Er:YAG laser scanner for implant site preparation

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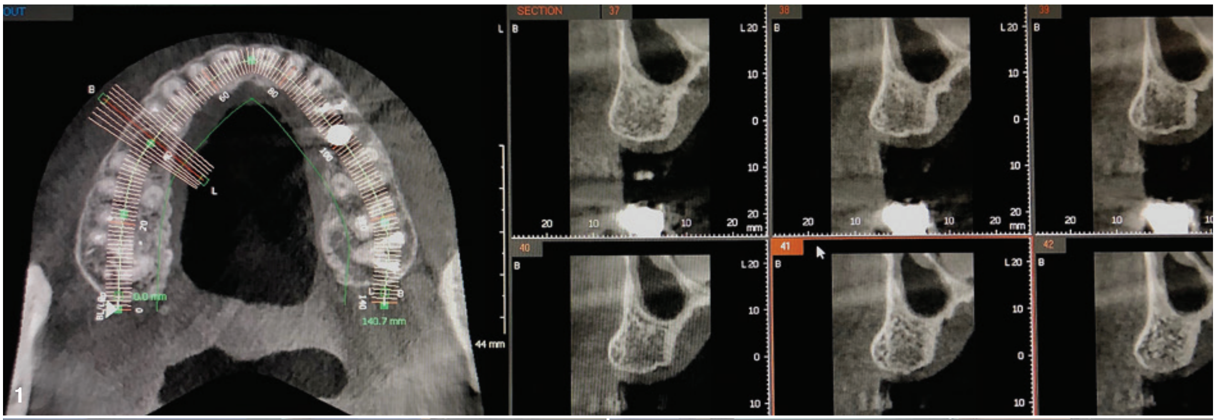
Introduction

Numerous studies have reported the ability of mid-infrared lasers (Er:YAG laser with a wavelength of 2,940 nm and Er,Cr:YSGG laser with a wavelength of 2,780 nm) to ablate hard biological tissue without creating thermal damage.[1–5] Among the various applications, the possibility of preparing the implant site entirely with laser irradiation was originally illustrated *in vivo* by Dr Berna, one of the authors of this article, in 2003. A patent for this form and method was issued and registered at that time. The first group of 62 patients received this method of treatment, using an Er,Cr:YSGG laser, between November 2001 and December 2002. Since then, another larger group of patients have been treated with this method. An Er:YAG laser and a dedicated laser scanner handpiece have never been used in human patients for this procedure, however. The major obstacles to the wide use of this technique are the time to create the osteotomy,[6] the low energy capability of the devices previously available and the time required to learn to use a handpiece that works in no contact. In the present study, a high performance Er:YAG laser was used with a tipless laser scanner handpiece that allows more precision, a higher energy output and a shorter pulse duration in comparison with the previously used device.

Materials and methods

A 67-year-old patient, a non-smoker without any systemic diseases, was examined using CBCT (PaX-i3D Smart, Vatech) in order to assess the surgical area, the bone volume and the bone density in the edentulous area, region #15 (Fig. 1). Before the surgery, the patient



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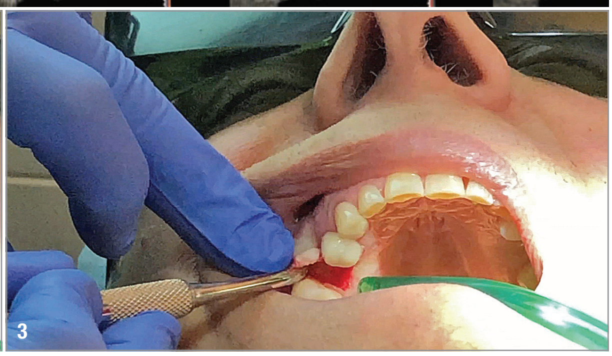

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Fig. 1: A CBCT scan was taken pre-op. **Fig. 2:** Flap incision using a LightWalker Nd:YAG laser head (200 µm diameter fibre, 3 W, 70 Hz, MSP). **Fig. 3:** Flap reflection was carried out with a Prichard elevator.

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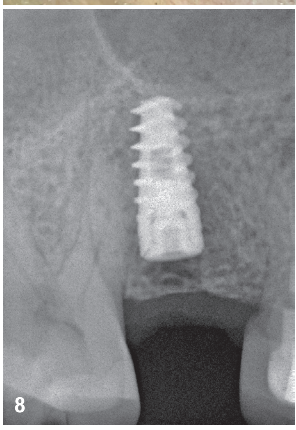

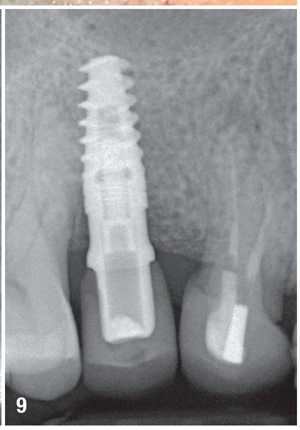

Fig. 4: The stabilised laser preparing the osteotomy, operated at 380 mJ, 20 Hz and 50 microseconds. **Fig. 5:** The Osstell handpiece detecting primary stability. **Fig. 6:** Determining the ISQ value. **Fig. 7:** Clinical situation post-op. **Fig. 8:** Radiograph taken immediately after surgery. **Fig. 9:** Radiograph taken after eight months of loading.

had received all the information regarding the treatment and the possible alternative treatment through a personalised informed consent form. The implant insertion axis has been planned for the best functional result of the prosthesis. A customised dental resin holder was created to support the laser scanner handpiece intra-orally, in the correct position according to the insertion axis of the implant. Local anaesthesia was administered using articaine (1 : 100,000). A full-thickness incision was performed using an Nd:YAG laser (1,064 nm wavelength; 200 µm diameter fibre; MSP: 3 W, 70 Hz; LightWalker AT, Fotona) on the palatal paramedian line; two mesial and distal releasing incisions were also performed without involving the papillae (Fig. 2). The access flap was then reflected with a Prichard elevator (Fig. 3).

An Er:YAG laser with a wavelength of 2,940 nm (LightWalker AT) equipped with a laser scanner handpiece (X-Runner, Fotona) was used (Fig. 4). The laser parameters used were 380 mJ and 20 Hz, delivered with a super-short pulse (50 microseconds). An external source of sterile saline solution stored at 5 °C in a refrigerator was used, and the saline was delivered via a peristaltic pump to promote photothermal ablation and to reduce the temperature in the surgical site. The scanner allows one to program and precisely perform a circular osteotomy of 3.5 mm in diameter, the same diameter as the implant manufacturer's final drill. During the osteotomy, the insertion depth was checked using a millimetre probe, until the preset depth of 12 mm was reached. The author prefers to place implants 2 mm deeper sub-crestally to prevent angular resorption and to manage the emergence profile of the prosthesis more effectively. A tapered screw implant made of Grade IV titanium and with a sandblasted and acid-etched surface (HELI, IDC) was inserted. It had a maximum diameter of 4.2 mm on the external thread and a length of 10.0 mm. Once inserted, the implant stability quotient (ISQ) was determined using the Osstell handpiece (Osstell; Figs. 5 & 6). The flap was sutured (Fig. 7), a postoperative radiograph was taken (Fig. 8), and after five days, the sutures were removed. At that time, the patient was asked to assess the postoperative pain he had experienced by assigning a numeric value of between 0 and 10 on a verbal numeric scale.

Results

The total clinical time for preparing the osteotomy was approximately 7 minutes. The implant had a high primary stability value at the time of insertion: the ISQ score measured in the buccolingual direction was 84 and the score measured in the mesiodistal direction was 81. The reported numeric value of postoperative pain was 1. At the second stage of the implant treatment, which was performed after 40 days, new ISQ values of 84 buccolingually and 82 mesiodistally were determined. After three months, the values had increased to 86 buccolingually

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and 84 mesiodistally. The radiographic control image taken after eight months of loading showed complete osseointegration of the implant with very good healing of the bone around the neck of the abutment (Fig. 9).

Discussion

The Er:YAG laser technology used in this study allowed a reduction of bone preparation time compared with the laser system used previously. Also considering the absence of pauses needed to replace the drills, the total time for preparing the osteotomy was very close to that of the conventional method.[7] However, there are other advantages of using a laser for preparing osteotomies. Besides a comparable preparation time, the higher energy delivered through a tipless stabilised laser scanner handpiece to the target, with a super-short pulse and efficient water spray, reduced the minor thermal damage to the bone cells adjacent to the osteotomy site and avoided the smear layer typically associated with conventional drill preparation.[8,9] This could reduce the time necessary for osseointegration.[10] The laser site preparation is very precise and compatible with different implant geometries, owing to the absence of micro-movements and skidding induced by the impact of drills on the bone, especially for large-diameter final drills.[11] Such a scanner technology is of major significance for developing laser use in implantology further, as it allows osteotomies of different sizes and shapes (circular and possibly oval) to be created with very high precision and compatibility with new implant geometries.

The ISQ score analysis used in this clinical study reports the values of resonance frequency analysis using the Osstell handpiece. The scale of values ranges from 0 to 100, and the lowest threshold value for single implant loading, even in cases of immediate placement, corresponds to 70. This is the only non-invasive method accepted by the international scientific community for clinical evaluation of osseointegration.[12–15] In the clinical case described in this article, the high primary stability value increased postoperatively over the course of 40 days, indicating the absence of bone damage during the laser procedure and that cell healing had started promptly and successfully. Indeed, erbium laser bone irradiation has been reported to increase release of bone morphogenetic protein, suggesting quicker osseointegration and stability as a result.[16] Among the other advantages of laser osteotomy preparation, the lack of contact, vibration and pressure made for a more comfortable experience for the patient during the intervention. Finally, the immediate postoperative period, as reported by the patient, was free of pain and complications.

Conclusion

This first clinical case highlights the many advantages of the use of the Er:YAG laser to perform an implant osteotomy without drills. The absence of postoperative pain and complications and the very high value of primary implant stability described in this case report suggest that the use of an Er:YAG laser and a dedicated laser scanner handpiece is a viable treatment alternative for creating osteotomies. These positive results support the realisation of a pilot study with a greater number of implants.

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Dr Norberto Berna graduated in Medicine and Surgery and specialised in dentistry and stomatology. He holds an MSc in Odontology and Forensic Science. Since 1987, he has been working in his private office with lasers of different wavelengths. He holds three patents and is frequently invited to speak at international conferences. He is a joint scientific coordinator of the master's degree in laser dentistry at the Università Cattolica del Sacro Cuore in Rome in Italy. Between 2012 and 2018, he was an adjunct professor at the University of Genoa in Italy.

Dr Giovanni Olivi graduated cum laude in Medicine and Surgery (MD) and in Dentistry (DDS) from universities in Rome. He obtained a postgraduate diploma in laser dentistry from the University of Florence in Italy in 2002 and master status from the Academy of Laser Dentistry in Coral Springs in Florida in the US in 2009. Since 2007, Dr Olivi has been a contracted professor and a joint scientific coordinator of the master's degree in laser dentistry at the Università Cattolica del Sacro Cuore. He is the author of over 70 peer-reviewed articles, several chapters in dentistry textbooks and four books on laser dentistry.

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