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CASE REPORT
Clinical Experience with a Quantum Square Pulse (QSP) Er:YAG Laser

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ABSTRACT

Lasers in everyday dental practice are getting more and more popular since the introduction of the Er:YAG laser for hard-dental tissue preparation in 1992. Patient acceptance of the procedure due to the painless and quiet mode of operation of laser devices are just some of the advantages which contribute to the decision of dental professionals to add a laser to their clinic. Versatility combined with greater precision and shorter procedure times, in addition to preserving or improving the cost-effectiveness of the procedure, is expected of the latest generation medical laser devices.

An important advancement in the field of Er:YAG laser technology was recently introduced in the form of the Quantum Square Pulse (QSP) operating modality (Fotona, Slovenia).

In this paper, we present several clinical cases from everyday dental practice, demonstrating the efficiency and versatility of QSP technology.

Key words: Er:YAG laser, cavity preparations, clinical case, quantum square pulse, QSP.

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I. INTRODUCTION

Er:YAG lasers are setting new standards in the concept of patient care [1,2]. In comparison to classical tools (e.g. burrs or scalpels), a dentist is able to perform a much wider range of treatment protocols with greater precision and control. The progress made in the development of dental lasers has been rapid in the last decade [3,4]. One of the recent advances in Er:YAG laser technology is the introduction of the proprietary Quantum Square Pulse (QSP) technology. In QSP mode, a longer laser pulse is divided, i.e. quantized, into several short pulses (pulse quanta) that follow each other at an optimally fast rate. This, in turn, enables the QSP mode to deliver short, low-energy pulses while retaining the efficiency of long-duration, higher energy laser pulses as well as the efficiency and precision that is provided by short-duration pulses. One of the major advantages of the QSP mode is that it significantly reduces the undesirable effects of laser beam scattering and absorption in the debris cloud during hard-tissue ablation. The cavities made with the QSP mode are sharp and well defined, and with minimal thermal effects at the edges of the cavities [5, 6].

In this paper we present five photo-documented clinical cases from everyday clinical practice performed with the new QSP mode.

II. CASE DESCRIPTION

Patients with chronic and acute conditions were included in this case report, all taken from everyday practice. All were treated from the middle of 2011 to the first quarter of 2012. All patients signed informed concent forms after reading the explanation of the procedures to be performed with the Er:YAG laser, and permitted our team to make pre-, intra- and post-op pictures. Anesthesia (Dentocaine 40/0,01 mg/ml – Inibsa laboratorios) was used only in a single case, because of anxiety and the possibility of reaching the pulp of the tooth.

All treatments were performed with a Fotona LightWalker AT laser (Fotona, Slovenia). Prior to the beginning of the treatment, the effects of the Er:YAG laser treatment, benefits and possible risks and complications were explained in understandable terms to every patient. Laser safety rules were strictly observed by the LSO (dr. Evgeniy Mironov) during the treatments.

A focusing (non-contact) handpiece H02 (beam spot size in focus: 0.6 mm) was used for the enamel and composite preparation. For surface modification in dentine, the H14 handpiece with a cylindrical tip 0.8 mm diameter was used. The R17 handpiece was used

for teeth whitening. QSP mode was used for all preparations and surface modification. In some cases, we used MSP for comparison, when multiple preparations were necessary. Pulse energy used varied from 120 mJ to 500 mJ, with repetition rates ranging from 10 to 15 Hz.

The composites used for fillings, bonding and bleaching materials were supplied especially for the study by Voco (Cuxhaven, Germany).

The parameters shown in these cases are subject to modification according to patient sensitivity and the specifics of the target tissue, but constants which guarantee a cold ablation regime, such as power density, time of exposure and proper water supply, should be observed at all times.

a) Clinical case No. 1

A 26-year old female patient visited the clinic with complaints of progressive abrasion and discoloration of the masticatory surfaces of her teeth, as well as transitive hypersensitivity to thermal irritation and sweets. She's not vegetarian, denies bruxism, bulimia or diets. During examination, a light-to-moderate abrasion on the occlusal surfaces of the premolar and molar teeth in the upper and lower jaws were observed, along with insufficient contact between the second molars and premolars (see Fig. 1). The decision was to made to perform a minimally invasive preparation for a selective adhesive restoration of the damaged sections with the purpose to normalize the chewing function and sensitivity and to improve the aesthetics.

Fig 1: Lower molar before the treatment (Case 1).

The dentin surface modification was done with standard SSP parameters, and the QSP mode was used for enamel (see Fig. 2). In the lower molars no cavities were formed, only surface modification was performed with light-cured composite Grandioso Heavy Flow (Voco) – flow nanohybrid specific. With its high percentage of filler content – 83% W/W and 68 V/V, it is strong enough for restoration of the occlusal parts in a thin layer and has a high enough viscosity to fill the very fine micro-rough surface left after the laser etching. This material is available in new colors like A5 and A3 (25 added to the standard shade range) and enables highly aesthetic restorations with a minimally invasive preparation. For the bonding system, Futurabond M – one bottle of 7th generation self-etching bond was used. The clinical situation after the treatment is shown in Fig. 3.

Fig 2: Parameter settings for enamel modification (Case 1).

Fig 3: Lower molar after the treatment (Case 1).

The first upper session treatment was to change the filling on tooth 16. Nanohybrid Grandioso (Voco) with liner Calcimol LC (Voco) and Grandioso Heavy Flow (Voco) were used. For removal of the residual composite of the old filling, the parameters were set to QSP, 500 mJ, 12 Hz, and for the dentine preparation to QSP, 160 mJ, 15 Hz. QSP pulses make the preparation faster and more precise in comparison to MSP. The QSP mode is very suitable for the removal of secondary and chronic caries which are not so rich in internal substrate water like acute caries. In deeper zones the risk of thermal damage because of insufficient water inflow is also avoided by the use of the QSP mode. This clinical preparation was done without anesthesia, and the patient didn't show any signs of discomfort or pain. (Fig. 4)

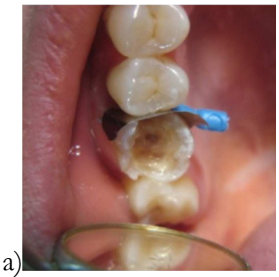
a)  b) 

Fig 4 a) Tooth 16 after the preparation with QSP; b) Tooth 16 after complete restoration (Case 1).

The upper teeth session continued with therapy for tooth 26. A deeper abrasion was made on the filling, thus making a fresh and sterile surface for changing only it's occlusal part. QSP mode was used for the composite preparation with 300 mJ /15 Hz, water and air spray. Grandioso Heavy Flow with the same bonding system was used for adding a new layer of composite and improving the function and aesthetics (see Fig. 5). On the 5th day post-op check-up, the patient reported a significant improvement of chewing ability and the disappearance of hypersensitivity. On the 6th month check-up, new pictures were taken, proving the stability and functionality of the restorations.

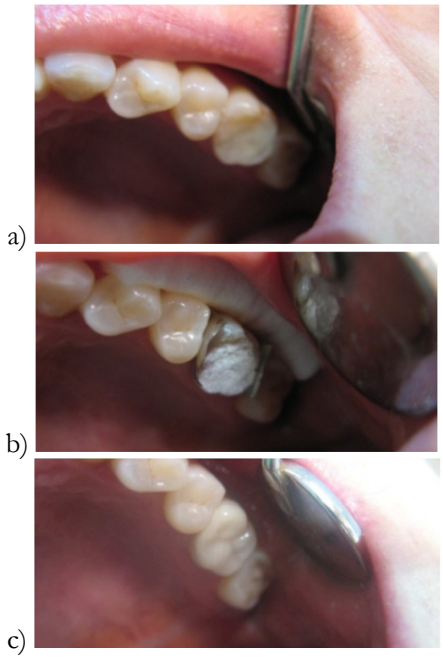


Fig 5: a) Tooth 26 before the treatment; b) Tooth 26 after the preparation with QSP; c) Tooth 26 after complete restoration (Case 1).

b) Clinical case No. 2

This is a clinical case with a complex treatment for improving the smile aesthetics with bleaching and bonding. The patient came in the office and asked for the Fotona TouchWhite™ teeth whitening procedure [7] after hearing the recommendation of her friend, who had already been treated with this novel method.

After the initial check-up and discussion of options, the patient decided for a bleaching procedure (see Fig. 6), and after one week – the replacement of her existing direct-made composite veneers due to their unsatisfying shape and discoloration.

The bleaching was performed in one session with two applications of 35% hydrogen peroxide gel – Perfect Bleach Office + (Voco) – according to the Fotona TouchWhite™ protocol (R17 handpiece, 40 mJ/10 Hz, 20 seconds per tooth, 3 times on each application of the bleaching gel). No sensitivity was reported by the patient during the procedure, and the teeth were slightly sensitive only on the same day. The main reason for the lower sensitivity with the Fotona TouchWhite™ procedure is that the Er:YAG laser light activates the gel only, and heat diffusion into tooth structures is negligible. The peroxide gel also stays on the teeth for only a very short period of time.

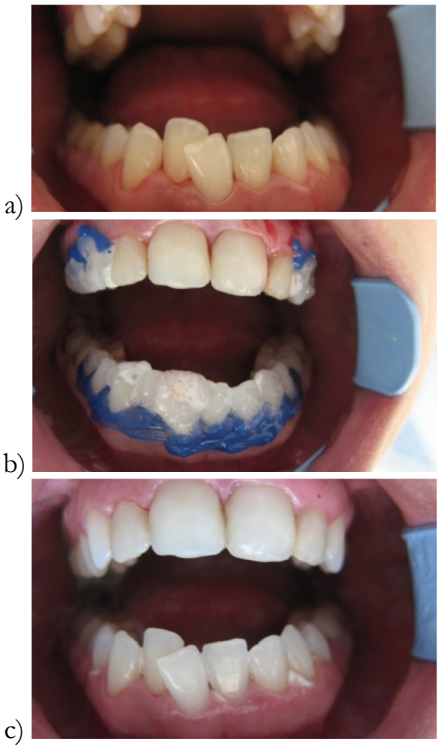


Fig. 6: a) Clinical situation before the treatment; b) During TouchWhite™ treatment. Upper four teeth are not bleached because of composite veneers; c) Clinical situation after TouchWhite™ (Case 2).

One week later and after precise investigation of the tooth position and existing veneers, a decision was taken to keep the enamel untouched and to work in the previous composite, which had been placed 2 years prior, and aside from aesthetic factors was not compromised. The ablation was started with QSP, 150 mJ, 12 Hz – higher settings than for surface modification in enamel/dentine because in this case more volume than in laser-etching procedures needed to be removed (Fig. 7a). According to the material's response, the energy was raised to 180 mJ and in areas with a thicker layer of the existing composite, the frequency was increased to 15 Hz. In QSP mode the effect of changing the energy or repetition rate is more notable than in MSP preparation modes – this helps to work more quickly with the same precision. The preparation took 1.5–2 minutes for each of central incisors and one minute each for the laterals.

After placing the rubber dam, direct adhesive restorations were made with a layer of Grandioso Heavy flow (Voco) to establish a strong and uniform connection between the two kinds of composites. A brush was used to homogenize the material, and after curing the flow material, the final shaping was done with Grandioso B1. Finishing and polishing were performed with the Dimanto (Voco) polisher set. After a total time of one hour and a half, the patient was satisfied with her new look and felt relaxed after the painless procedure.

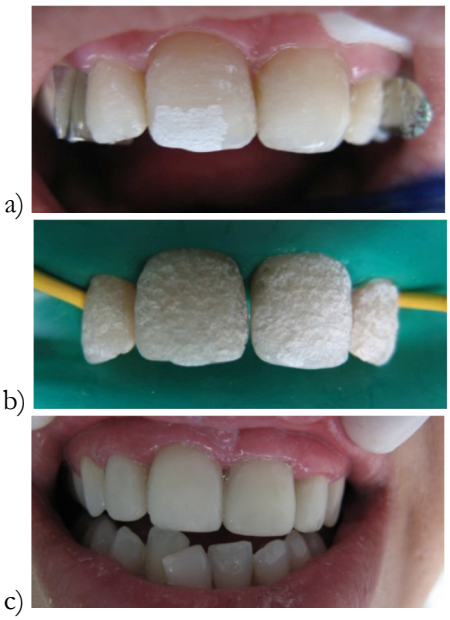


Fig 7: a) Removal of old composite veneer with QSP mode; b) After complete surface preparation; c) Clinical situation after complete direct restoration (Case 2).

c) Clinical case No. 3

A 56 year old woman, a regular patient of the clinic, wanted to make a aesthetic correction to the cervical area of tooth 14 (previously root-canal treated). Gingival hypertrophy was observed and tooth-brush erosion of enamel was present (see Fig. 8).

Fig 8: Clinical situation before the treatment (Case 3).

Hard-tissue ablation was started in QSP mode, marking the borders of the preparation (for parameters, see Fig. 9a). The absence of carious tissue allowed for working superficially, with the aim to provide good micromechanical retention and bond strength due to hard-brushing habits. As seen on Fig. 9b, the margins of the preparation are well defined and clearer than would be obtained with other modes of preparation. Standard settings for gingivectomy were used for shaping the gum; only for the final resurfacing was water added to make a smoother appearance of the gingival tissue (Fig. 10).

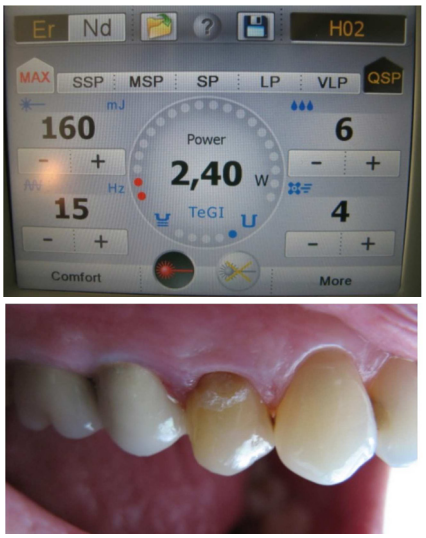


Fig 9: a) LightWalker settings for marking the borders; b) Border is marked by QSP mode (Case 3).

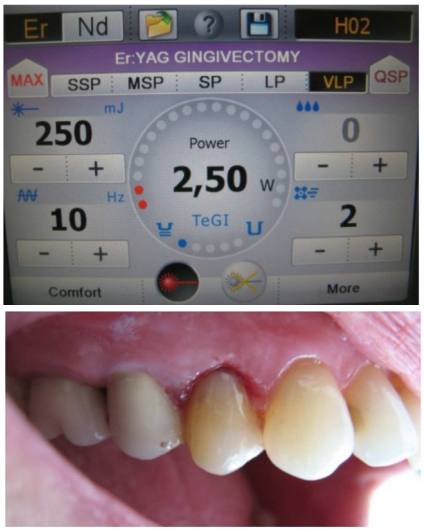


Fig 10: a) LightWalker settings for gingivectomy; b) Clinical situation after gingivectomy and filling. (Case 3)

The filling was made with flow composite only (Grandioso Heavy flow – Voco) and without isolation of the gum since the coagulation was good and no bleeding occurred during the filling procedure. The whole treatment procedure was performed without anesthesia and the patient didn't report any pain or discomfort. A control picture was taken one week later, showing perfectly healed tissue in the vestibular site with a nice contour and no sign of inflammation – as well as no complaints from the patient (see Fig. 11).

Fig 11: Clinical situation one week after the treatment shows excellent healing of the gum and a nice aesthetic result (Case 3).

d) Clinical case No. 4

The patient was a 30-year-old man who reported hypersensitivity to cold liquids and mechanical irritation in the region of the lower premolars after using a rotating electric tooth brush for a long time. Starting with the LightWalker laser's preset mode for surface modification, a slightly deeper ablation in the dentine was achieved using QSP mode. The gums were healthy allowing for work to proceed without isolation cord and still keep the gingival tissues untouched. Good focus and a strictly directional laser beam allowed the preparation to be finished this way in less than 20 seconds for both teeth. The restorations were made with flow composite. Light gingival bleeding around tooth 44, which is seen in Fig. 12, was caused by polishing. This case clearly shows how fast and accurate work can be achieved using QSP mode.

a)

b)

Fig 12: a) Clinical situation on both premolars before the treatment; b) Clinical situation after surface modification with QSP mode and filling with flow composite (Case 4).

e) Clinical case No. 5

A 23-year-old male patient, with deep cervical caries on tooth 45, was afraid of dental procedures and asked for anesthesia. A fast procedure was required, so the parameters were set to QSP, 500 mJ, 12 Hz. The first step of the preparation was done in 5 seconds. Just after 5 seconds, deep carious dentine was reached, so the energy was decreased to 300 mJ, but to be fast enough the frequency was increased to 15 Hz. Another 5 seconds were enough to finish the preparation (see Fig. 13). After placing the haemostatic cord (#8, Pascal Co. USA), Calcimol LC (Voco) was used as a liner, covered with Grandioso Heavy Flow and finally filled with Grandioso.

a)

b)

c)

d)

Fig 13: a) Clinical situation before the treatment; b) LightWalker screen during the treatment; c) The situation just after the treatment with QSP mode showing completely untouched gingiva, even though high energy was used for the treatment; d) Clinical situation after final restoration (Case 5).

III. DISCUSSION

QSP mode appears to be a method of choice when requiring a fast, precise and minimally invasive method which yields excellent results. None of the patients reported subsequent sensitivity and their gums healed well. A one week post-op vitality test with electro-stimulation returned normal values. Where the TouchWhite™ teeth whitening procedure was used,

transitory hypersensitivity was observed in the evening right after the procedure, but didn't require any additional intervention with analgesics.

Clinical benefits from the new QSP mode are easily recognizable. The margins of preparations for fillings or for surface modification are clearer and sharper than with any other operational mode used to date. This is of primary importance when working close to the pulp or near the gingiva. QSP is also a safe and reliable mode in class II cavity preparations where the neighboring teeth should be kept intact.

As well as being an optimal mode for procedures that require high finesse (i.e. tissue treated with high spatial precision and with small or moderate pulse energy and short-duration laser pulses at high repetition rates), the QSP mode also guarantees a high speed with the procedure. For example, in a separate ongoing study, the preparation with QSP was faster when compared to a green coded diamond bur (Kavo Gentlesilence Lux 8000 B, Meissinger, Germany).

Speed of preparation is important in pediatric dentistry and with anxious patients, and QSP mode is the method of choice if we require short preparation times without sacrificing finesse. We also observed that the noise level generated with this mode is lower than in other currently available laser operating modes, which notably increases the level of comfort of the procedure for both the patient and the operator.

IV. CONCLUSIONS

In all clinical cases, QSP mode excelled in preparation of dental hard tissues. Working in QSP mode allows the dentist to perform procedures with an unprecedented level of finesse without sacrificing speed, and with the added advantage of decreasing the noise level of the procedures.

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