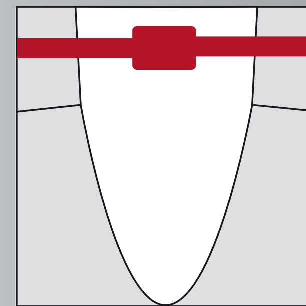
KIEFERORTHOPÄDIE
DIE ZEITSCHRIFT FÜR DIE PRAXIS



SPECIAL REPRINT

Clinical indications and application of lasers in orthodontics

The use of diode lasers in the practice

Sachin Chhatwani, Philipp F. Gebhardt, Björn Ludwig

VOLUME 31
MARCH 2017

1/17

QUINTESSENCE PUBLISHING


sirona
Dr. Müller
Gingivectomy
Perio. germ reduction
Endo. germ reduction
Sulcular debridement
Favorite 5
Favorite 6
STOP
SIROLaser Blue
sirona

Sachin Chhatwani, Philipp F. Gebhardt, Björn Ludwig

Clinical indications and application of lasers in orthodontics

The use of diode lasers in the practice

KEYWORDS *laser, gingivectomy, esthetics, frenectomy, orthodontics*

For nearly 30 years, various types of lasers have been used in dentistry; however, the use of lasers in orthodontics has not been as widespread. Different reactions occur when a laser beam strikes a biologic surface. Some of these reactions may be beneficial for dentistry. Indications for the use of lasers in orthodontics include enamel conditioning, debonding, light polymerization, soft tissue surgery, and biostimulation. In the field of soft tissue surgery, lasers are especially suitable for esthetic gingival corrections in the finishing phase of treatment, surgical exposure of teeth, frenectomies, and the excision of hypertrophic gingival tissue. This article provides the orthodontic clinician with the fundamentals of lasers, and illustrates the use of diode lasers in orthodontics through practical case studies.

Sachin Chhatwani
Dr. med. dent.
Witten/Herdecke University
Dental clinic
Orthodontics department
Alfred-Herrhausen-Str. 45
58455 Witten, Germany

Philipp F. Gebhardt
Dr. med. dent.
Biss45
Bismarckstr. 45
10627 Berlin, Germany

Björn Ludwig
Dr. med. dent.
Private practice
am Bahnhof 54
56841 Traben Trarbach, Germany
and
Polyclinic for Orthodontics
Saarland University
Homburg/Saar
Kirrberger Straße
66421 Homburg, Germany

Correspondence address:
Dr. Sachin Chhatwani
E-Mail:
sachin.chhatwani@uni-wh.de

Introduction

Light is an electromagnetic energy composed of photons that travel in wave form at the speed of light. A wave of photons is defined by two properties: the amplitude (height of the wave) and the wavelength (horizontal distance between two corresponding points on the wave). Ordinary light consists of different wavelengths and is unfocused and incoherent. Light created by a laser, however, possesses a single wavelength, synchronicity, and identical amplitudes. As a result, it is monochromatic and coherent. This type of electromagnetic energy can be used in various areas. Lasers were first used in dentistry in 1989[1].

If laser energy comes into contact with tissue, then, in principle, four interactions take place:

- Reflection = deflection of the beam with no influence on the target tissue.
- Transmission = penetration of the tissue with no influence on it.
- Scattering = as defined by a weakening of the beam with an accompanying transfer of thermal energy to the surrounding tissue.
- Ablation = thermal heating with subsequent deflagration due to energy absorption of the chromophores present in the tissue. A thermal influence that is too strong can lead to carbonization (charring of the tissue).

The primary chromophores in the intraoral soft tissue are melanin, hemoglobin, and water. In dental hard tissue, water and hydroxylapatite absorb the most laser energy. Chromophores possess a different absorption coefficient, meaning they have different absorption properties for different wavelengths. As a result, the correct laser must be chosen depending on the surgery. In dentistry, CO_2 lasers, neodymium lasers, erbium lasers or diode lasers are used first and foremost[1]. The term "laser" stands for "Light Amplification by Stimulated Emission of Radiation."

Manuscript
Received: 26/01/2017
Accepted: 04/02/2017

Types of lasers

There are three basic components to a laser: an active laser medium, an energy supplier (eg, flash light, electricity or an electric coil), and an optical resonator. The emission of photons occurs due to the energy supplied to the laser medium. This stimulated emission is amplified in an optical resonator. Using mirrors, the photons are reflected back and forth, and then subsequently leave through the resonator that is partially permeable on one side[2]. Lasers differ mainly in terms of their active laser medium, but also in terms of their size, weight, and price.

CO_2 laser

The wavelength is 10,600 nm and the active laser medium is a CO_2 compound. The CO_2 laser is the strongest gas laser. The greatest amount of absorption takes place through hydroxylapatite and water. This laser is therefore most suitable for the treatment of dental hard tissue and for soft tissue surgery[2].

For surgical interventions in soft tissue, care must be taken when acting in the vicinity of dental hard tissue due to the affinity to hydroxylapatite.

He-Ne laser

The He-Ne laser was the first gas laser. Its wavelength of 623.8 nm radiates in the visual red region visible to the human eye. Until now, this laser has been used mainly in the areas of biology, medicine, and physics[2].

Argon laser

Argon lasers work with a wavelength of 488 and 514.5 nm. Lasers that possess noble gases as an active laser medium are used in the area of soft tissue surgery and light polymerization. The wavelengths specified are absorbed particularly by melanin and hemoglobin[2].

Erbium laser

A distinction is made between two different erbium-doped lasers: Er:YAG and Er,Cr:YSGG. Er:YAG produces a wavelength of 2,790 nm and Er,Cr:YSGG produces 2,940 nm. Most of the energy is absorbed by water and hydroxylapatite. Erbium lasers are highly recommended for the treatment of dental hard tissue. For surgical procedures in soft tissue, they have no hemostatic effect[3]. Care must be taken when performing soft tissue surgery in the immediate vicinity of the teeth.

Neodymium laser

The laser energy from neodymium lasers (Nd:YAG) is absorbed by pigmented cells. As the emitted wavelength of 1,064 nm is hardly absorbed by dental hard tissue cells, neodymium lasers are ideal for soft tissue surgery[1].

Diode laser

Diode lasers have a semi-conductor as the active element and mostly produce wavelengths that range from 810 to 980 nm. The handpiece is fitted with an exchangeable glass fiber as the therapeutic light conductor. These lasers are used in particular for soft tissue surgery, as the wavelengths are absorbed by pigmented cells such as melanin, but to a lesser extent by hydroxylapatite and water in dental hard tissue[1].

More modern diode lasers can also create wavelengths of 445 nm (Fig 1). This is particularly advantageous since the maximum absorption of hemoglobin is lower than 600 nm[4]. Due to the high energy input in the hemoglobin cells, coagulation and hemostasis occur quickly. In contrast, there is very little water absorption in this range, and because of this a thermally limited impact on the tissue is achieved[5].

Due to their wavelengths, diode lasers are also used for biostimulation.

In comparison to other lasers, diode lasers are very suitable for orthodontic practices, given their size, price, and indications.

Caution

Wavelength-specific protective goggles must be worn when using most lasers in dental practice. This applies to the practitioner, the assistant, the patient, and to any other individuals located in the room while the treatment is carried out. According to regulations, there should be a clear label on the door and/or outside the room in which the laser treatment is performed to inform people that the room is a laser workplace. The authorities responsible must be informed before the laser is commissioned. If the operator cannot demonstrate specialist knowledge, then a qualified laser safety expert should be commissioned in writing.

Fig 1 Diode laser with three wavelengths: 445 nm, 660 nm, and 970 nm (Image source: Sirona Dental Systems GmbH, Bensheim).

Orthodontic indications

Enamel conditioning

Using erbium lasers can cause micro-irregularities and alterations, such as enamelization and recrystallization on the enamel surface[6,7]. This surface corresponds to a type III etching pattern according to Silverstone[7,8]. Basran et al also reported that the shear strength achieved is comparable to that achieved by conventional etching[7]. In contrast, it has also been stated that it would be expedient to re-etch conditioned enamel with an erbium laser in order to achieve a certain degree of shear bond strength[9].

The comparatively expensive use of erbium lasers currently makes their application in clinical practice unnecessary.

Debonding

Since the 1990s, lasers have been used experimentally to remove ceramic brackets[2]. Using neodymium lasers, debonding was achieved where the brackets could be dislodged due to the force of the deflagration[10].

Another methodology showed that, with the use of CO_2 lasers and YAG lasers, the adhesive between the tooth and the bracket could be softened thermally. The brackets could then be removed with minimal force[11].

In a recent study, ceramic brackets were irradiated using a new type of 445-nm diode laser before debonding, with the result that less residual adhesive remained on the tooth when removing the brackets than was the case with the control group[12].

Anand et al describe that, with the use of a diode laser before the removal of ceramic brackets, the shear bond strength can be reduced by 33.3%, and hence the danger of enamel cracks during debonding is reduced[13].

The study by Yassai et al provides evidence of the superiority of diode lasers (980 nm) for the removal of ceramic brackets compared to conventional debonding. In the process, the pulp was only heated up minimally by 1.46°C, which did not cause any damage to the pulp[14].

Light polymerization

Argon lasers work with a wavelength of 488 nm in the area of the absorption peak of camphorquinone, an initiator radical in dental adhesives. Many reports exist about the use of argon lasers for light polymerization, but the price of the laser makes its use in clinical practice uneconomical at the moment[2].

Soft tissue surgery

The significant advantage of laser-assisted surgical procedures, in contrast to electrosurgery, is that there is an absence of problematic electromagnetic interactions[15].

Esthetic gingival corrections

In the finishing phase of orthodontic treatment cases, important concepts from cosmetic dentistry play a role. Particular attention should be paid to the length of the tooth crowns, the proportionality of the teeth, as well as the form and contour of the gingiva[3]. The esthetic result can be negatively influenced by excessive gingival exposure, uneven contours of the gingival margin or disproportionate tooth sizes[1]. In this case, laser surgery can provide assistance to improve the form and the contour of the gingiva, carry out crown lengthening, and recreate the proportionality of the teeth[3].

In an ideal case, 2 mm of gingiva can be seen below the high smile line[1]. How much gingiva can be seen, however, varies from one individual to another[16]. The curvature of the gingival margin, the maxillary central incisors, and the maxillary canines should be at the same height. The curvature of the maxillary lateral incisors should lie slightly underneath[1]. Ideally, the most apical point of the gingiva curvature (the zenith) should be at the maxillary central incisors, and the maxillary canines distal to the longitudinal axis of the tooth. For the maxillary lateral incisors and the mandibular incisors, the zenith should correspond with the longitudinal axis[16].

The tooth length of a maxillary central incisor is on average 10.6 mm for men and 9.6 mm for women, with the variations in this value ranging from 9 to 12 mm[16]. In order to correctly assess the tooth proportions, the tooth width must be correlated with the tooth length. Here, there should be a value of 80% for the maxillary central incisors[17].

Using these values as a guide, the orthodontist can decide clinically to what extent the exposure of the anterior teeth and the gingiva of the patient will influence the esthetic result. Should the exposure of the anterior teeth be too low, the clinician should assess whether a vertical maxillary underdevelopment is present, whether lip movement is restricted, or whether the clinical crown is shortened. If the clinical crown is shortened, the questions that arise are whether the tooth has erupted completely, whether a “passive altered eruption”[18] of the gingiva is present, or whether the loss of hard tooth substance has occurred due to attrition or abrasion[16]. “Passive altered eruption” or pseudo eruption can be treated by lengthening the crown by means of laser surgery.

In some cases, it is just as helpful to carry out surgical crown lengthening before the bracket is placed, in order to avoid unwanted side effects due to false placement of the brackets.

Before shaping the gingiva, the clinician should check the heights of the gingival curvatures in both quadrants of the jaw for their symmetry, and investigate the described ratios between the gingival curvatures of the individual teeth. In the event of asymmetry or if there is a false ratio between the curvatures, then corrections must be performed to create an esthetic result.

The tissue should be removed with a stroking movement of the fiberglass tip. In order to round off the gingival curvature and avoid any sharp edges, the angle of incidence of the instrument tip should be varied. The fundamental periodontal principles should be observed, and the biological width of 3 mm should not be violated. This consists of the gingival sulcus, epithelial, and connective tissue attachment. Loss of the biological width could lead to unpredictable bone loss[1].

As regards the contour, the three-dimensional (3D) expansion of the papillae can be thinned out using laser surgery if the papillae act in a hyperplastic manner. In order to carry out such gingival contouring, the instrument is guided in a rolling, stroking movement over the papillae[3].

With a diode laser there is no hemorrhaging due to the coagulating effect, and an exact contouring of the papillae and shaping of the gingival curvature is guaranteed. As a rule, no particular aftercare is necessary.

Exposure of retained and partly retained teeth

Soft tissue lasers are also suitable for the exposure of retained and partly retained canines, if the crown is not covered by bone[1]. The orthodontic attachment can then be secured immediately afterwards using an adhesive[19].

Removing hypertrophic tissue

The use of soft tissue lasers is helpful in thinning the hypertrophic gingiva, eg, after gap closure[19], and also for the removal of growths of the gingiva over orthodontic apparatus (eg, springs, mini-pins)[1].

When placing orthodontic bands on the mandibular second molar, a mucosal hood can sometimes be obstructive. An operculectomy can be easily carried out using a soft tissue laser in the same session.

Frenectomy

Soft tissue lasers are very useful for performing frenectomies to reduce the labial frenulum or, in the case of ankyloglossia, for the transection of the tongue frenulum. In both cases, the frenectomy can be carried out easily and seamlessly, and in a hemostatic and almost pain-free manner. Following administration of an anesthetic, the transection is carried out by stretching the lip and tongue in order to extend the relevant frenulum. Once it is stretched, strokes are made back and forth with the fiberglass over the tissue to be resected, as if using a brush.

If the labial frenulum reaches to the papilla, then one also transects the musculature centrally along the papilla to the periosteum, leaving the tip of the papilla intact[1]. The labial frenulum should only be removed once the diastema has closed as far as possible[20].

Following frenectomies, no particular postoperative aftercare is generally necessary.

Coagulated tissue can remain on the fiber tip from the surgical work. It is helpful for the assistant to remove this tissue in the interim using a damp gauze cloth. It is advisable to work with suction removal, as the surgical procedure using a laser can have an unpleasant effect on olfactory perception.

Remaining coagulated tissue on the gingiva can be dabbed away gently with a microbrush and a 3% hydrogen peroxide solution[1]. It can also be rinsed with physiological saline solution.

Biostimulation

The biostimulating effect of low-level laser therapy (LLLT), also known as soft laser therapy, is a component of current research. There are no standards as a result of the use of different wavelengths and methods[2]. It has been confirmed that stimulation of the ATP synthesis takes place, and the synthesis of DNA and RNA in the mitochondria is stimulated[21]. Additionally, collagen synthesis could be stimulated by the irradiation of fibroblasts[22]. Additional primary and secondary effects due to LLLT have also been described in the literature[2,23].

In orthodontics, LLLT can be used for accelerated tooth movement. Both Cruz et al and Genc et al, in double-sided extraction cases, irradiated only one quadrant, and used the other quadrant as a control group. Accelerated tooth movement on the irradiated side could be demonstrated in both research groups[24,25].

LLLT can also be used for enamel reduction[2], the treatment of aphtae[17], and for improved wound healing[26].

For biostimulation using LLLT, He-Ne lasers or a diode laser that can create different wavelengths are suitable. Wavelengths in the visible red spectrum (625 to 780 nm) and the infrared spectrum (780 to 1400 nm) are used for this purpose.

Case studies on the practical application of a diode laser

In all of the case studies listed below, Ultracain D-S forte anesthetic (Sanofi-Aventis, Frankfurt a.M.) and SiroLaser Blue (Dentsply Sirona Dental Systems GmbH, Bensheim) were used.

For case studies 1, 2, and 3, as well as the exposure in case study 4, the laser was applied with the following settings: wavelength 445 nm, power 2.0 W, time 0 s, duty cycle cw, frequency cw, average power 2.0 W. For the biostimulation in case study 4, the laser was operated in the following mode: wavelength 970 nm, power 2.0 W, time 0 s, duty cycle 50%, frequency 1 GHz, average power 1.0 W.

Case study 1

- Problem: Recession on tooth 31 as a result of labial tilting and high inserting labial frenulum; gingival hyperplasia on teeth 32 and 42 (Fig 2).
- Orthodontic therapy: Placement of tooth 31.
- Laser therapy: Frenectomy for the removal of the mandibular labial frenulum; gingivectomy on teeth 32 and 42 (Figs 3 to 5).
- Anesthesia: Selective injections of 0.2 ml each.
- Aftercare: No particular aftercare is necessary.

Case study 2

- Problem: Persistence at tooth 52; retention at tooth 13; agenesis at teeth 12 and 22 (Figs 6 and 7).

Fig 2 Recession at tooth 31, gingival hyperplasia at teeth 32 and 42, and high inserting labial frenulum.

Fig 3 Situation after frenectomy of mandibular labial frenulum.

Fig 4 Hyperplasia of the gingiva can be clearly seen at teeth 32 and 42.

Fig 5 The gingivectomy at teeth 32 and 42 took place in the same session.

Fig 6 Persistence at tooth 52, retention at tooth 13, and agenesis at teeth 12 and 22.

Fig 7 Retention of tooth 13 can be reliably diagnosed on the orthopantomogram (OPG).

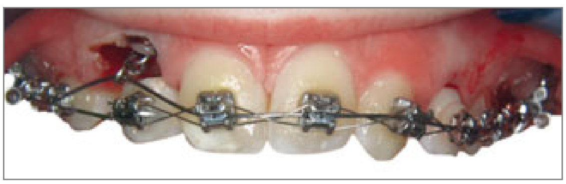


Fig 8 Situation after exposure of tooth 13. Adhesion of the brackets could be achieved directly.

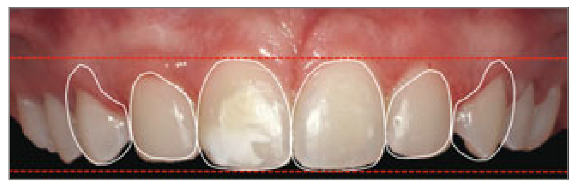


Fig 9 Esthetic result of the gingival shaping could be simulated using digital visualization. Composite veneers on teeth 14, 13, 23, and 24.

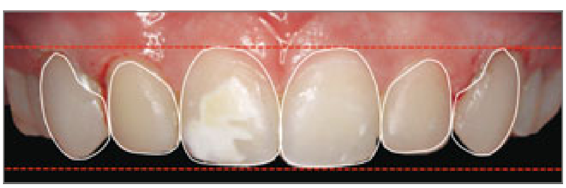


Fig 10 Result after immediate gingival shaping.

Fig 11 Final results of the gingival shaping correspond to the digital simulation.

Fig 12 (left, top) Persistence of tooth 52 with retention of tooth 13.

Fig 13 (right, top) Placement of tooth 13 to the position of tooth 12.

Fig 14 (left, bottom) Situation after active orthodontic therapy; enamel recontouring of tooth 13. Misalignment of the heights of the gingival curvature resulting in compromised esthetics.

Fig 15 (right, bottom) Composite veneers on teeth 14, 13, 23, and 24, and esthetic gingival shaping for an ideal gingival line.

- Orthodontic therapy: Extraction of tooth 52; arranging of tooth 13; gap closure in region 12.
- Laser therapy: Exposure of tooth 13; gingival shaping of the maxillary anterior region (Figs 8 to 15).
- Anesthesia: Selective injections of 0.2 ml each.
- Aftercare: No particular aftercare necessary.

Fig 16 Median diastema. Low-inserting labial frenulum with muscular involvement.

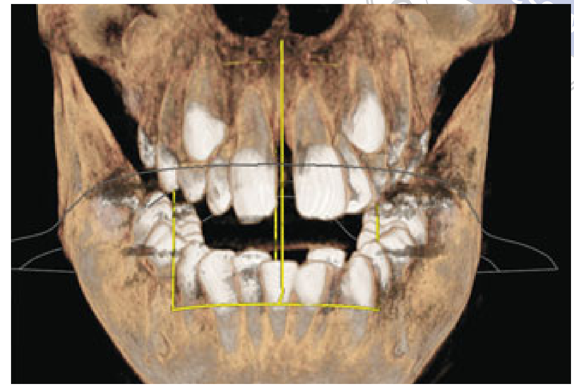


Fig 17 On the cone beam computed tomography (CBCT) scan, a bone defect is evident in region 11/ 21.

Fig 18 The diastema is closed.

Fig 19 Situation immediately after the frenectomy.

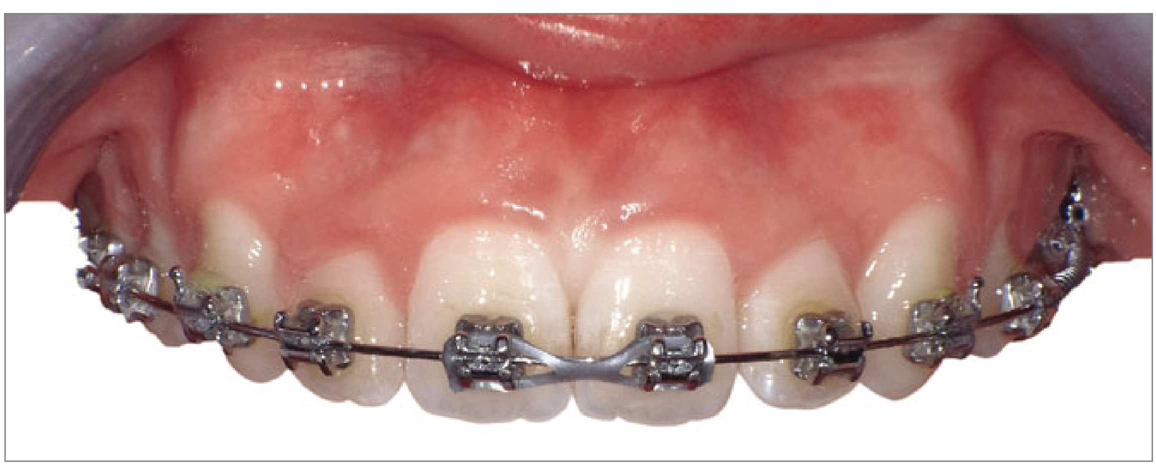


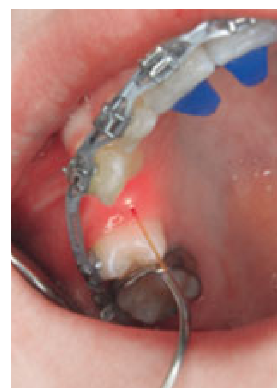
Fig 20 Wound healing without aftercare following laser surgery.

Case study 3

- Problem: Deep muscular insertion of the maxillary labial frenulum in a bone defect; median diastema; secondary crowding in the maxilla; primary and secondary crowding in the mandible (Figs 16 and 17).
- Orthodontic therapy: Closure of the diastema; dealing with the crowding (Fig 18).
- Laser therapy: Frenectomy (Fig 19).
- Anesthesia: Selective 0.2 ml each in the area of the frenectomy.
- Aftercare: No particular aftercare is necessary (Fig 20).

Fig 21

Fig 22 (left, top) Situation after extraction of teeth 75 and 85.



Figs 23 and 24 (middle and right, top) Biostimulation of extraction gaps in opposing jaw for accelerated tooth movement, irradiated from vestibular and oral with a wavelength of 970 nm for 60 s every 14 days.

Fig 25 (lfet, bottom) Exposure of tooth 37 with a wavelength of 445 nm.

Fig 26 (right, bottom) Situation after exposure of tooth 37 with subsequent adhesive attachment of a tube. The gaps have closed almost completely after 9 months.

Case study 4

- Problem: Persistence of teeth 75 and 85; agenesis of teeth 35 and 45; retention of tooth 37 (Fig 21).
- Orthodontic therapy: Extraction of teeth 75, 85, 14, and 24; subsequent gap closure (Fig 22).
- Laser therapy: Biostimulation for faster tooth movement in the area of the gaps (Figs 23 and 24) and exposure of tooth 37 (Figs 25 and 26).
- Anesthesia: Selective 0.2 ml in the area of the exposure.
- Aftercare: No particular aftercare is necessary.

Conclusion

Diode lasers can be used for nearly all orthodontic indications for lasers in clinical practice. As a result of their hemostatic effect in soft tissue surgery, it should be possible for orthodontists to carry out smaller surgical procedures themselves. Biostimulating laser applications could also shorten the length of treatment.

References

1. Tracey S et al. Lasers in Orthodontics In: Graber L (Hrsg). Current Principles and Techniques. Amsterdam: Elsevier, 2012:1051–1073.
2. Fekrazad R et al. Laser in Orthodontics In: Naretto S (Hrsg). Principles in Contemporary Orthodontics. Rijeka, Kroatien: InTech, 2011:129–180.
3. Sarver DM et al. Principles of cosmetic dentistry in orthodontics: part 2. Soft tissue laser technology and cosmetic gingival contouring. Am J Orthod Dentofacial Orthop 2005;127:85–90.
4. Beard P. Biomedical photoacoustic imaging. Interface Focus 2011;1:602–631.
5. Braun A et al. Die 445-nm-Halbleiterlaser in der Zahnmedizin – Einführung einer neuen Wellenlänge. Quintessenz 2015;66:205–2011.
6. Hossain M et al. Effects of Er,Cr:YSGG laser irradiation in human enamel and dentin: ablation and morphological studies. J Clin Laser Med Surg 1999;17:155–159.
7. Basaran G et al. Etching enamel for orthodontics with an erbium, chromium:yttrium-scandium-gallium-garnet laser system. Angle Orthod 2007;77:117–123.
8. Silverstone LM et al. Variation in the pattern of acid etching of human dental enamel examined by scanning electron microscopy. Caries Res 1975;9:373–387.
9. Jaberi Ansari Z et al. The effect of an Er,Cr:YSGG laser on the micro-shear bond strength of composite to the enamel and dentin of human permanent teeth. Lasers Med Sci 2012;27:761–765.
10. Tocchio RM et al. Laser debonding of ceramic orthodontic brackets. Am J Orthod Dentofacial Orthop 1993;103:155–162.
11. Strobl K et al. Laser-aided debonding of orthodontic ceramic brackets. Am J Orthod Dentofacial Orthop 1992;101:152–158.
12. Stein S et al. 445-nm diode laser-assisted debonding of self-ligating ceramic brackets. Biomed Tech (Berl.) 2017 [Epub ahead of print].
13. Anand P et al. Immediate and Delayed Effects of Diode Laser on Debonding of Ceramic Brackets: An in vitro Study. J Contemp Dent Pract 2016;17:275–281.
14. Yassaei S et al. Effects of removing adhesive from tooth surfaces by Er:YAG laser and a composite bur on enamel surface roughness and pulp chamber temperature. Dent Res J (Isfahan) 2015;12:254–259.
15. Skora P et al. Chirurgische Kronenverlängerung mit Unterstützung eines Blaulichtlasers (445nm) – Ein Fallbericht In: Oemus TR, (Hrsg). Jahrbuch Laserzahnmedizin. Leipzig: Oemus Media AG, 2016:59–60.
16. Sarver DM et al. Special Considerations in Diagnosis and Treatment Planning In: LW Gs, ed. Proceedings of the Orthodontics Current Principles and Techniques. Amsterdam: Elsevier, 2012:59–98.
17. Sarver DM. Principles of cosmetic dentistry in orthodontics: Part 1. Shape and proportionality of anterior teeth. Am J Orthod Dentofacial Orthop 2004;126:749–753.
18. Dolt AH. Altered passive eruption: an etiology of short clinical crowns. Quintessence Int 1997;28:363–372.
19. Sarver DM. Principles of cosmetic dentistry in orthodontics: Part 3. Laser treatments for tooth eruption and soft tissue problems. Am J Orthod Dentofacial Orthop 2005;127:262–264.
20. Olivi G et al. Evidence-based dentistry on laser paediatric dentistry: review and outlook. Eur J Paediatr Dent 2009;10:29–40.
21. Karu TI. Effects of visible radiation on cultured cells. Photochem Photobiol 1990;52:1089–1098.
22. Abergel RP et al. Control of connective tissue metabolism by lasers: recent developments and future prospects. J Am Acad Dermatol 1984;11:1142–1150.
23. Karu T. Primary and secondary mechanisms of action of visible to near-IR radiation on cells. J Photochem Photobiol B 1999;49:1–17.
24. Cruz DR et al. Effects of low-intensity laser therapy on the orthodontic movement velocity of human teeth: a preliminary study. Lasers Surg Med 2004;35:117–120.
25. Genc G et al. Effect of low-level laser therapy (LLLT) on orthodontic tooth movement. Lasers Med Sci 2013;28:41–47.
26. Hopkins JT et al. Low-Level Laser Therapy Facilitates Superficial Wound Healing in Humans: A Triple-Blind, Sham-Controlled Study. J Athl Train 2004;39:223–229.