APPLICATION OF DENTAL LASERS IN BONE SURGERY

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ABSTRACT

INTRODUCTION: In oral surgery, lasers have been extensively used in soft-tissue manipulations, yet their application to bone tissue remains limited.

AIM: The literature review in the present paper aims to discuss and summarize current applications of dental lasers on bone tissue, specifying the advantages and drawbacks related to their usage, and also indicate the types of lasers appropriate for bone cutting.

MATERIALS AND METHODS: The academic databases used as sources are: Pub Med, Google Scholar, and Medline, from 2005 to December 2020. The academic search returned a total of 321 publications relevant to the topic concerned. Twenty-nine articles were then shortlisted as containing specific information on the practical application of lasers in bone surgery. The following keywords or combinations of them were used: "bone cutting"; "oral surgery"; "laser".

RESULTS: Dental lasers have found many applications in bone surgeries such as crown lengthening, extraction of impacted wisdom teeth, apical osteotomy, cystectomy, autogenous bone grafting procedures, implant surgery, etc. Laser bone removal provides some indisputable advantages over the conventional methods with mechanical drills: operative comfort for the patient, absence of the unpleasant sensations of vibration, pressure and noise, a decontaminating, bactericidal and sterilizing effect on the irradiated bone tissues, cleaner ablated surfaces without debris, microcracks and smear layer, lack of thermal damage to the bone, and minimal bone loss. The main downside of laser use is associated with the extended surgical time and the lack of tactile sensation due to their non-contact mode of operation. Er:YAG and Er,Cr:YSGG lasers remain the most widely used ones for bone removal due to their minimal thermal effects and negative impact on adjacent tissues.

CONCLUSION: Lasers have the potential to become a more efficient alternative to conventional mechanical instruments for osteotomy. However, due to the current limited application of dental lasers in bone surgery, they need to be further explored for use in this field and certain issues remain yet to be resolved. Therefore, further studies must be carried out to obtain sufficient evidence that lasers are superior to conventional techniques for bone removal.

Keywords: *laser, bone cutting, oral surgery*

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INTRODUCTION

The application scope of dental lasers has been widely extended over recent years following the ever-growing interest in laser system possibilities not only in dentistry but also in medicine in general. This trend is ascribed to the fact that laser treatment proves to be a minimally invasive modern method that provides maximum reduction of patients' postoperative discomfort. In oral surgery, lasers have

been extensively used in soft-tissue manipulations, yet their application to bone tissue remains limited. Over the last decade, however, efforts to demonstrate their feasibility and effectiveness in this area have steadily increased in the attempt to suggest a reliable alternative to standard surgical techniques related to bone cutting and removal. In most cases, these interventions are radical and marked by a prolonged recovery period, greatly feared, and thereby avoided by patients.

Dental lasers have found many applications in bone surgeries ranging from minimally invasive crown lengthening, extraction of partially impacted wisdom teeth, and apical osteotomy requiring minimal bone removal to large-scale surgical procedures such as cystectomy, autogenous bone grafting, alveolar ridge contouring, removal of benign bone formations, etc.

The main types of lasers used in oral surgery are diode lasers Nd:YAG, CO2 and erbium lasers Er:YAG, Er,Cr:YSGG. Different laser applications have been explored over the years with the aim to employ them in bone surgery. However, since FDA approval of erbium lasers in 2000, the use of other dental lasers has been limited. Er:YAG and Er,Cr:YSGG lasers remain the most widely used ones for dental purposes, including bone removal due to their minimal thermal effects and negative impact on adjacent tissues.

AIM

The literature review in the present paper aims to discuss and summarize current applications of dental lasers on bone tissue, specifying the advantages and drawbacks related to their usage, and also indicate the types of lasers appropriate for bone cutting.

MATERIALS AND METHODS

Search strategy: the academic databases used as sources are Pub Med, Google Scholar, and Medline, from 2005 to December 2020. The following were set as inclusion criteria for the present study:

- publications written in English
- clinical studies involving humans
- laboratory in vivo animal studies
- laboratory studies with animal and human material
- review articles

The academic search returned a total of 321 publications relevant to the topic concerned. Twenty-nine articles were then shortlisted as containing specific information on the practical application of lasers in bone surgery. The remaining 296 publications were excluded from the study as they failed to meet the inclusion criteria, or for the lack of sufficient scientific justification.

RESULTS

A thorough research of the latest dental literature data revealed the results presented below.

Many authors pursued the use of dental lasers as an alternative tool to drilling handpieces and surgical burs for the extraction of impacted third molars (1–4). The odontectomies in the studies reviewed were performed using Er:YAG lasers. The parameters under study included duration of manipulation, bleeding, degree of postoperative pain, edema, and wound healing. Authors are unanimous that laser-assisted bone removal is marked by a prolonged operative time. On the other hand, compared to the conventional bone cutting group, the laser group observations revealed a decrease in pain and swelling as well as reduction of the risk of infection and postoperative complications (e.g., alveolitis). There were no significant differences in the healing quality of surgical wounds.

Er:YAG lasers were used in apical osteotomy not only to remove the bone vestibularly in the apical region but also to resect the tooth apex (5,6). The authors observed a considerable improvement in the quality of the postoperative period in the laser-treated group compared to the control group in terms of reduced levels of hyperemia, edema, and dysfunctions. However, no differences were reported in patients' perception of the procedure.

Lasers can also be used in oral implantology for removal of osseointegrated dental implants and as an aid in the exposure of implants. The authors found out that the laser-treated group exhibited a smaller amount of bone loss than the trephine bur-treated group. They recognized the disadvantage of lasers with regard to the longer preparation time for bone removal compared to the conventional mechanical removal (7). The study was carried out using Er,Cr:YSGG erbium lasers.

Another feasible application of lasers in implantology is the possibility to create and prepare the osteotomy bed using Er:YAG lasers (8). The authors did not detect significant advantages of this method of osseointegration of implants over conventional methods and piezosurgery, however, removal torque values decreased in the Laser group.

Er,Cr:YSGG lasers have also been applied in esthetic crown lengthening procedures where biologic width needs to be re-established. The minimally invasive Er:YAG lasers provide many advantages: avoidance of the flap elevation techniques, reduction of intraoperative bleeding, thus shortening the time for impression procedures and definitive restoration (9,10,11,12).

Atalay et al. (13) found an interesting application of the Er:YAG laser as a beneficial alternative in the treatment of patients with bisphosphonate-related osteonecrosis of the jaws. Initially, the larger bone segments were removed with the aid of bone forceps, then Er:YAG laser was used for the remaining bone tissue as well as for ablation of fibrous and inflammatory granulation tissues. The authors recorded faster epithelialization and healing in the laser-treated group.

Some authors studied the feasibility of harvesting autogenous bone graft using lasers (4,14,15). This laser-assisted surgical intervention once again confirmed an extended operative time compared to the conventional technique. The authors reported ambiguous results: minimal bone loss was observed following harvesting, but difficulty was experienced in procuring graft from hard-to-reach areas due to the lack of tactile sensation since lasers are non-contact surgical instruments.

Most authors performed their experimental laboratory research on animal bones with the purpose to determine the laser effects on bone tissues (16–20). The results of most studies revealed reduced thermal effects, minimal damage to adjacent tissue around the ablation crater, and more regular smooth incisions, promoting bone repair. In contrast to most authors, one study established shortened surgical time in the laser-treated group and increased volume of the bone removed compared to the control group (16).

DISCUSSION

Operative time is an important factor in surgical manipulations since any extension of this period leads to a longer time of flap retraction needed to facilitate access to and visibility of the bone. Contrary to expectations, however, most studies reported that the longer operative time did not result in an increased volume of postoperative edema (1,2,5). On the other hand, the authors of one of the studies observed a more severe trismus related to longer period manipulation of the flap with a retractor (1). Moreover, the longer duration of surgical interventions clearly contributed to discomfort on the part of the patient and the operator.

Laser irradiation exerts a decontaminating, bactericidal, and sterilizing effect on tissues (21,22). This contributes to a reduced risk of infections and development of postoperative complications. Passi et al. (1) discussed a reduced risk of developing alveolitis following an extraction of impacted third molars using Er:YAG laser compared to the control group. This property of lasers enabled their application in irradiation of the bone cavity after cystectomy (22). Atalay et al. (13) also demonstrated the marked decontaminating and sterilizing effect in laser-assisted surgeries, reporting acceleration in healing for patients undergoing bisphosphonate-related osteonecrosis treatment compared to the control group.

Oral surgeons experience one significant disadvantage of the laser instrument associated with the lack of tactile sensation due to the non-contact mode of operation during bone removal (23). Papadaki et al. (18) mentioned that the challenging part of handling the laser beam was to maintain the same distance, focus, and course along the bone during the time period required to make the cut. According to Stubinger et al. (14) laser osteotomy offered no depth control and, in another study they carried out (15), they encountered difficulties in harvesting autogenous grafts from hard-to-reach areas. The authors also observed that the slight deviations of the original angulation of the laser beam led to considerable bone loss. Depth control was limited to visual inspection but no significant time loss occurred.

Nevertheless, the contact-free mode of laser-assisted surgeries offered far more operative comfort in patients, without the unpleasant sensations of vibra-

tion, pressure and noise associated with conventional mechanical rotary instruments (3,16). Stubinger et al. (3) reported a significant advantage in this respect, pointing out that lasers could be a promising alternative to standard mechanical bone removal, particularly for patients with a pronounced sense of pain or patients with temporomandibular disorders.

Many authors acknowledged the advantages of laser-assisted bone operations as surgeons were able to obtain cleaner ablated surfaces without debris and microcracks, typical of osteotomies performed with mechanical cutting burs (7,14,16–19,24–28). Their findings included faster bone regeneration.

The main concern regarding laser-assisted osteotomies is the thermal effect produced on the underlying bone, leading to alterations and bone necrosis. The present paper reviewed many studies presenting sufficient evidence for the lack of thermal bone damage using erbium lasers as they have a shallow depth of beam penetration than other types of dental lasers. The use of erbium lasers facilitates the localization of their effects on the target tissues and reduces damage to the surrounding bone (7–9, 14, 16, 18). The fact that the erbium laser irradiation uses air/water-air surface cooling contributes to a steady bone temperature and prevents bone charring. Laser osteotomies are performed with great precision with minimal bone loss (7,14,29).

CONCLUSION

Despite the limited number of clinical and experimental studies on the effectiveness of dental lasers on bone tissues compared to soft-tissue laser surgeries, the present paper discussed many advantages of laser use for bone cutting. Laser application is superior in that it offers the patient more comfort as the interventions are vibration- and pressure-free. In laser-assisted operations, the oral surgeon can obtain cleaner and smoother bone incisions by the precise direction of laser beams, resulting in minimal bone loss, lack of necrosis, and bone charring after irradiation. The main downside of laser use is associated with the extended surgical time and the lack of tactile sensation due to their non-contact mode of operation. Overall, dental laser application has the potential to become a more efficient alternative to conventional mechanical instruments for osteotomy as laser cutting speed is further increased.

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