X-Runner Er:YAG dental laser application

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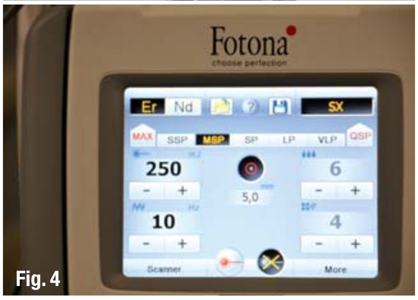

Fig. 1_Tooth sample for optical microscope and SEM observation.
Fig. 2_LightWalker AT dental laser.
Fig. 3_X-Runner handpiece.
Fig. 4_X-Runner settings screen.

_Introduction

The notion of utilising laser technology in conservative dentistry was proposed in 1990 by Hibst and Keller, who introduced the possibility of using an Er:YAG laser as alternative to conventional instruments such as the turbine and micro-motor.[1,2] Widespread interest in employing this new technology stems from a number of significant advantages, as described in several scientific studies. Thanks to the affinity of the Er:YAG laser wavelength to water and hydroxyapatite, laser technology allows for efficient ablation of hard dental tissues without the risk of micro- and macro-fractures, as have been observed with the use of conventional rotating instruments.[3-5] The dentin surface treated by laser appears clean, without a smear-layer, and with the tubules open and clear.[6]

Thermal elevation in the pulp, recorded during Er:YAG laser irradiation, is lower than that recorded by using a turbine and micro-motor with the same conditions of air/water spray.[7,8] This wavelength also has an antimicrobial decontamination effect on the treated tissue, which destroys both aerobic and anaerobic bacteria.[9] The most interesting aspects of this new technology are related to the goals of modern conservative dentistry, i.e. minimally invasive treatments and adhesive dentistry. Er:YAG lasers can reach spot dimensions smaller than 1 mm, which enables a selective ablation of the affected dentin while preserving the surrounding sound tissue to produce highly efficient restorations.[10] Several *in vitro* studies have demonstrated that the preparation of enamel and dentine by Er:YAG laser, followed by orthophosphoric acid-etching, enhances the effectiveness in terms of reduced microleakage and increased bond strength.[11]

To understand the role that a scanner can perform in dental treatments, it is useful to take a comparative look at the field of aesthetic medicine. The Er:YAG laser has been used for many years in the field of dermatology, where it is employed for the vaporisation of lesions such as condyloma, naevi, warts, mollusca contagiosa, as well as for the treatment of keloid scars and wrinkles with so-called laser "resurfacing".[12] For many years, scanners have proven highly effective in dermatological treatments, enabling high-precision surface treatments without overlapping or under-coverage of the laser treatment area.

The aim of our study, which began several years ago, has been to evaluate the possibility of transferring the same type of scanner technology that is widely utilised

Fig. 5_a) During laser-scanner conditioning; b) After the enamel preparation for brackets with the scanner; c) Brackets bonding completed.

in dermatology to the dental field. The first *in vitro* tests were performed on extracted teeth by using a scanner and a dermatological Er:YAG laser. Because of the fact that this particular dermatological device operates without water, it was necessary to modify it by adding a double external pipeline in order to deliver an air/water spray at the point of the laser's impact on the tooth.

The results of this first sequence of tests were very promising and convinced the manufacturer Fotona to invest in a major research and development effort to construct a scanner handpiece of reduced size, able to be employed intra-orally. Once developed, the new dental-optimised scanner was given another series of "*in vitro*" tests, and after the safety of its utilisation was demonstrated via K-thermocouple records, optical microscope (Fig. 1) and SEM observation, it was subsequently applied to in vivo tests on human subjects.

_Material and method

The laser appliance used was a LightWalker (Fotona, Fig. 2). The scanner handpiece is similar to the usual non-contact Er:YAG laser handpiece. The scanning mechanism is integrated inside an ergonomic box that lies on the operator's hand, with a supplementary electrical cable delivering the digital information from the laser device to the scanning mirrors (Fig. 3). Its application is the same as with the usual non-contact handpiece; the only difference is that it covers a bigger area than the standard handpiece. However, it is useful because it can cover a larger area, or, by pressing the button on the screen, it can be used as a classical one-spot laser handpiece. The scanner handpiece can thus be used for all kinds of treatments by switching from the scanner modality to classic handpiece modality, without swapping handpieces.

The following settings are available for the scanner handpiece on the touch screen (Fig. 4):
- scanning of the area shape (circular, rectangular, hexagonal),
- size of the scanning area (width and length of the rectangle, diameter of circle and hexagon),
- number of scan passages (a function of the requested ablation depth),
- delay between consecutive scans (duration of the pause between scans).

Moreover, all parameters available with the classic handpiece (energy, frequency, mode, spray) are also used with the scanner handpiece. By reducing one of the sides of the rectangular shape, it is possible to obtain a linear cut without moving the handpiece, for instance to cut the root apex during endodontic surgery or to perform an incision in soft tissues surgery.

In this preliminary study, clinical applications are shown below which illustrate this new Er:YAG laser technology.

_Case 1: Enamel laser conditioning for orthodontic bracket bonding

The employment of an Er:YAG laser to prepare the enamel for improving the strength of adhesion of composite resins has been proposed by several authors in conservative dentistry as well as for bracket bonding in orthodontics.[13] Several studies, based both on traction and microleakage tests, have shown that the best values were obtained with samples irradiated by an Er:YAG beam before acid etching.[14] Additionally, an "*in vitro*" study on extracted human teeth demon-

Fig. 6_a) Enamel lesions in the right upper lateral incisor, canine, and the first premolar; b) During scanner treatment; c) After the scanner ablation of enamel lesions; d) After the complete treatment.

Fig. 7_a) Damaged frontal teeth crowns; b) During scanner ablation of enamel; c) After the scanner ablation of dental tissue; d) After bonding a coat of composite resin.

strated that preparation by Er:YAG laser alone also gives a stronger adhesion than orthophosphoric acid alone.[15] Moreover, other authors have underscored these results when using lasers to prepare enamel surfaces to make them more resistant to decay.[16] This is possible because of the modification of hydroxyapatite crystals, which is important in the prevention of decalcification zones around brackets, particularly in patients with scanty oral hygiene.[17] Another advantage of laser utilisation is the ability to prepare a very small surface area of enamel, exactly of the same dimension of the bracket. We initially proposed a technique based on the use of a plastic template with rectangular windows designed to limit the irradiated area. Now, by using the scanner handpiece, the procedure is faster, easier and more precise.

The case described presents a 14-year-old female receiving orthodontic fixed treatment of the upper arch. The parameters used were determined by SEM observation in order to give the best enamel conditioning coupled with the minimal ablation: 55 mJ, 8 Hz, MSP mode, 4/6 air/water spray. The dimension of the ablation area was 2.5 x 3 mm and the number of passes was 10, once for each tooth.

_Case 2: Treatment of amelogenesis imperfecta spots on permanent incisors

The term amelogenesis imperfecta is defined as a diverse group of hereditary disorders that primarily affects the quantity, structure, and composition of enamel.[18] In the hypomature type, the affected teeth exhibit mottled, opaque white-brown or yellowish discoloured enamel, which is softer than normal. The hypocalcified type shows pigmented, softened, and easily detachable enamel, while in the hypoplastic type, the enamel is well mineralised but the amount is reduced.[19]

In our daily practice, we have worked with several young patients exhibiting zones of discoloration in their frontal teeth and who needed treatment to improve the aesthetics of their smile. Due to the impossibility of treating these cases with classical bleaching techniques, it was necessary to ablate the affected zones and to fill the cavities produced with composite resins. We have already described the use of the Er:YAG laser in this type of case as a good example of minimally invasive dentistry[20] but the use of the scanner improves the precision of the ablation even further by programming the extent and depth of the zone in advance.

The case presented concerns an 18-year-old male who had enamel lesions in the right upper lateral incisor, canine, and the first premolar. The treatment was performed without anaesthetics, with a total laser irradiation time of 186 sec. For this case we used the following parameters: 250 mJ, 10 Hz, MSP mode, 4/6 air/water spray. The ablation area was a 3.5 mm diameter circle and the number of passes was 15.

_Case 3: Direct composite veneering of permanent incisors

In cases concerning damage to the frontal teeth crowns from a number of possible causes, i.e. traumas or bruxism, and if the patient does not wish to choose a prosthetic option, the solution is to ablate a portion of the enamel and to directly bond a coat of composite resin. The role of the Er:YAG laser in improving the

Fig. 8_a) Old composite on tooth 34; b) During scanner ablation; c) Immediately after scanner treatment; d) After the complete treatment.

adhesion of resin to enamel has been well demonstrated[21,22] and the advantage with the use of a scanner handpiece is the possibility to limit the volume of ablated dental tissue. The case presented regards a 64-year-old male who needed repair of his upper incisors. The treatment was performed without anaesthetics, with a total laser irradiation time of 253 sec. The parameters used were: 300 mJ, 10 Hz, MSP mode, 4/6 air/water spray. The ablation area was a 4.5 mm diameter circle, the number of passes was 15.

_Case 4: Aesthetic re-treatment of an aging composite restoration

In some cases, composite restorations may present discolorations and spots after a number of years, particularly in patients who do not observe an adequate level of oral hygiene. The vestibular face of the frontal teeth or the cervical area of the premolars may pose a problem, from an aesthetical point of view, and this is the reason why several patients have come to our offices to regain a pleasant smile. The Er:YAG laser may be very helpful in this situation; in fact, because of its wavelength (2,940 nm) it is well absorbed by Glycidyl methacrylate (GMA) and Silicon Dioxide, two important components of composite. It is very effective in the ablation of old restorations without thermal elevation[23] and can produce a rough surface, very difficult to obtain with orthophosphoric acid, which is able to bond the new coat of resin.

The case presented here involves a 55-year-old female with an aging infiltrated and spotted cervical restoration on tooth 34. The treatment was performed without anaesthetic. The parameters used were: 250 mJ, 10 HZ, MSP mode, 4/6 air/water spray. The ablation area was a 4 mm diameter circle and the number of passes was 15 for two times.

_Discussion and Conclusion

Laser technology was introduced in dentistry by Goldman in 1967.[24] Since that time, a continuing effort has been made by clinicians, researchers and companies to improve the results of clinical treatments. The introduction of Er:YAG in 1990 provided the option to also treat hard tissues, and this technology was further improved through greater control of pulse duration (VSP—variable square pulse technology).

The recent introduction of a scanner handpiece enabled a higher precision of irradiation and depth of ablation as well as reduced treatment time, allowing laser technology to more fully realise the vision of "minimally invasive" conservative dentistry._

Editorial note: A list of references is available from the author.

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