

Diode Lasers in Dentistry: Current and Emerging Applications

Tahira Hyder

MDS Resident



OBJECTIVE: The objective of this review is to describe basic diode laser physics and to delineate the application of diode lasers in dentistry.

REVIEW: Over the past few decades lasers have become a popular alternative to conventional methods owing to the advantages they carry such as decreased cellular destruction and tissue swelling, minimal bleeding, enhanced visualization of surgical sites and reduced requirement for suturing. Among the various lasers in dentistry, diode lasers are currently the most commonly used, with applications extending from soft tissue procedures to photo-activated disinfection of periodontal pockets, endodontics and laser-assisted tooth whitening. With its versatility and numerous benefits, small size, ease of operation and, relative and cost-effectiveness when compared to other lasers, the diode laser is proving itself as a valuable addition to dental setups.

CONCLUSION: The diode laser provides a relatively pain-free minimally invasive technique for removal of soft tissue lesions such as exophytic lesions and operculum, gingival depigmentation, implant exposure, biostimulation, canal disinfection in endodontics and teeth whitening.

KEYWORDS: laser dentistry, biostimulation, oral surgery.

HOW TO CITE: Hyder T. Diode lasers in dentistry: Current and emerging applications. J Pak Dent Assoc 2022;31(2):100-105.

DOI: <https://doi.org/10.25301/JPDA.312.100>

Received: 14 August 2021, **Accepted:** 26 December 2021

INTRODUCTION

The term LASER is an abbreviation for "Light Amplification by the Stimulated Emission of Radiation".¹ Since its introduction in dentistry in the 1960s by Maiman², there has been continuous research on its numerous soft and hard tissue applications. Lasers are broadly classified on basis of tissue adaptability into two types: the first type being hard lasers, such as Neodymium Yttrium Aluminum Garnet (Nd: YAG), Er:YAG and Carbon dioxide (CO₂), which have both hard tissue and soft tissue applications, but are more costly and can potentially cause thermal injury to tooth pulp³, while the second type are cold or soft lasers usually semiconductor diode devices, which are compact, affordable and versatile devices used for soft tissue surgical procedures and "biostimulation".⁴ A second classification is based upon the physical construction of the laser (such as solid laser and gas laser) and a third one is according to the range of wavelength.

METHODOLOGY

In order to get material on the application of diode lasers in dentistry a, literature search was conducted, using Medline-PUBMED and Google Scholar search based

electronic databases. Reviews of literature, clinical trials and case series that used diode laser to evaluate histologic or clinical variables were selected. "Diode laser", "dentistry", "oral cavity" and "oral surgery" were employed for the search strategy.

MECHANISM OF ACTION OF DIODE LASERS

Laser light is a single wavelength, monochromatic light.⁵ A laser essentially consists of three parts: a source of energy, lasing medium and mirrors that cause resonance. Typically an optical flexible fiber ranging from 200 to 600 μm to deliver the laser light from the laser to the target tissues. The wavelength and other properties of the laser are determined primarily by the composition of an active medium which produces photons of energy on stimulation, and can be a gas, a crystal, or a solid-state semiconductor.⁶

When laser energy hits a target issue, four possible interactions occur depending on optical properties of the target tissues and the wavelength of the laser: reflection, transmission, scattering, and absorption.^{7,8} Once the laser light is absorbed in the tissues its temperature elevates, thereby causing photochemical effects which are dependent upon the water content of the tissues. At temperature between 60°C and 100°C protein denaturation occurs; at temperature exceeding 100°C, ablation or vaporization of the water occurs and at temperatures above 200°C, the tissue lose their water content and dehydrate, resulting in burn or carbonization.

Department of Periodontology, Faculty of Dentistry, Ziauddin University.

Corresponding author: "Dr. Tahira Hyder" < tahira.h.hyder@gmail.com >

For absorption to occur, a chromophore or an absorber of light with affinity for a particular wavelength is required.⁹ Common chromophores in the soft tissues of the oral cavity include water, melanin and hemoglobin while those of hard tissues are typically water and hydroxyapatite.^{10,11} Absorption coefficients of lasers differ with respect to hard and soft tissues, thereby making the laser selection procedure-dependent.^{8,12,13} Accordingly, dental lasers are classified as hard or soft tissue lasers, depending on their affinities.

DIODE LASERS

The diode laser has a compact and portable unit with a wide variety of clinical applications. A solid state semiconductor is made up of aluminum, gallium, arsenide, and occasionally indium converts electrical energy into light energy of approximately 810 nm to 980nm wavelength.¹⁴ These wavelength are easily absorbed by "chromophores" such as hemoglobin and melanin, while they are poorly absorbed by the hydroxyapatite and water which constitute the enamel, therefore diode lasers have no role in hard tissue application.¹⁰

A flexible optic fibre in the form of a handpiece delivers the treatment rays to the target area. The clinical approach and treatment methods dictate the selection between continuous and pulsed modes and between contact and noncontact tissues application.¹⁵ Literature suggests some advantages of the laser over conventional methodologies like scalpel, including precise soft tissue incisions, a relatively bloodless surgical field and better visualization, no requirement for suturing, good post-operative recovery period with minimal to none bleeding, swelling and reduced postsurgical pain.¹⁶

Dental lasers do carry some disadvantages. The high financial cost makes it not accessible to all dental set ups. Secondly, eye damage is a serious complication that can occur, but is prevented by the use of wavelength-specific eye wear.¹⁷ Operations of lasers also require specialized training. Additionally, laser soft tissue incision is slower than that performed with a scalpel.¹⁶

APPLICATIONS

Crown-Lengthening

Laser-assisted crown-lengthening surgery has a wide variety of clinical applications such as surgical exposure of fractured tooth or subgingival caries, correction of gummy smile in altered passive eruption cases, and access to root perforations.¹⁸ Because of its inability to remove hard tissue, diode laser assisted crown lengthening can only be performed for the treatment of type IA altered passive eruption¹⁹ with

a wide band of keratinized tissue and optimal space (approximately 1.5 mm) between the alveolar crest and cemento-enamel junction.

When compared with conventional crown lengthening using scalpel, laser has been associated with minimal bleeding which allows improved visualization of the surgical field, with reduced post-operative pain and lower visual analogue score (VAS), thereby demonstrating laser-assisted crown lengthening as a safe and effective alternative to conventional methods.^{19,20}

GINGIVAL DEPIGMENTATION

Gingival depigmentation is a periodontal plastic surgical procedure whereby hyper-pigmented zones of the attached gingiva are removed or reduced by various techniques including scalpel surgery, ablation with high-speed handpiece, cryosurgery, electrosurgery, and dental laser.²¹ Laser assisted gingival depigmentation is typically performed as a single step technique with no requirement of the use of a periodontal dressing, and is accompanied by a fast healing process with minimal pain and discomfort.²²

EXPOSURE OF UNERUPTED AND PARTIALLY ERUPTED TEETH

Diode lasers allow precise and easy excision of soft tissue over unerupted or partially erupted teeth such as the maxillary canine for the placement of a bracket or for the removal of an operculum around a partially erupted third molar, with an additional advantage over conventional scalpel surgery in sealing small blood and lymphatic vessels, thereby.²³ Postoperative tissue shrinkage is reduced, resulting in decreased scarring. In most cases the need for suturing is eliminated and healing occurs by secondary intention.²⁴

REMOVAL OF HYPERTROPHIC TISSUE AND BIOPSY SPECIMENS

Denture-induced fibrous hyperplasia is a benign overgrowth of soft tissue that occurs in response to a chronically ill-fitting denture. These overgrowths can be removed without the need of sutures and with good hemostasis and less post-operative pain using diode lasers. Diode laser can also be a useful treatment modality for obtaining biopsy specimens.²⁵

FRENECTOMIES

When the removal of a high labial frenal attachment is indicated, laser-assisted frenectomy provides a relatively

painless, bloodless procedure not requiring suturing or a periodontal pack, and without the requirement of any special postoperative care. Diode lasers can also be used to remove the thick frenular band seen in ankyloglossia, in which a band of tissue extends from the bottom of the tongue's tip to the floor of the mouth and limits the tongue movements. The attachment of the tongue to the floor of the mouth results in difficulty in speech and deglutition, malocclusion and occasionally difficulty in performing oral hygiene, resulting in periodontal problems, thereby requiring removal of the band of tissue.

IMPLANT EXPOSURE

Studies have concluded that second-stage implant surgeries performed with diode lasers are not only efficient, safe, bloodless and painless procedures but they also linked with a faster rehabilitation phase and greater patient satisfaction.^{26,27}

In a randomized controlled clinical trial Kholey et. al²⁸ concluded that diode laser assisted implant exposure could be performed without the need for local anaesthesia, however it was similar to scalpel surgery in outcomes including duration of surgery, postoperative pain, healing time, and overall success rates of the implants.

PHOTOACTIVATED DISINFECTION USING LASERS

Low-level laser energy from a diode laser is being used as a photo-activator of oxygen releasing dyes (such as toloum chloride), which cause membrane and DNA damage to the microorganisms upon activation. Commonly referred as photoactivated disinfection (PAD), this technique has been proven in literature to effectively kill bacteria including subgingival plaque in deep periodontal pockets, which are typically antimicrobial agents-resistant.²⁹ Photoactivated disinfection has been demonstrated to kill Gram positive bacteria (including Methicillin resistant *Staphylococcus aureus* (MRSA)), Gram negative bacteria, fungi, and viruses.^{30,31} The application of PAD is being extended to disinfection in cases of peri-mucositis and peri implantitis.^{32,33}

WOUND HEALING AND BIOSTIMULATION

Low-level laser therapy (LLLT) is commonly referred to as "bio-stimulation". Studies indicate that low dose of laser energy (e.g., 2 J/cm²) stimulates proliferation of fibroblasts, while high doses (e.g. 16 J/cm²) suppress it.^{34,35} An increase in proliferation and locomotion of fibroblasts may result in increased tensile strengths of the healed

wounds.³⁶ The effects of LLLT on proliferation and differentiation of human osteoblast cells have been investigated.³⁷ Studies report that LLLT bio-stimulates or enhances the multiplication and differentiation of the human osteoblast-like cells during the first 72 hours after irradiation. This application indicates the use of LLLT in combination with regenerative methods and even as stand-alone treatment for stimulation of bone repair and acceleration of the healing process.^{38,39}

POST HERPETIC NEURALGIA AND APHTHOUS ULCERS

Low levels laser therapy has been demonstrated to reduce pain and enhance healing of aphthous ulcers and recurrent herpetic lesions.^{40,41} For recurrent herpes simplex labialis lesions, if photostimulation is performed during the prodromal (tingling) stage, the lesions have been shown to get arrested with acceleration of the healing time and a reduction in recurrences.⁴²

ROOT CANAL DISINFECTION

In invitro studies diode laser irradiation has been shown to increase disinfection of deep radicular dentin.^{43,44} It is also associated with effective sealing of dentinal tubules and elimination of *Escherichia coli* and *Enterococcus Faecalis*⁴⁵, thus increasing the efficacy of root canal treatment. For this effect, the diode laser's optic fibre is first entered 3 mm short of the apex into the canal and gradually withdrawn, being kept in approximately 1 minute per canal.⁴⁶

REMOVAL OF PERIODONTAL POCKET LINING

Diode lasers are increasingly being used as part of the laser assisted new attachment procedures (LANAP), whereby the epithelium lining the pocket is removed in an attempt to gain new attachment.⁴⁷ To perform this procedure, after the completion of scaling and root planing the optical fiber is introduced into the periodontal pocket and ascending and descending movement are performed. Through the duration of the procedure the optical fiber must be maintained parallel to the tooth root main axis, with the laser being rotated around the perimeter of each involved tooth.⁴⁸

TEETH WHITENING

Laser lights activates hydrogen peroxide within the bleaching agent to yield better results compared to hydrogen peroxide activation using light-emitting-diodes (LEDs). It has been noted that the teeth bleached by the LEDs suffer

a major chroma reduction and turn gray; laser irradiation however produced better chroma and less gray.^{49,50} Additionally, better luminosity and less sensitivity was achieved with laser activation of hydrogen peroxide.⁵¹

CONCLUSION

Over the span of the last four decades, applications of diode lasers have steadily increased across dentistry and extends from soft tissue surgical procedures (frenectomy, gingivectomy, operculectomy etc.) to biostimulation of wounds, teeth whitening gel activation, photodynamic disinfection, and improved root canal disinfection. Owing to its relatively low cost and compatible size, it is growing in popularity in dental clinics and hospitals, making it essential for dentists to know its applications and be proficient in its handling.

CONFLICT OF INTEREST

None declared

REFERENCES

- Gross AJ, Hermann TR. History of lasers. *World J Urol* 2007;25:217-20
<https://doi.org/10.1007/s00345-007-0173-8>
- Center, D. Application of Laser in Dentistry: A Brief Review. *J Advanced Medical and Dental Sciences Research*. 2021 9(11).
- Maheshwari S, Jaan A, Vyaasini CS, Yousuf A, Arora G, Chowdhury C. Laser and its implications in dentistry : a review article. *J Curr Med Res Opin*. 2020;3
<https://doi.org/10.15520/jcmro.v3i08.323>
- Luke AM, Mathew S, Altawash MM, Madan BM. Lasers: A review with their applications in oral medicine. *J Lasers Med Sci*. 2019;10:324-9
<https://doi.org/10.15171/jlms.2019.52>
- Goldman L, Goldman B, Van-Lieu N. Current laser dentistry. *Lasers Surg Med*. 1987;6:559-62.
<https://doi.org/10.1002/lsm.1900060616>
- Nazemisalman B, Farsadeghi M, Sokhansanj M. Types of lasers and their applications in pediatric dentistry. *J Lasers Med Sci*. 2015;6:96-101
<https://doi.org/10.15171/jlms.2015.01>
- Aoki A, Mizutani K, Takasaki AA, Sasaki KM, Nagai S, Schwarz F, et al. Current status of clinical laser applications in periodontal therapy. *Gen Dent*. 2008;56:674-87.
- Carroll L, Humphreys TR. Laser-tissue interactions. *Clin Dermatol*. 2006;24:2-7.
<https://doi.org/10.1016/j.clindermatol.2005.10.019>
- Suliman M. An overview of the use of lasers in general dentist practice: Laser physics and tissue interactions. (233-4). *Dent Update*. 2005;32:228-20. 236
<https://doi.org/10.12968/denu.2005.32.4.228>
- Fasbinder DJ. Dental laser technology. *Compend Contin Educ Dent* 2008;29:452-4, 456, 458-9.
- Green J, Weiss A, Stern A. Lasers and radiofrequency devices in dentistry. *Dent Clin North Am*. 2011;55:585-97
<https://doi.org/10.1016/j.cden.2011.02.017>
- Martens LC. Laser physics and a review of laser applications in dentistry for children. *Eur Arch Paediatr Dent*. 2011;12:61-7.
<https://doi.org/10.1007/BF03262781>
- Tracey SG. Light work. *Orthod Products*. 2005:88-93.
- Weiner GP. Laser dentistry practice management. *Dent Clin North Am*. 2004;48:1105-26
<https://doi.org/10.1016/j.cden.2004.05.001>
- Desiate A, Cantore S, Tullo D, Profeta G, Grassi FR, Ballini A. 980 nm diode lasers in oral and facial practice: current state of the science and art. *Int J Med Sci*. 2009;6:358.
<https://doi.org/10.7150/ijms.6.358>
- Desiate A, Cantore S, Tullo D, Profeta G, Grassi FR, Ballini A. 980 nm diode lasers in oral and facial practice: current state of the science and art. *Int J Med Sci*. 2009;6:358.
<https://doi.org/10.7150/ijms.6.358>
- Romanos G, Nentwig GH. Diode Laser (980 nm) in Oral and Maxillofacial Surgical Procedures: clinical observations based on clinical applications. *J Clin Laser Med Surg*. 2009;17:193-197
<https://doi.org/10.1089/clm.1999.17.193>
- Stabholz A, Zeltser R, Sela M, et al. The use of lasers in dentistry: principles of operation and clinical applications. *Compendium of Cont Educ Dent (Jamesburg, N.J. : 1995)*. 2003;24:935-48; quiz 949.
- Camargo, PM., Melnick, P R., Camargo, LM. (2007). Clinical crown lengthening in esthetic zone. *J Calif Dent Assoc*. 35,487-98.
- Farista, S., Kalakonda, B., Koppolu, P., Baroudi, K., Elkhatat, E. and Dhaifullah, E., 2016. Comparing laser and scalpel for soft tissue crown lengthening: a clinical study. *Glob J Health Sci*. 8, p.55795.
<https://doi.org/10.5539/gjhs.v8n10p73>
- Rajesh Kumar, Garima Jain, Shrikant Vishnu Dhodapkar, Kanteshwari Iranagouda Kumathalli, Gagan Jaiswal. The comparative evaluation of patient's satisfaction and comfort level by diode laser and scalpel in the management of mucogingival anomalies. *J Clin Diagn Res*. 2015;9:56-8.
<https://doi.org/10.7860/JCDR/2015/14648.6659>
- Nandakumar K, Roshna T. Anterior Esthetic Gingival Depigmentation and Crown Lengthening: Report of a Case. *J Contemp Dent Pract* 2005;3:139-47
<https://doi.org/10.5005/jcdp-6-3-139>

23. Balcheva, G and Balcheva, M., 2014. Depigmentation of gingiva. *J IMAB* Annual Proceeding Scientific Papers, 20, pp.487-489. <https://doi.org/10.5272/jimab.2014201.487>
24. Sarver DM, Yanosky M. Principles of cosmetic dentistry in orthodontics: part 2. Soft tissue laser technology and cosmetic gingival contouring. *Am J Orthod Dentofac Orthop.* 2005;127:85-90. <https://doi.org/10.1016/j.ajodo.2004.07.035>
25. Chawla K, Lamba AK, Faraz F, Tandon S, Ahad A. Diode laser for excisional biopsy of peripheral ossifying fibroma. *Dent Res J.* 2014;11:525-530.
26. D'Arcangelo C, Di Nardo Di Maio F, Prosperi GD, Conte E, Baldi M, Caputi S. A preliminary study of healing of diode laser versus scalpel incisions in rat oral tissue: a comparison of clinical, histological, and immunohistochemical results. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2007;103:764-73 <https://doi.org/10.1016/j.tripleo.2006.08.002>
27. Yeh S, Jain K, Andreana S. Using a diode laser to uncover dental implants in secondstage surgery. *Gen Dent.* 2005; 53:414-7.
28. Gianfranco S, Francesco SE, Paul RJ. Erbium and diode lasers for operculisation in the second phase of implant surgery: a case series. *Timisoara Med J* 2010;60: 117-23.
29. El-Kholey, KE. Efficacy and safety of a diode laser in second-stage implant surgery: a comparative study. *International J Oral Maxillofac Surg.* 2014;43:633-38. <https://doi.org/10.1016/j.ijom.2013.10.003>
30. Grzech-Lesniak K. Making use of lasers in periodontal treatment: a new gold standard?. *Photomed Laser Surg.* 2017;35:513-4. <https://doi.org/10.1089/pho.2017.4323>
31. O'Neill JF, Hope CK, Wilson M. Oral bacteria in multi-species biofilms can be killed by red light in the presence of toluidine blue. *Lasers Surg Med* 2002;31:86-90 <https://doi.org/10.1002/lsm.10087>
32. Seal GJ, Ng YL, Spratt D, Bhatti M, Gulabivala K. An in vitro comparison of the bactericidal efficacy of lethal photosensitization or sodium hypochlorite irrigation on *Streptococcus intermedius* biofilm in root canals. *Int Endodont J.* 2002;35:268-74. <https://doi.org/10.1046/j.1365-2591.2002.00477.x>
33. Rakašević D, Lazic Z, Rakonjac B, Soldatovic I, Jankovic S, Magic M, Aleksic Z. Efficiency of photodynamic therapy in the treatment of peri-implantitis: A three-month randomized controlled clinical trial. *Srpski arhiv za celokupno lekarstvo.* 2016;144(9-10):478-84. <https://doi.org/10.2298/SARH1610478R>
34. Dortbudak O, Haas R, Bernhart T, Mailath-Pokorny G. Lethal photosensitization for decontamination of implant surfaces in the treatment of peri-implantitis. *Clin Oral Implants Res* 2001;12:104-8 <https://doi.org/10.1034/j.1600-0501.2001.012002104.x>
35. Tominaga R. Effects of He-Ne laser irradiation on fibroblasts derived from scar tissue of rat palatal mucosa. *Kokubyo Gakka Zasshi* 1990;57:580-94. <https://doi.org/10.5357/koubyou.57.580>
36. Posten W, Wrone DA, Dover JS, Arndt KA, Silapunt S, Alam M. Low-level laser therapy for wound healing: mechanism and efficacy. *Dermatol Surg.* 2005;31:334-40. <https://doi.org/10.1097/00042728-200503000-00016>
37. Bloise N, Ceccarelli G, Minzioni P, Vercellino M, Benedetti L, De Angelis MG, Imbriani M, Visai L. Investigation of low-level laser therapy potentiality on proliferation and differentiation of human osteoblast-like cells in the absence/presence of osteogenic factors. *J biomedical optics.* 2013;18:128006. <https://doi.org/10.1117/1.JBO.18.12.128006>
38. Fujihara NA, Hiraki KR, Marques MM (2006) Irradiation at 780 nm increases proliferation rate of osteoblasts independently of dexamethasone presence. *Lasers Surg Med.* 38:332-36. <https://doi.org/10.1002/lsm.20298>
39. Fujihara NA, Hiraki KR, Marques MM (2006) Irradiation at 780 nm increases proliferation rate of osteoblasts independently of dexamethasone presence. *Lasers Surg Med* 38:33236 <https://doi.org/10.1002/lsm.20298>
40. Torres CS, dos Santos JN, Monteiro JS, Amorim PG, Pinheiro AL (2008) Does the use of laser photobiomodulation, bone morphogenetic proteins, and guided bone regeneration improve the outcome of autologous bone grafts? An in vivo study in a rodent model. *Photomed Laser Surg.* 26:371-77 <https://doi.org/10.1089/pho.2007.2172>
41. Olivi G, Genovese MD, Caprioglio C. Evidence-based dentistry on laser paediatric dentistry. *Eur J Paediatr Dent.* 2009;10:29-40
42. Ross G, Ross A. Low level lasers in dentistry. *Gen Dent* 2008;56:629-34
43. Hargate G. A randomized double-blind study comparing the effect of 1072-nm light against placebo for the treatment of herpes labialis. *Clin Exp Dermatol.* 2006;31:638-41 <https://doi.org/10.1111/j.1365-2230.2006.02191.x>
44. de Souza EB, Cai S, Simionato MR, Lage-Marques JL. High-power diode laser in the disinfection in depth of the root canal dentin. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology.* 2008;106:e68-72. <https://doi.org/10.1016/j.tripleo.2008.02.032>
45. Theodoro LH, Haypek P, Bachmann L, Garcia VG, Sampaio JEC, Zezell DM, et al. Effect of Er:YAG and diode laser irradiation on the root surface: morphological and thermal analysis. *J Periodontol.* 2003;74:838-43. <https://doi.org/10.1902/jop.2003.74.6.838>
46. Menezes M, Prado M, Gomes B, Gusman H, Simão R. Effect of photodynamic therapy and non-thermal plasma on root canal filling: analysis of adhesion and sealer penetration. *J App Oral Sci.* 2017;25:396-403. <https://doi.org/10.1590/1678-7757-2016-0498>

47. Caccianiga G, Rey G, Baldoni M, Caccianiga P, Baldoni A, Ceraulo S. Periodontal Decontamination Induced by Light and Not by Heat: Comparison between Oxygen High Level Laser Therapy (OHLT) and LANAP. *App Sci*. 2021;11:4629. <https://doi.org/10.3390/app11104629>
48. Jha A, Gupta V, Adinarayan R. LANAP, periodontics and beyond: A review. *J Lasers in Med Sci*. 2018;9:76. <https://doi.org/10.15171/jlms.2018.16>
49. Dostalova T, Jelinkova H, Housova D, Sulc J, Nemeč M, Miyagi M, Junior AB, Zanin F. Diode laser-activated bleaching. *Brazi Dent J*. 2004;15:SI-3.
50. Ursus Wetter N, Walverde D, Kato IT, De Paula Eduardo C. Bleaching efficacy of whitening agents activated by xenon lamp and 960-nm diode radiation. *Photomed Laser Therapy*. 2004;22:489-93. <https://doi.org/10.1089/pho.2004.22.489>
51. Vildósola P, Bottner J, Avalos F, Godoy I, Martín J, Fernández E. Teeth bleaching with low concentrations of hydrogen peroxide (6%) and catalyzed by LED blue (450±10 nm) and laser infrared (808±10 nm) light for in-office treatment: randomized clinical trial 1-year follow-up. *J Esthetic and Restorative Dentistry*. 2017;29:339-45. <https://doi.org/10.1111/jerd.12318>
-