

# Er:YAG caries treatment according to minimally invasive therapy

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**Main MiCD principles** are based on the following five rules:

1. "The-sooner-the-better"—Early diagnosis of illness or the cavity allows minimising the need of invasive treatment in the future.
2. Smile Design Wheel—the procedure taking into account the psychological, health, functional, and aesthetic situation of the patient.
3. "Do-no-harm"—One should choose therapeutic methods which saves healthy tissues of teeth to a maximum extent.
4. "Evidence-based approach"—The choice of materials and instruments should be based on the results of scientific research.
5. "Keep-in-touch"—more attention should be paid to regular check-ups and examining the patients carefully, explaining to them why this is so important.

Tooth decay is one of the most prevalent infectious diseases, and continuous progress of knowledge, development of new techniques of treatment in the early stages cause that physicians face new challenges and opportunities.

Currently, the patient also expects from the clinician an interdisciplinary, innovative and minimally invasive approach. Over the years, a significant change of the approach of surgical treatment for so-called biological treatments has been made. Biological treatment presupposes the elimination of bacterial infection (by the use of ozone or laser, for example) and impermeability of fillings, relying on the adhesion properties of the restorative materials. This concept is also based on the selective removing of the decayed tissues without unnecessary preparation of healthy tissues surrounding the defect.

Thus, the concept of minimally invasive therapy and early diagnosis correlate with the innovative idea of treatment involving laser techniques.

In conservative dentistry, in order to prepare decayed hard dental tissue and replace dental fillings, high-energy Er:YAG laser is used.<sup>2</sup> Er:YAG eliminates many harmful experiences of the patient (vibration, overheating of the tissues during preparation, unpleasant sound)<sup>3</sup>, introducing him/her to a new dimension of treatment. No pressure occurs, as unpleasant experiences of the patient are fully eliminated, and thus, the patient is motivated to further cooperation. Moreover, pain sensation is limited. In the case of Er:YAG laser, there is very short pulse duration and nerve endings are often not stimulated.

In many clinical trials, limited use of anesthetics was reported and full acceptance of this therapy method by the patients was demonstrated. The technique of laser preparation of the cavity allows performing the procedure painlessly, or with a mild pain sensation (NRS—Numerical Rating Scale <3) for profound tooth decay in 59.8%, and medium tooth decay—at 94.8%.<sup>5</sup>

The use of laser technology in restorative dentistry refers to the action scheme described below. Er:YAG laser radiation at 2,940 nm is preferably absorbed by water and hydroxyapatite. This process of a non-thermal nature is based on "evaporating" the tissue by short light pulses of high energy (photoablation). The key role is played by the water molecules incorporated in the crystalline structure of the mineralised tooth tissue. Water, activated by the supplied energy, is converted into steam, and the pressure within the mineral structure of teeth increases rap-



Fig. 1

**Fig. 1:** Laser screen. The parameters of Er:YAG laser: H14/conical tip, QSP, 0,90 W/90 mJ, 4 W/4 A.

idly, leading to microexplosion heard in the typical form of a short acute sound.<sup>6</sup> During work, a certain amount of heat is emitted, being dispersed together with the removed material. Only its small part is transferred to the surrounding tissue. This process, based on maximal reduction of the thermal effects, has been tested for more than 30 years, and still focuses on determining the most optimum parameters of the laser beam for minimally invasive work.<sup>7-9</sup> The thickness of the evaporated surface layer (the depth of ablation) depends on the tissue parameters (the depth of absorption of laser radiation, thermal conductivity coefficient, temperature diffusion coefficient, and heat evaporation coefficient), and the

laser beam parameters (wavelength, energy density and duration of the laser pulse).

At high energies and pulses of short duration the entire laser energy is consumed in the so-called cold ablation because ablation speed is higher than the speed at which the heat passes into the tissue. However, using too little energy and/or too long pulse duration leads to an increased heat transfer to the deeper layers of the tooth.<sup>10</sup> Thermal effects become more pronounced and therefore we are dealing with the so-called warm and hot ablation, bearing in mind that this is an undesirable phenomenon. In the precise and safe procedures of the therapeutic work



Fig. 2

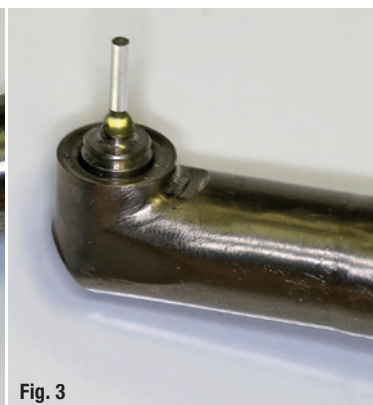


Fig. 3

**Figs. 2 & 3:** Tips dedicated to preparation of the cavity.



Fig. 4

Fig. 5

**Figs. 4 & 5:** Caries on tooth 47.

on hard tissues—both on enamel and dentin, it is recommended to work at energies and pulse durations that are significantly above the threshold value of ablation.<sup>11</sup> Moreover, efficiency and the safety level of work with the Er:YAG laser can be increased by spraying the water spray on the target tooth surface.<sup>12</sup> This also improves the efficiency of the cavities preparation. The radiation penetrates into the water molecules, causing the molecules vibrations to increase and therefore raising the pressure and temperature in the area of application, thus initiating the ablation process. Note, however, that a thick layer of water can cause the opposite effect— isolation of the laser beam from the tissue.

ization, resulting in a color change to soft bronze.<sup>11</sup> Properly prepared tissue has a microporous structure. A macroscopic view of cavity prepared with the use of drill shows its smooth walls, compared to the image of the ablation with Er:YAG laser, where the edges and walls of the cavity are of irregular shape.<sup>13</sup> After laser preparation, we get the characteristic view of craters with smooth walls with no carbonised areas, pre-melted enamel and dentin, or the smear layer. Surface of the enamel obtains micro retention structure, enamel prisms are clearly recognizable, dentine tubules are open and free from the smear layer, allowing the bonding material to penetrate deeply and enhancing the adhesion of the composite material to the cavity walls.<sup>14-16</sup> Er:YAG laser operating speed depends not only on the laser beam parameters and the operator's skills,

**Figs. 6-8:** Cavity of 47 and 48 healed.

Preparation of tissue without water can lead to raising their temperature, causing surface carbon-



Fig. 6

Fig. 7

Fig. 8

but also on the tissue's chemical composition. The enamel contains 95 per cent of hydroxyapatite ( $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$ ), 4 per cent of water and 1 per cent of collagen fibres. Dentine consists of 70 per cent of hydroxyapatite, 20 per cent of collagen fibres and 10 per cent of water.<sup>17</sup> Decayed tissue contains more water than healthy tissue.

The above information suggest that the speed of Er:YAG laser preparation of dentine is higher than of enamel, and diseased tissue is more easily removed than healthy tissue. This should be kept in mind during the cavity preparation, in order to safely and consciously control the scope of the cavity according to the concept of minimally invasive therapy. The light of laser shows antibacterial properties, and it acts through overheating and disruption of bacteria cell.<sup>18</sup> Er:YAG laser is a promising tool for the cavity preparation in primary teeth due to the reduction of pain perception and antibacterial effect.<sup>19</sup> The contraindications to the use of Er:YAG laser are cutting crowns and the removal of amalgam fillings. There are no restrictions on the removal of cement and composite fillings; however, in these cases, because of the modest speed, take advantage of the combined approach and use the turbine additionally. The big advantage of Er:YAG laser is its low invasiveness, which allows to work according to the concept of minimally invasive therapy.<sup>20-21</sup> Simultaneously, it is characterized by the efficiency and safety at work,<sup>22</sup> and is well perceived by patients.

## Clinical case

A 23-year-old, non-smoker, generally healthy patient visited the clinic. The following was reported in a clinical study: numerous carious focuses in the buccal grooves of 46 and 47, the primary decay on the occlusal surface of 47 and recurrent decay on the occlusal surface of 46. The patient reported no pain of these teeth. During the

preparation according to the concept of minimally invasive therapy, various techniques of Er:YAG laser application with the same parameters were used (H14 conical tip, QSP, 0.90 W/90 mJ/10 Hz, 4 W/4 A). The average caries in the buccal groove of the tooth 46 was prepared using a non-contact technique (head  $\text{H0}_2$ ). No pain during the preparation (NRS = 0). Deep caries in the buccal groove of 47 was prepared using a contact technique (head H14, cylindrical tip). Moderate sensation of pain during the preparation (NRS = 4). Deep caries on the occlusal surface of the tooth 47 was prepared using a combined method—a turbine (diamond drill) and Er:YAG laser (H14 head, cylindrical tip). During the preparation, severe pain was experienced (NRS = 8), infiltration anaesthesia was administered (Ubistesin forte 1/2 of ampoule) and the preparation was completed. Direct reconstruction of hard tissues of tooth was performed with the use of composite material (Gradia A3/NT).

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## Kurz & bündig

In ihrem Artikel beschreiben die Autoren die fünf Prinzipien der Kavitätenpräparation und Kariesbehandlung: 1) So schnell wie möglich, 2) Beachtung von physiologischen, gesundheitlichen, funktionalen und ästhetischen Faktoren, 3) Minimalinvasive Behandlung, 4) Evidenzbasierte Behandlungsansätze, 5) Regelmäßige Check-ups und Recall-Intervalle. Im Anschluss gehen sie näher auf die Kariestherapie mithilfe des Er:YAG-Lasers ein, der zur Preparation des betroffenen Hartgewebes für den Austausch dentaler Füllungen genutzt werden kann. Gleichzeitig zeigen sie die Vorteile der dentalen Lasertherapie auf: Schmerzreduktion aufgrund geringer Vibrationen und Wärmeentwicklung, kurzer Pulsdauer und der Vermeidung einer Stimulation der Nervenenden sowie eine Minimierung der für manche Patienten angstausslösenden Geräusche. Dies habe zur Folge, dass die Patienten stärker für die weitere Zusammenarbeit motiviert werden können. Neben umfassenden Erkenntnissen aus der Literatur führen die Autoren auch einen kurzen Fallbericht an, um die Vorteile der Er:YAG-Kariestherapie zu belegen.

Literature

