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

Elena S. Moll

a Private practice, Firenze, Italy.

Abstract: Teeth are extracted for various reasons. Proper wound care is crucial for avoiding postoperative morbidity and promoting 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 regrowth.

This case report illustrates the use of Er,Cr:YSGG laser in extraction surgery in a 48-year-old female with an extensive periapical abscess and a fractured root on tooth 34. Conventional post-extractive wound care with sutures was replaced by laser decontamination and coagulation. Twenty-four hours postoperatively, the wound was completely closed by a fibrin network. Radiographic follow-up at 1, 3, 6 and 12 months showed resolution of the defect with evident bone regrowth and mineralization.

Low-power Er,Cr:YSGG laser irradiation may have enhanced rapid wound closure within 24 h after extraction. 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 the extraction socket seemed to prevent its growing down into the extraction site.

Keywords: Er,Cr:YSGG laser, bone regeneration, natural scaffold formation.

level laser irradiation, results have been contradictory regarding the expected higher bone density or diminished patient morbidity.\textsuperscript{7,8} In other studies, however, enhanced bone healing and repair were documented after low-power laser irradiation with a 632.5 nm wavelength in vitro\textsuperscript{9} and in vivo with 637 nm irradiation after peri-apical surgery\textsuperscript{10} or with an 810-nm wavelength laser after extractions.\textsuperscript{11}

When hard lasers are applied at low power, biological effects in soft tissues consist of low post-operative patient morbidity and highly predictable quality of tissue healing.\textsuperscript{12} Reports concerning mineralized tissues describe precise osteotomies with the 2780-nm wavelength, resulting in minimal thermal damage and subsequent normal bone healing.\textsuperscript{13,14} Regeneration of periodontal tissues was found in studies where the laser’s decontaminative capacity created favorable circumstances for fibroblast attachment on root surfaces.\textsuperscript{15,16} Crespi suggested clinical improvements in periodontal healing also after CO\textsubscript{2} laser treatment.\textsuperscript{17}

This case report illustrates an indication of the Er,Cr:YSGG laser, a 2780-nm wavelength 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 coagulation of the wound, is reviewed. With this method, an alternative to conventional postoperative wound care is presented, and the effects of decontamination and biostimulation with this specific wavelength are described.

PATIENT AND TREATMENT

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 buccally and lingually (Figs 1 and 2), 15 mm mesially, and 4 mm distally. Dental history showed high caries incidence with consequent tooth loss. The remaining dentition consisted of 9 teeth in the maxilla and 12 in the mandible. Periodontal probing depths (PPD) of tooth 33 were 4 mm mesially, 3 mm buccally, 12 mm distally (CAL=12), and 3 mm lingually. Periodontal probing depths of tooth 35 were 3 mm mesially, 2 mm buccally, 2 mm distally, and 2 mm lingually. The periodontal status of the remaining teeth was characterized by generalized gingivitis, with mean PPD ≤ 4 mm, PI = 53\%, and GI = 68\%. No angular defects were visible on the radiograph. Crestal bone seemed corticalized and was at the same level throughout the remaining dentition. No periodontal breakdown evident.

Endodontically, however, radiographic examination of tooth 34 showed an extensive periapical abscess and fractured root. Bone resorption had extended along...
the distal apical region of tooth 33. Tooth 35 had intact bone support mesially, which was adjacent to the peri-apical radiolucency of tooth 34 (Fig 3).

After administration of infiltration anesthetics, fiber dissection and post-extractive site decontamination was performed with an Er,Cr:YSGG laser (2780 nm wavelength; Biolase; Irvine, CA, USA), a Class IV, free running, pulsed laser with a fixed pulse repetition rate of 20 Hz, pulse width of 140 μs, and a fiber optic delivery system mounted on a straight or angled handpiece with water/air spray. Patient, operator, and assistants wore protective eyewear. Optical magnification was used by the operator.

The Z600, a 600-μm sapphire tip, inserted in an angled handpiece, with laser settings on 20 Hz, 1.0 W, 13% air, 11% water (29.4 J/cm² fluency), was used to de-epithelialize the free gingiva and dissect the connective tissue fiber attachment (Fig 4) The tooth was removed by forceps in two pieces (Fig 5).

For wound care, the C12, a 1200-μm quartz tip was used, with laser settings 20 Hz, 2.0 W, 60% air, 60% water (7.4 J/cm² fluency). All granulation tissue was removed, and the alveolar bone decorticalized (Fig 6). In the mesial direction, power settings were adjusted to 1.5 W (5.5 J/cm² fluency), to avoid ablating but allow etching the root surface of tooth 33 at a distance of ca 2 mm. However, 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 W, 11% air, 0% water (3.6 J/cm² fluency), at a distance of 5 to 10 mm, and the wound was gently blown dry. A whitish aspect 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 h, and avoid using the extraction site. Analgesics (ibuprofen 800 mg every 12 h) were prescribed to be used if needed, but no prescription for antibiotics was given.

RESULTS

At the 24-h recall, the patient reported no discomfort or postoperative bleeding. No analgesics had been consumed. Neither extra- nor intraoral swelling of the soft tissues was present. A clinically closed wound was observed. An overall pink aspect of the surrounding tissues and a network of fibrin closed over the coagulum were seen. Some carbonization of marginal tissues was present, caused by holding the tip too long at one site while coagulating the wound (Fig 8).

Soft tissues appeared healthy and clinically healed at 1 week postoperatively. The soft tissue “roof” over the extraction socket, however, had collapsed (Fig 9).

Radiographic exams showed an extensive radiolucency. Tooth #33 displayed a wide two-wall defect distally, with a radiographic angle xx? 90 degrees. No more than 1 mm of distal bone support was left. The radiolucency measured 10 mm horizontally and 12 mm vertically. Tooth #35 had bone support both mesially and distally (Fig 10).

Without anesthesia, the wound was irradiated again with the Z6, a 600-μm sapphire tip, with laser settings of 20 Hz, 1.0 W, 60% air, 60% water (29.4 J/cm² 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 neighboring teeth was seen. Horizontally however, soft tissues showed an incipient concavity in the buccal outline.
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.
After a month postoperatively, a removable appliance was placed. Clinically healthy soft tissues were observed (Fig 11). The radiograph shows a slight remineralization 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). The radiograph showed incipient new bone formation (Fig 14).

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

The radiograph showed evident new bone growth and remineralization of the defect (Fig 16).

One year postoperatively, soft tissues were clinically healthy (PI = 24%, GI = 15%). The horizontal soft tissue outline showed an evident buccal concavity (Fig 17). The radiograph showed high bone fill in the extraction site. The resolution of the defect with mineralized tissues was both horizontal and vertical. The latter measured 12 mm distal to #33 and 8 mm at the deepest point of the scalloped feature of the radiographic bone outline. An overall remineralization could be seen with corticalization 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 h, a blood clot is formed. At 48 to 72 h after extraction, granulation tissue formation starts, which replaces the blood clot. After 4 days, the wound entrance shrinks by proliferation of epithelium from the marginal gingiva. At 7 days, a thin layer of epithelium grows over the coagulum, closing the defect. The socket is characterized 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-epithelialization of the covering connective tissue takes place. Six weeks after extraction, woven bone and trabeculae may be radiographically visible. Bone fill in the alveolus takes up to 4 months and does not seem to reach the level of adjacent teeth.\textsuperscript{18}

It is known that after extraction, a soft tissue contraction takes place. Epithelium in-growth is around 0.5 to 1.0 mm per 24 h.\textsuperscript{18}

In this case report, the bone defect after extraction was not a self-containing four-wall defect, but an wide two-wall defect, consisting of extensive vertical and horizontal bone destruction due to endodontic pathology and root fracture. Conventional wound hygiene, after removal of a tooth with a large amount of granulation tissue, consists of accurate curettage of the socket, removing infected soft tissues and eventual tooth remnants or other debris. The alveolar bone is debrided to remove abscess lining and periodontium remnants. 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 pad on the extraction site and to not rinse or disturb the wound in the first 24 h. Antibiotics would have been prescribed.4 Subsequent healing might have been characterized by soft tissue down-growth, lining the defect. Especially the compression of the wound would have probably caused the collapse of buccal and lingual soft tissues, as PPD of #34 measured 13 mm both buccally and lingually. In animal studies, it was found that a four-wall extraction socket which was covered with mobilized 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

Wound care 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 (its 2940-nm wavelength is similar to Er,Cr:YSGG) which state that the laser appears to exert its stimulative action on gingival fibroblast proliferation, which accelerates wound healing in vitro.20,21 The low-power laser irradiation with the 2780-nm wavelength might have enhanced the rapid soft tissue closure over the extraction site. The tensile strength of the overgrowing new soft tissue and its complete coronal closure might have prevented the epithelium from growing down into the socket. The thick rigid soft tissue biotype might have influenced the maintenance of the naturally formed scaffold. Nowadays, early epithelialization, increased fibroplastic reactions, leucocytic infiltration and neovascularization are seen in wounds irradiated using low-evel laser therapy.22 Because of the overall impact of these influences, the time required for complete wound closure is shortened.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

Wound care performed with low power settings of 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 sagittal extent of the defect. After a repeated laser irradiation, the site remained closed and re-epithelialized. Bone regeneration could occur in the scaffold naturally formed by epithelium. The principle of space maintenance by membranes (scaffold) for coagulum stabilization and exclusion of epithelium cells was established as one of the “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. 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 which closed tightly over the extraction wound became its own hindrance, and did not grow down into the socket; it thus formed a natural scaffold, in which radiographically identifiable bone growth occurred.

Furthermore, the effective debridement and decontamination of the socket created the ideal circumstances for bone in-growth, proceeding from the distal and apical bone walls (Figs 10, 12, 14, 16, 18). Comparative studies on bone healing suggested that erbium laser irrigation could be advantageous for wound healing of bone tissues.27 Nevertheless, it cannot be excluded that functional forces exerted by the removable appliance also enhanced bone remineralization in a later stage.

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

CONCLUSION

This case report demonstrates an application of an Er,Cr:YSGG laser in extraction surgery. An alternative to conventional wound care 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.

There is a need to develop laser approaches which facilitate 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 any biostimulative effect on soft and hard tissues with this 2780-nm wavelength in a number of different subjects. It is necessary to confirm and extend the reported positive outcome with histological studies and evaluate the predictability of natural scaffold formation and subsequent bone regeneration after laser irradiation.
REFERENCES


Contact address: Elena S. Moll, Via Amilcare Ponchielli, 21, 50018 Scandicci Firenze, Italy. Tel/Fax: +39-055-755347. e-mail: esmoll@tiscali.it