Direct Pulp Capping Using an Er,Cr:YSGG Laser

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Abstract: Due to tooth preparation while treating a cavitated carious lesion or because of trauma, pulp exposition is a common event in the dental office. Many treatment modalities for this kind of lesions have been studied and evaluated. This paper presents cases in which carious teeth with pulp exposition were treated using an Er,Cr:YSGG laser. Because the use of lasers in treating carious lesions has become more common and provides certain major advantages where the vitality of the pulp is concerned, a literature review is included. Some treatment considerations are discussed, as well as future questions and objectives.

Key words: Er,Cr:YSGG laser, pulp capping, trauma, caries.

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Pulp exposition is a common event in the daily practice of a dental office. For instance, trauma can cause a complicated crown fracture where pulp exposition becomes evident. Much past research has focused on treating these kinds of exposures, mostly with a relatively high success rate, possibly due to the fact that these pulps hardly suffered from bacterial contamination, if at all.

Instrumentation is the other likely cause of a pulp exposition, and occasionally occurs during the process of excavating a carious lesion. Today, it is no longer necessary to remove all demineralized dentin. If the collagen matrix is still present, we now know that remineralization of the demineralized dentin is most likely to occur. The prerequisite, however, is the absence of bacterial contamination or recontamination. It is known that the pulp can survive trauma and some degree of infection due to caries. Thermal trauma, however, is another matter.

Since the early 90s, Er:YAG lasers have been used to ablate enamel and dentin in a predictable and safe manner.[1] Research on these lasers has shown that the temperature rise with adequate air/water spray cooling is very low, lower than with conventional rotary instruments, and sometimes even drops during treatment. Therefore, this may be an important aspect in terms of minimizing pulp trauma.

The bactericidal effect of Er:YAG lasers is by now also widely accepted. During preparation and excavation, we may assume that ahead of our area of ablation, a zone is created with considerably fewer bacteria. Laser excavation thus also reduces the potential of bacterially induced trauma.

Volumetric expansion of the water component of the hard tissue is regarded as the mechanism of ablation. The higher the water content, the more efficient the process proceeds. Demineralized dentin contains more water, up to 30%, where sound dentin contains around 10%. Therefore, demineralized dentin can be ablated more selectively in the hands of an operator with some experience.

If the pulp is exposed using burs, dentin chips with debris are always seen in the pulp. Although some authors consider them to be important for dentin bridge formation, others find them undesirable since they are usually contaminated. Using Erbium lasers, these chips are not produced. Bacterial infusion is also very unlikely. An animal study showed that after using an

Er:YAG laser, dentin bridge formation took place rapidly. Therefore, it might be assumed that in an in vivo situation in humans, this may also occur.

Indications for a Pulp Capping Procedure[2]

- Vital pulp.
- Primary teeth.
- Secondary teeth when root formation is not yet finished, or in case of pulpitis considered to be reversible.
- Opening not too small, to obtain good adaptation with the covering material.
- Opening can be 0.5 to 4.0 mm. Research showed 96% success after up to 31 months.[3] Due to trauma, the exposures in this study were sometimes rather large.

TREATMENT OBJECTIVES

- Maintaining a vital pulp. The vitality of the pulp might be a problem to evaluate, but tests will work after a pulp capping procedure. After a pulpotomy, however, they will not be predictable.
- Covering the exposed tissue with medication, wound dressing, or restoration.
- Formation of tertiary dentin and dentinoblast formation (after differentiation from dentinoblastoid cells)
- Preventing bacterial (re)infection through leakage.

Success

Since vitality tests do not always appear to be reliable, success can be better defined by the absence of clinical complaints and radiological abnormalities. In addition, a continuance of root formation in not fully developed teeth is a good indicator of intact pulp vitality.[5]

Success rates will be higher after traumatic exposure of the pulp. Success also seems to be dependent on study protocols and materials used. Lower success rates can be found in the literature after an exposure during caries excavation. After traumatic exposure, success rates found in literature range from 30% to 96%. It might be assumed that bacterial contamination after a traumatic exposure that receives immediate treatment will be shallow. However, one study showed that the success rate decreased from 96% to 56% when the time of exposure was extended from 1 h to 7 days.[5] The key factor in the failure or success of treatment is thought to be bacterial contamination.[6] In contrast, some authors obtained rather high success rates of 93% after 4.5 years of prolonged contamination using a $Ca(OH)_2$ dressing in younger patients.[7,8] Thus, the discussion continues on the role of prolonged contamination.

Dentin Bridge Formation

Dentin bridges have been associated with successful pulp capping. They are thought to be a barrier against leakage of bacteria and bacterial products, and a mechanical barrier against forces applied to the tooth and the restoration. The evaluation of dentin bridge formation, however, can only take place histologically. Early research focused on Ca $(OH)_2$ as a capping material, but much porosity in the newly formed tertiary dentin was seen after the use of this material. Furhter, disintegration of the capping material and reinfection were seen after some years.[9] More recent research has shown that restoration materials could serve as bridges, and that direct bonding allows healing.[10] It has also been shown that acid materials can stimulate dentin bridge formation. Other studies have found that many pulps survived under $ZnPO_4$, RMGI (resin-modified glass ionomer), or composite without dentin bridge formation.[11]

Microleakage

Where early research focused on the toxicity of the materials used, later research has concentrated on leakage and bacterial contamination, showing that the latter may be a greater concern.[12]

Materials Used

Ca $(OH)_2$ has been used since the 1930s. Its disadvantages are lack of strength, disintegration, and inability to bond to dentin. ZnOE is toxic (depending on the concentration) and causes chronic inflammation. Formocresol is also toxic, and causes an immune response. Although Ca $(OH)_2$ is still used, the other materials are more likely to have been abandoned because of their undesirable effects.

More modern and currently commonly used materials are:

- RMGI, resin-modified glass ionomer. This material produces a mild pulp reaction, good adhesion, and bridge formation; it also enables healing.[13] It is, however, considered more irritating than Ca $(OH)_2$.[14]
- MTA, mineral trioxide aggregate. It has shown promise in animal studies,[15] as it is strong, provides good adaptation, is nonresorbable, biocompatible, and hardly cytotoxic. Because the setting time is 3 to 4 h, a temporary restoration is necessary.
- Composites produce a low tissue response and good adhesion; dentin bridge formation is possible.[16,17]
- BMPS, bone morphogenetic proteins. Applied in experiments, they appear to be promising and can induce dentin bridge formation.[18]

Laser

Er:YAG or Er,Cr:YSGG lasers may prove to be an interesting device for treating exposed pulps. Temperature increase during treatment is minimal, and may even sometimes decrease while working with water-spray cooling.[19] Many lasers, including the two previously mentioned here, have bactericidal capacities.[20,21] No smear layer is produced, and dentinal tubules are open, allowing hybrid layer formation. Another feature is the very superficial thermal effect. Therefore, the necrotic zone is likely to be very small.

Moritz et al[23] conducted a parallel study in which some 260 pulp capping procedures were performed using Ca $(OH)_2$. The CO_2 laser was used in superpulsed mode. The controls were conventionally treated. After 2 years, the success rate was 93% in the laser group compared to 66.6% in the control group. Santucci[24] performed a retrospective study in which 93 pulp cappings in permanent teeth were evaluated. He used an Nd:YAG laser with Vitrebond as a capping material and $Ca(OH)_2$ as a control; results were evaluated after 54 months. The success rate was 90.3% in the lased and 43.6% in the control group.

In a study on rats, Jayawardena et al[25] made 76 pulp exposures with an Er:YAG laser. The evaluation was done histopathologically. Directly after preparation, no bleeding was seen and no dentin chips were found in the pulps of the lased groups. Significantly more reparative dentin was found in the lased group.

With an Er:YAG or Er,Cr:YSGG laser, one laser can be used to perform a whole procedure: caries excavation, coagulation of the exposed pulp, pulpotomy, or pulpectomy.[22] It may be useful to consider a treatment concept in which treatment with Er:YAG or Er,Cr:YSGG laser is viewed as a continuum, from treating a carious lesion to disinfecting deep carious layers, to disinfecting, cleaning and coagulating exposed pulpal tissue, and on to performing a (partial) pulpotomy or pulpectomy, and if possible, shaping the root canal or at least cleaning and disinfecting it. This, of course, can be done only according to the strict inclusion criteria mentioned earlier in this paper.

CASE REPORTS

Nine cases were treated in the dental practice. All cases involved previously vital teeth. There were no radiological abnormalities and there was no pain. All cases were treated without anesthesia.

All teeth suffered from caries. The deep lesions were treated with an Er,Cr:YSGG laser (Biolase, San Clemente, CA, USA) with spray cooling. Pulp capping was performed using Vitrebond, a modified glass-ionomer cement (3M, St Paul, MN, USA). Permanent restorations were made with Cavex Clearfil APX (Kuraray, Tokyo, Japan).

The pulpal tissue did not stop bleeding after exposure in 2 cases. The decision was made to perform a partial pulpotomy at soft tissue settings until bleeding stopped. If necessary, coagulation was then achieved with 0.25 to 0.50 W without spray cooling in a defocused mode.

All cases were evaluated clinically and radiographically after 3 to 8 months. There were no clinical signs of inflammation, and all teeth responded positively to vitality tests. Except for one tooth, there were no radiographic indications that suggested a possible chronic inflammation. One tooth gave the impression of a slightly broader periodontal gap around the apex, and will therefore be kept under observation.

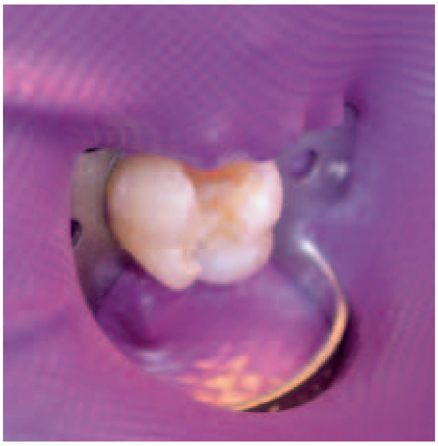

Fig 1 Tooth 16. Exposed pulp.

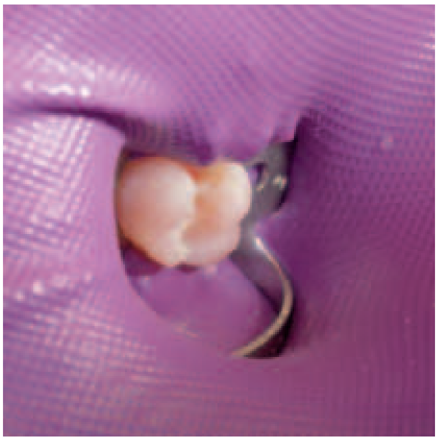

Fig 2 After coagulation with 0.25 W, no water-spray cooling.

Fig 3 Vitrebond in place.

Case 1

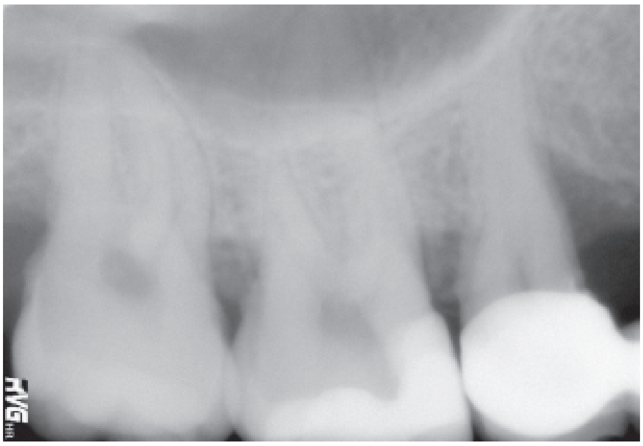

Fig 4 Radiograph after treatment.

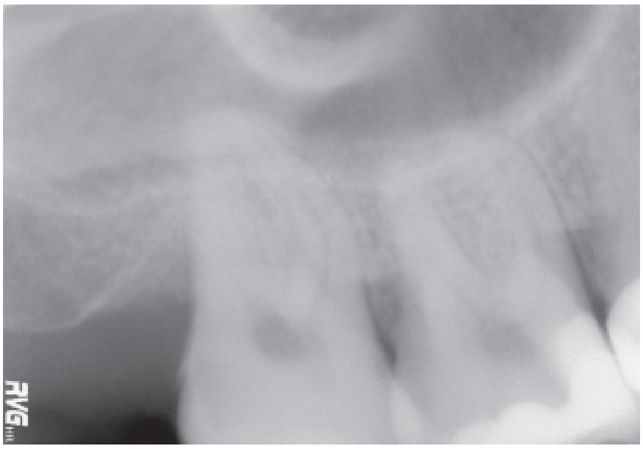

Fig 5 Control after 5 months.

DISCUSSION

Further research is required to determine indications and prognoses. Preferably, human in vivo or experimental animal studies should be conducted. It would be of particular interest to examine the effects of different parameters, such as power settings.

A possible complication mentioned by some authors is the obliteration of the pulp chamber and root canals due to chronic stimulation or infection. This situation should be considered and evaluated. Therefore, histopathological examinations would be helpful, possibly combined with scanning electron microscopy (SEM). In addition, dentin bridge formation, inflammation, cellular changes, and osteoblast differentiation of osteoblastoid cells should be examined with SEM.

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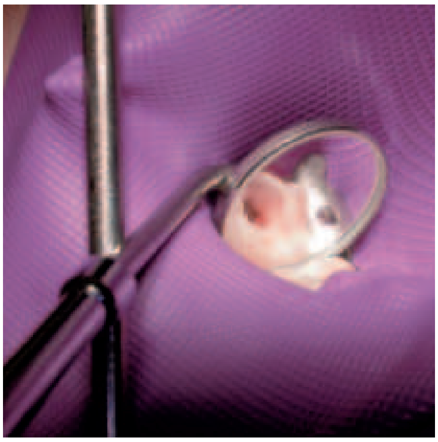

Fig 6 Tooth 26. Exposure during excavation.

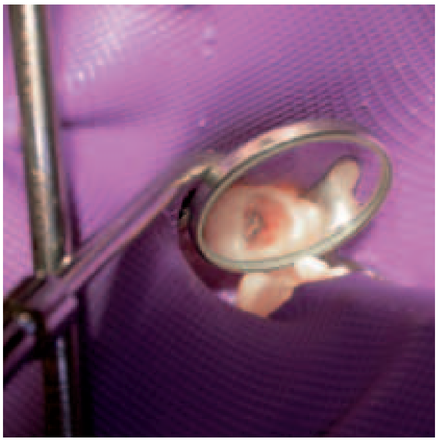

Fig 7 After coagulation.

Fig 8 Vitrebond in place.

Case 2

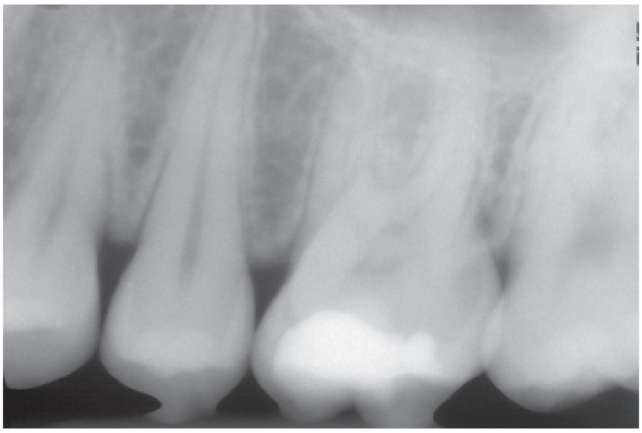

Fig 9 Postoperative radiograph.

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Fig 10 Tooth 43. Exposure after excavation. Partial crown pulpotomy.

Fig 11 Vitrebond in place.

Fig 12 Tooth 43 restored with Clearfil AP-X.

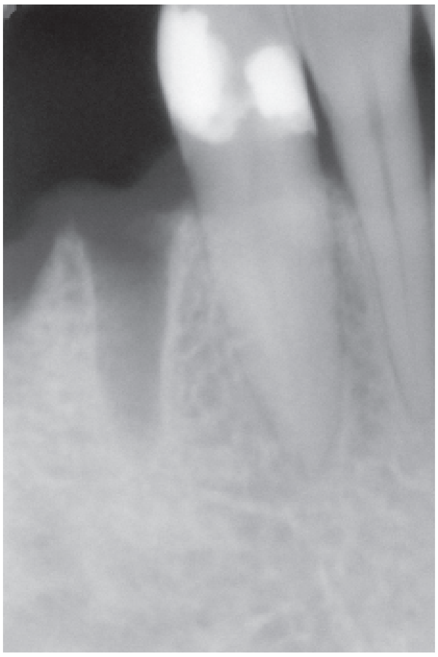

Fig 13 Postoperative radiograph.

Fig 14 Control after 5 months.

Case 3

Fig 15 Tooth 25. Exposition during deep excavation.

Fig 16 After coagulation.

Case 4

Fig 17 Vitrebond in place.

Fig 18 Postoperative radiograph.

Fig 19 Control after 5 months.

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