Removal of epithelium in periodontal pockets following diode (980nm) laser application in the animal model

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Introduction

The goal of periodontal therapy is to eliminate bacteria in the pockets, to remove the hard and soft tissue deposits, to remove the granulation tissue and pocket epithelium in the periodontal lesions, to make root planning and later, enhance the attachment gain. Various Instruments are used on the root surface for the reduction of bacteria, removal of soft and hard tissue deposits as well as granulation tissue. Moreover, there is a biological reaction to any mechanical intervention that results in partial removal of the pocket epithelium and following healing, a new formation of a long junctional epithelium. This is a "healing mechanism" where clinical studies"have demonstrated the reduction of the probing pocket depth and a relative gain of clinical attachment. Regenerative surgical procedures have been established which enhance connective tissue regeneration, followed by new bone formation as the treated lesion has higher stability, when connective tissue attaches to the root surfaces and periodontal apparatus can be firmly established. Using the guided tissue regeneration (GTR) technique, special barriers (resorbable and non-resorbable) may be used in order to control epithelial migration. The epithelium covers the wounds relatively fast and restricts new connective tissue formation, which is of great significance in the periodontal wound to establish effective regeneration. The concept of the GTR-technique is broadly accepted by clinicians and scientists from the biological point of view, however there are a number of surgical complications, high costs, specialised dental training, implantation of additional materials and occasional poor clinical outcomes associated with this surgical approach. (Cortellini and Tonetti, 2000).

For these reasons, there is significant interest and focus on other regenerative techniques in the periodontium using enamel matrix proteins (Emdogain®) (Sculean et al., 1999), local drug delivery systems (Rams and Slots, 1996), bone grafting materials (Laurell et al., 1998) and polypeptide growth factors (Giannobile, 1999). The main goal of these techniques is to regenerate damaged periodontal tissues.

Lasers have been used in the last decades in periodontology to reduce periodontopathogenic bacteria (Gutknecht et al., 1997; Moritz et al., 1997), remove pocket epithelium and retard epithelial migration into the pocket. If the wavelength is appropriate, it is possible to remove the hard deposits (i.e. calculus) and to make a root planning (Schwarz et al., 2001). In the past there was misunderstanding among clinicians implying that lasers alone should be applied in periodontology without the adjunctive and complimentary use of mechanical instrumentation. The broad spectrum of potential applications for laser systems has received criticism when used only in association with conventional instruments, although, there are additional benefits of this approach. A significant reduction of the periodontopathogenic bacteria has been demonstrated regardless of laser wavelength (White et al., 1991; Cobb et al., 1992; Purucker et al., 1994; Ando et al., 1996; Coffelt et al., 1997; Moritz et al., 1998). Many laser systems have demonstrated the ability to significantly reduce (not "eliminate") bacterial species, leading to possible bacterial reduction and not a "pocket elimination". Furthermore, it has been shown that a removal of the calculus using the Er:YAG laser and special handpiece tips occurs as demonstrated in different in vitro and in vivo studies (Aoki et al., 1994).

A comparison between curette use and Nd:YAG laser application in the periodontal pockets followed by immediate histological examination (biopsies taken) after the procedure showed removal of the epithelium in the lased group biopsies without inducing damage to the underlying connective tissue when using the laser at relatively low power settings. The pocket epithelium was shown not to be completely removed after the use of hand instruments (Gold and Vilardi, 1994). Additional benefits are seen when removing the pocket epithelium leading to retardation of epithelial migration which enhances connective tissue attachment. A specific treatment protocol has been developed following mucoperiosteal flap elevation involving elimination of the granulation tissue and finally removal of the epithelium of the flap once every 10 days with the CO_2 laser for the first 4-6 weeks of healing. This surgical procedure demonstrated histologically, a higher connective tissue attachment and new cementum formation, without epithelial migration in the lased pockets when compared with the control group, where only hand instruments were used to remove the inflamed tissues (Rossmann et al., 1992; Israel et al., 1995; Rossmann and Cobb, 1995; Israel and Rossmann, 1998; Rossmann and Israel, 2000).

Furthermore, diode lasers (810 nm) have been used in the treatment of periodontal disease as well as periimplant therapy because of the characteristic antibacterial effects (Moritz et al., 1997, 1998; Bach and Neckel, 2000) without inducing dramatic changes in the underlying tissues (connective tissue, pulp and bone) as discussed previously following Nd:YAG laser

use. Another laser wavelength (980nm) may also be used in the soft tissue surgery without complications presenting additional benefits for patients and clinicians (Romanos and Nentwig, 1999). This laser wavelength may also be used in the periimplant tissues without damage to the implant surfaces (Romanos et al., 2000; Romanos 2002).
The aim of this study was to examine the use of a diode (980 nm) laser for the removal of epithelium in comparison to conventional methods in an animal experimental model.

Material and methods

Ten lower jaws of freshly sacrificed, periodontally diseased adult pigs with all periodontal soft tissues intact were used in this study. All the pigs had periodontal inflammation and pocket formation caused by bacterial accumulation. The buccal pockets of the posterior teeth (P2-P4, M1-M3) were scaled by three different examiners using conventional curettes (control group; Fig. 1). The lingual pockets were treated using a diode (980nm) laser (Biolitec, Bonn, Germany) (test group; Fig. 2). The laser was used in a continuous wave (c.w.) mode with two different power settings (2 and 4 Watts) with a 300 µm thick glas fiber (power density: 1.96-3.93 x 10^5 W/cm^2). All of the test and control sites were scaled for a period of 15 sec for each site. The three examiners who scaled the teeth had three different levels of surgical experience in the field of periodontal surgery as follows:

Level 1: one postgraduate student in the field of oral surgery (S.B.)
Level 2: a specialist in the field of oral surgery (H.P.)
Level 3: a dentist specialized in the field of oral Surgery and Periodontology (G.R.)

Immediately following surgery full thickness soft tissue biopsies of the buccal and lingual sites, excluding the surrounding papillae were removed with a scalpel, fixed in 4% formalin solution and following sectioning, stained with haematoxylin-eosin and examined histologically (Fig. 3, drawing).

Results

Test group: In all of the examined sections no epithelial remnants in the lased areas were found. The laser with a low power setting (2 Watts) was able to remove the thin pocket epithelium in the same way in all of the tissues scaled by all three examiners regardless of the level of experience (Fig.4a,b,c).

Using a higher power setting (4 Watts) significant damage to the underlying connective tissues was seen with coagulation similar to necrosis caused by increased thermal tissue damage induced by the laser (Figs. 5a,b).

Control group: Regardless of the level of periodontal surgical experience of the surgeon who scaled the tissue, epithelial remnants were found in the areas of pocket epithelium presenting a linear epithelial attachment on the tooth surface. The epithelium thickness decreased in the tissues of the level 3 examiner as well as the level 1 examiner when compared to the control, non-treated tissues. An additional inflammatory response in the connective tissue was seen even when special care was taken in the scaling process. The collagen fibres and the extracellular matrix showed normal distribution without any tissue damage (Figs. 3a,b).

Discussion

One of the most important goals of the periodontal surgery is to eliminate or to remove the epithelium of the pocket using special surgical techniques which allow a better connective tissue formation. Enamel matrix proteins (Gardaropoli and Leonhardt, 2002), bone grafting materials (Rosen et al., 2000) as well as membranes (Cortellini and Tonetti, 2000) have been clinically used with different success rates presenting in different papers. From the biological point of view the periodontal barriers of the epithelium are able to enhance the connective tissue attachment.

In the periodontal wound, special macromolecules of the fibrin clot may initiate these mechanisms for the further periodontal regeneration (Aukhil, 2000). Growth factors and cytokines present in the fibrin clot signals the start of the wound repair process. Using different surgical techniques it is possible the instrumentation of the root surface as well as the removal of the inflamed connective tissue and epithelium present a maturation of the healthy tissue matrix and contraction or scarring in the soft tissue.

The data presented in this in vitro study using the pig model showed that instrumentation of the soft periodontal tissues (no flap surgery) with a diode laser (980nm) leads to a complete epithelial removal in comparison to conventional treatment methods with hand instruments in the pocket. Independent of the level of surgical experience in periodontal treatment each dentist treating the lesion was able to efficiently remove the epithelium using the diode laser. It is of clinical significance that the laser had characteristically easy handling in comparison to soft tissue curettage using conventional methods. The power setting used in the laser unit must be relatively low in order to eliminate the risk of collateral damage to the healthy underlying tissues. The additional antibacterial effects of the diode laser have a significant benefit for the regeneration and new bone formation in the lased periodontal tissues.

With the additional instrumentation of the root surface using conventional techniques this concept of epithelial removal may be of significant clinical importance. The laser allows for adequate coagulation (Rastegar et al., 1992), which does not damage the surrounding healthy tissues and may stimulate new bone formation if applied in the correct way. This has been observed in a number of previous studies (Dörbudak et al., 2000; Silva Junior et a., 2002).
Further animal and clinical studies are required before this concept of treatment is introduced into daily practice.

Moreover, specialised training in laser surgery and techniques is of great importance in order to give the clinician the knowledge required for appropriate clinical use. A complete understanding of the benefits of these applications will help to eliminate the complications.

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