Natural Scaffold Formation After Er,Cr:YSGG Laser Irradiation: Case Report of a Laser-assisted Extraction

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Abstract:

Background: Teeth are extracted for various reasons. Wound toilet is, amongst others, crucial for post-operative morbidity and uneventful healing. It has been reported that low level hard laser irradiation enhances fibroblast proliferation, which accelerates wound healing and might be advantageous for bone in-growth.

Objectives: This case report has the purpose to illustrate an indication of an Er,Cr:YSGG-laser in extraction surgery. Conventional post-extractive wound toilet with sutures is replaced by laser decontamination and relative coagulation.

Materials and Methods: In a 48 year old female tooth number 34 presents purulent discharge. Radiographic exams show an extensive periapical abscess and a fractured root. After infiltration anaesthetics, the tooth is removed. Fibre dissection and post extractive site decontamination was performed by an Er,Cr:YSGG 2780nm wavelength laser.

Results: At 24 hours follow up, a wound, completely closed by a fibrin network, was observed. Radiographic exams 1 week post-operative showed an extensive radiolucency. Neighbouring tooth #33 had on the distal a wide two–wall defect, with an radiographic angle ≥90° and no more than 1mm distal bone support.

Radiographic follow up showed at 1,3,6,and at 12 months resolution of the defect with evident bone in-growth and mineralization.

Conclusion: Low power Er,Cr:YSGG laser irradiation might have enhanced rapid wound closure within 24 hours after extraction. As if a natural scaffold was formed, under which osteogenic cells were able to repopulate the defect, resulting in radiographic bone regeneration. Rapid epithelium growth closing over an extraction-socket seems to avoid its down-growth in the extraction site.

Keywords: Er,Cr:YSGG laser, Bone-regeneration, Natural Scaffold Formation.

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INTRODUCTION

The ultimate solution for dental problems is extraction. Teeth are removed for the following reasons:

1) Periodontal problems, where alveolar bone breakdown results in an insufficient amount of remnant sustaining hard tissues, which leaves poor prognosis for periodontal therapy.[1]
2) Failed surgical and non-surgical endodontic treatments, caused by extent of microbiological insult to pulp and periapical tissue, as reflected by the magnitude of periapical pathosis, but also caused by technical quality of periapical surgery and apical and coronal seal.[2,3]
3) Root fracture[4]
4) Impacted teeth[4]
5) Deciduous teeth[4]
6) Prosthetic and orthodontic reasons[4]

A conventional, simple extraction consists of dissecting peri-radicular fibres disconnecting gingiva and

Fig 1 #34 buccal PPD = 13 mm.

Fig 2 #34 lingual PPD = 13 mm.

Fig 3 #34 Radiograph of bone destruction involving distal root #33.

papilla from the tooth. Mobilizing the tooth with an elevator and removing it with a forceps. Post-extractive wound toilet consists of cleaning the socket from granulation tissues and grating alveolar bone, to stimulate the blood clot formation in the socket. Sutures are placed to stabilize soft tissues closely against the wound narrowing the gap and to protect the coagulum. The patient is instructed to exert pressure with a gauze on the extraction site and to not rinse or disturb the wound in the first 24 hours, as the blood clot is essential for uneventful wound-healing.[4]

Low level Laser therapy, or soft laser therapy has been applied in various disciplines of dentistry and is widely documented. However, most reports regard Diode lasers, operating on wavelengths of 830 nm and 635 nm. There is a wide range of biological effects obtained by lasers with low power settings.[5,6] Nonetheless, on molar extractions with treatments of post-operative low level laser irradiation, there are contradictory reports, regarding the expected higher bone density or diminished patient morbidity.[7,8] In other studies, however, enhanced bone healing and repair is found, after low power laser irradiation with a 632,5 nm wavelenght in vitro.[9] But also in vivo with 637 nm irradiation after peri-apical surgery[10] or with a 810 nm laser after extractions.[11]

When hard lasers are applied with low power irradiation, biologic effects in soft tissues, consist of low post-operative patient morbidity and highly predictable quality of tissue healing.[12] Reports concerning mineralised tissues, describe precise osteotomies with the 2780nm wavelength, resulting in minimal thermal damage and subsequent normal bone healing.[13,14] Regeneration of periodontal tissues was reported in studies, where laser's decontaminative capacity created right circumstances for fibroblast attachment on rootsurfaces.[15,16] Authors have also suggested clinical improvements in periodontal healing after CO_2 laser treatment.[17]

OBJECTIVES

This case report presentation has the purpose to illustrate an indication of the Er,Cr:YSGG, a 2780 nm hard laser in extraction surgery. The laser application, which consists of removal of granulation tissues, decontamination and decorticalizing of alveolar bone of the extraction site and finally the relative coagulation of the wound, is reviewed. With this method, an alternative to conventional post-operative wound toilet is presented and the effects of decontamination and presumably, biostimulation with this specific wavelength are described.

Fig 4 #34 fiberectomy.

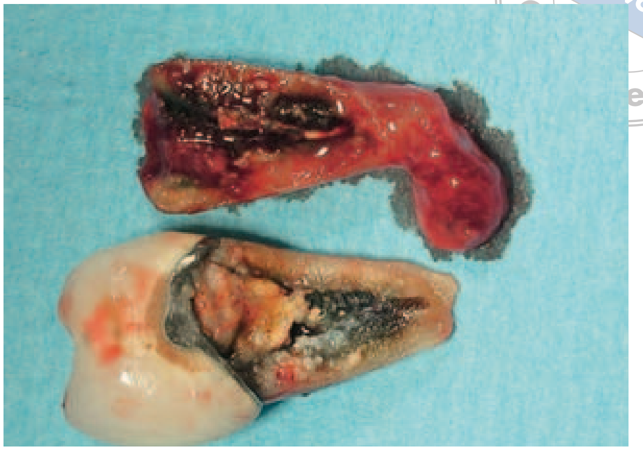

Fig 5 Extracted roots.

MATERIALS AND METHODS

In a 48 year old female, in general good health, tooth #34 was diagnosed with purulent discharge, and periodontal pocket probing depths of 13 mm on both the buccal and lingual (Fig.1, 2), mesial = 15mm and distal = 4 mm. Dental history showed high decay incidence with consequent tooth loss. The mutilated dentition consisted of nine teeth in the upper jaw, and in the lower jaw twelve teeth present. Periodontal probing depth of tooth #33 : mesial = 4 mm, buccal = 3 mm, distal = 12 mm (CAL = 12), lingual = 3 mm. Periodontal probing depth of tooth #35: mesial = 3mm, buccal = 2 mm, distal = 2 mm, lingual = 2 mm. Periodontal status of remaining teeth was characterised by generalised gingivitis, with mean PPD ≤ 4 mm and P.I = 53% and G.I. = 68%. Radiographic status showed general regular bone levels and no periodontal breakdown was evident.

Endodontically however, tooth #34 showed on RX an extensive periapical abscess and fractured root. Bone resorption had extended along distal apical region of tooth #33. Tooth #35 had mesial intact bone support, which neighboured the peri-apical radiolucency of tooth #34 (Fig.3)

After infiltration anaesthetics fibre dissection and post extractive site decontamination was performed by an Er,Cr:YSGG 2780 nm wavelength, laser(Biolase, Irvine CA). A Class IV, free running, pulsed laser with a fixed pulse repetition rate of 20 Hz, pulsewidth of 140 microseconds, a fibre optic delivery system, mounted by a straight or angled handpiece with water/air spray. All, patient, operator and nurses wore protective eyewear. Optical magnification was used by the operator.

The Z600, a 600 μ sapphire tip, inserted in an angled handpiece, with laser settings on 20 Hz, 1,0 Watt, 13% Air, 11% Water (29,4 J/cm^2 Fluency), was used to de-epithelialize the free gingiva and dissect the connective tissue fibre attachment (Fig.4) The tooth was removed by forceps in two pieces (Fig.5).

For the wound toilet the C12, a 1200 μ quarz tip was used, with laser settings 20 Hz 2,0 Watt, 60% Air, 60% Water (7,4 J/cm^2 Fluency). All granulation tissues were removed, and the alveolar bone decorticalized (Fig.6). In mesial direction power settings were adjusted to 1,5 Watt (5,5 J/cm^2 Fluency), to avoid ablating root surface of tooth 33, but rather etch it with a distance of circa 2 mm. Even though this could not be verified, as the root surface was never dry due to bleeding.

Coagulation was performed with the C12 tip and 20 Hz, 1,0 Watt, 11% Air, 0% Water (3,6 J/cm^2 Fluency), at a distance of 5-10mm, “blowing dry” the wound. A whitish aspects of the soft tissue and coagulum appeared (Fig.7). No sutures were placed.

The patient was instructed not to rinse or suck at the wound in the first 24 hours, and avoid using the operated site. In case of need, analgesics (Ibuprofen 800 mg every 12 hours)were prescribed, but no prescription for antibiotics was given.

RESULTS

At a 24 hour recall the patient referred no discomfort or post-operative bleeding. No analgesic medication had been assumed. Neither extra- nor intra-oral swelling of the soft tissues was present. A clinically closed wound was observed. An overall pink aspect of the

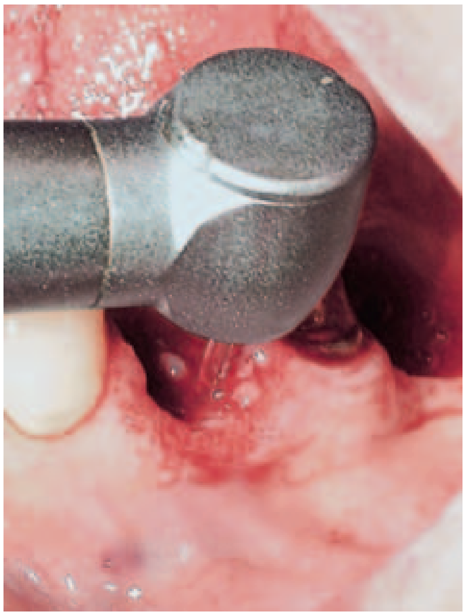

Fig 6 Removal of granulation tissues and bone decorticalization.

Fig 7 "Blowing dry " coagulum until whitish aspect appears.

Fig 9 Soft tissues 1 week postoperatively.

Fig 8 (left) At 24 h, tissue overgrowth, complete closure of wound by fibrin network.

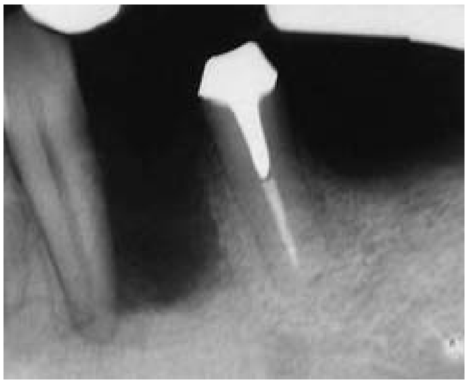

Fig 10 Radiograph 1 week postoperatively.

Fig 12 Radiograph at 1 month.

Fig 11 (left) At 1 month, scalloped soft tissue outline.

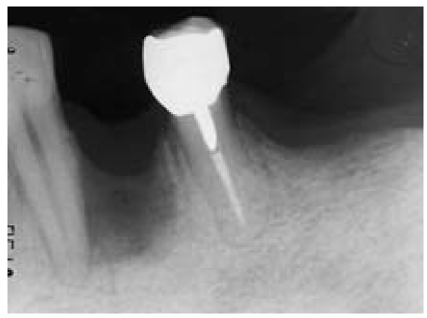

Fig 14 Radiograph at 3 months, initiating bone in-growth.

Fig 13 (left) Soft tissues at 3 months.

surrounding tissues and a network of fibrin, closed over the coagulum was seen. Some carbonization of marginal tissues was present, caused by insisting with laser coagulation at one point (Fig.8).

Soft tissues appeared healthy and clinically healed at 1 week post-operatively. The soft tissue "roof" over the extraction socket, however, had collapsed (Fig.9).

Radiographic exams showed an extensive radiolucency. Tooth #33 had on the distal a wide two–wall defect, with an radiographic angle ≥ 90°. No more than 1mm distal bone support was left. The radiolucency measured 10mm horizontally and 12 mm vertically. Tooth #35 had both on the mesial and on the distal bone support (Fig.10).

Without anaesthesia, the wound was irradiated again with the Z6, a 600 µ sapphire tip, with laser settings 20 Hz, 1,0 Watt, 60% Air, 60% Water, (29,4 J/cm^2 Fluency), causing moderate bleeding. At two weeks soft tissues were clinically healed and tissues had not collapsed into the socket, but vertically a scalloped feature in harmony with neighbouring teeth was seen. Horizontally however, soft tissues showed an initiating concavity in the buccal outline.

After a month post-operatively a removable appliance was placed. Clinically healthy soft tissues were observed (Fig.11). X-ray shows a slight remineralisation of the defect starting from the bone walls (Fig.12).

At three months, apart from a pressure spot of the removable appliance, clinically healthy soft tissues were observed (Fig.13). X-ray showed initiating bone in-growth (Fig.14).

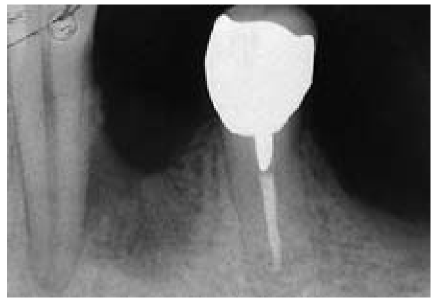

Fig 16 Radiograph at 6 months, evident bone in-growth and remineralization of defect.

Fig 15 (left) Inflamed soft tissues at 6 months.

Fig 18 Radiograph at 1 year.

Fig 17 (left) Soft tissues one year after extraction.

After six months due to insufficient patient compliance in oral hygiene, (PI = 54%, GI = 41%) gingivitis is present, with slightly swollen papilla of teeth 33 and 35 (Fig.15).

X-ray showed evident bone in-growth and remineralisation of the defect (Fig.16).

One year postoperatively soft tissues were clinically healthy (P.I = 24%, G.I. = 15%). The horizontal soft tissue outline showed an evident buccal concavity (Fig.17).The X-ray showed high bone-fill in the extraction site. The resolution of the defect with mineralised tissues was both horizontal and vertical. The latter measured 12 mm distal of #33 to 8 mm at the deepest point of the scalloped feature of the radiographic bone outline. An overall remineralisation could be seen with corticalisation of the coronal bone crest (Fig.18).

PPD of tooth#33: mesial = 4 mm, buccal = 2 mm, distal = 2 mm (CAL = 3 mm), lingual = 2 mm.

PPD of tooth #35: mesial = 2 mm, buccal = 2 mm, distal = 2 mm, lingual = 2 mm.

DISCUSSION

Extraction wounds heal neither per secundam nor per granulationem, but rather “over the coagulum”.

A four wall extraction site heals as follows: In the first 24 hours a blood clot is formed. At 48-72 hours after extraction granulation tissue formation starts, which replaces the blood clot. After 4 days the wound entrance is tightened together by proliferation of epithelium from marginal gingiva. At 7 days a thin layer of epithelium grows over the coagulum closing the defect. The socket is characterised by granulation tissue consisting of a vascular network, young connective tissue and osteoid formation in the apical region. After three weeks a trabecular pattern of bone starts emerging. Re-epithelialisation of the covering connective tissue takes place. Six weeks after extraction, woven bone, trabeculae may be radiographically visible. Bone fill in the alveolus takes up to 4 months and does not seem to reach the level of neighbouring teeth.[18]

It is known that after extraction a soft tissue contraction takes place. Epithelium in-growth is around 0,5-1,0 mm per 24 hours.[18]

In this case report the bone defect after extraction was not a self-containing four-wall defect, but a wide two-wall defect, consisting of extensive vertical and horizontal bone destruction due to endodontic pathology and root fracture. Conventional wound toilet, after removal of tooth with a large amount of granulation tissues, consists of accurate curettage of the socket, removing infected soft tissues and eventual tooth remnants or other debris. Grating the alveolar bone to remove abscess lining and periodontium rests. Sutures would have been placed to stabilize the soft tissues and protect the coagulum. The patient would have been instructed to exert pressure with a gauze on the extraction site and to not rinse or disturb the wound in the first 24 hours. Antibiotics would have been prescribed.[4] Subsequent healing might have been characterised by soft tissue down-growth, lining the defect. Especially the compression of the wound would have probably caused the collapsing together of buccal and lingual soft tissues, as PPD of #34 measured 13 mm both on the buccal as on the lingual. In animal studies it was found that a 4 wall extraction socket, which was covered with mobilised soft tissues, showed dimensional alterations in the first 8 weeks. This was caused by marked osteoclastic activity resulting in bone resorption, consisting of crestal height reduction and horizontal bone loss that occurred from the outer surface of the buccal and lingual bone walls.[19]

The wound toilet in this case was performed by a 2780 nm Er,Cr:YSGG laser with low power laser settings to obtain decontamination of the contaminated extraction site and accelerated healing by low power irradiation. There are reports on Er:YAG laser treatments, a 2940 nm wavelength near to Er,Cr:YSGG, which state that the laser appears to exert its stimulative action on gingival fibroblasts proliferation, which accelerates wound healing in vitro.[20,21] The low power laser irradiation with the 2780 nm wavelenght might have enhanced the rapid soft tissue closure over the extraction site. The tensile strength of the overgrowing young soft tissue and it's complete coronal closure might have prevented the epithelium to grow down into the socket. The thick rigid soft tissue biotype might have been of influence in maintaining the naturally formed scaffold.

Nowadays, early epithelialization, increased fibroblastic reactions, leucocytic infiltration and neo-vascularization are seen in wounds irradiated using Low Level Laser Therapy.[22] Because of the overall impact of these influences, the time required for complete wound closure is reduced.[23] Moreover, the mean breaking strength, as measured by the ability of the wound to resist rupture force, is increased using a Helium-Neon laser.[24]

The wound toilet performed with low power settings by an Er,Cr:YSGG laser resulted in accelerated wound closure. However, there was a collapse or rupture of the young connective tissue roof over the extraction socket. Presumably caused by the sagital extent of the defect. After a repeated laser irradiation the site remained closed and re-epithelialised. Bone regeneration could occur in the by epithelium naturally formed scaffold. The principle of space-maintaining by membranes(scaffold) for coagulum stabilisation and exclusion of epithelium cells was established as one of the conditions "sine qua non" for tissue regeneration.[25] Bone regeneration is based on the hypothesis that different cellular components in the tissue have varying rates of migration into a wound area during healing. A hindrance, with the membrane technique, prevents fibroblasts and other soft connective-tissue cells from entering the bone defect, so that the presumably slower-migrating cells with osteogenic potential are allowed to repopulate the defect.[26] In this case, the epithelium having closed tightly over the extraction wound, became its own hindrance and did not grow down into the socket, and had so formed a natural scaffold, in which radiographically identifiable bone growth had occurred.

Furthermore the effective debridement and decontamination of the socket created the ideal circumstances for bone in-growth, proceeding from the two, distal and apical bone-walls (Figs. 10, 12, 14, 16, 18).

Comparative studies on bone healing suggested that Er-laser irradiation could be advantageous for wound healing of bone tissues.[27] Even though, it cannot be excluded that functional forces exerted by the removable appliance also enhanced bone remineralisation in a later stage.

Actual periodontal regeneration of the distal root-surface of tooth #33 cannot be identified radiographically, but only histologically. However there was a clinical attachment level (CAL) gain on the distal site of tooth #33 of 9 mm.

CONCLUSION

This case report demonstrates an application of an Er,Cr:YSGG laser in extraction surgery. An alternative to conventional wound toilet is presented, which due to specific laser characteristics, resulted in accelerated healing of the coronal soft tissues. A natural scaffold was formed in a wide two wall bone defect, in which bone- regeneration could occur.

Scientific rationale for study: There is a need to develop laser approaches, which are able to favour wound stability after extraction, in order to improve the healing potential of soft tissues and accelerate coronal wound closure. Furthermore the ideal laser settings need to be evaluated and defined for eventual biostimulative effect on soft and hard tissues with this 2780 nm wavelength in different subjects. It is necessary to confirm and extend the reported positive outcome with histological studies and evaluate predictability of natural scaffold formation and subsequent bone regeneration after laser irradiation.

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