaches an age mature enough for good cooperation with the practitioner.

**Conclusion**

Use of the Nd:YAG laser in the treatment of Early Childhood Caries shows promise and should be considered by further clinical studies.

**References**


