

Soft tissue lasers: An innovative tool enhancing treatment outcomes in orthodontics – A narrative review

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Abstract

Lasers have been utilised in the field of dentistry for over 40 years, but their use has been limited in the field of orthodontics. The advent of lasers with accompanying computer interfaces has made them significantly user-friendly, adding to their appeal in the orthodontic profession. Knowledge regarding the laser device's capabilities and limitations is essential to optimise patient care and to make a satisfactory investment return. For the effective and successful integration of lasers in orthodontic practice, adequate training is required, limited not only to the orthodontist but the dental assistants and auxiliaries as well. Orthodontists may safely and readily execute gingivectomy, exposure of teeth, frenectomy, circumferential supracrestal fiberotomy, ankyloglossia release and uvulopalatoplasty. The current narrative review was planned to introduce the benefits and general principles of soft tissue lasers in the field of orthodontics and recent surgical research comparing different laser-assisted surgeries against conventional scalpel surgeries.

Keywords: Surgical procedures, Orthodontics, Diode lasers, CO₂ lasers.

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Introduction

In the past, majority of the orthodontic patients were satisfied with alignment of teeth that occluded well. This trend has rapidly changed over the turn of the century as patient expectations from orthodontic treatment have exponentially increased. They now demand pleasing smile aesthetics and better orofacial functional efficiency with an added desire for expediency and convenience in the accomplishment of these outcomes. To achieve this level of care, orthodontics must embrace state-of-the-art technology which assists them in achieving these objectives. One such technology is the soft-tissue laser. Though lasers have been utilised in dental surgery since the late 1960s and early 1970s,¹ they did not achieve

popularity in dentistry till the late 1990s, with orthodontists only entering the foray in the year 2000. The ability to dramatically enhance treatment results and reduce treatment duration has resulted in a rise in the use of soft-tissue lasers since that time.² With soft-tissue laser surgery training and education becoming more widespread in training programmes of orthodontics, the emphasis has shifted to teaching practitioners techniques for expediting treatment and improving results.

The term "laser" is an abbreviation for Light Amplification by Stimulated Radiation Emission. A laser is a device that emits monochromatic and collimated light by stimulating electromagnetic radiation via an optical amplification process. Since ancient times, light energy has been utilised therapeutically. Following the invention of the light bulb by Thomas Alva Edison in 1879, Finsen began experimenting with light to better understand how it affects living organisms.³ Finsen pioneered light therapy in 1896 as a treatment for lupus vulgaris, a form of tuberculosis (TB). Now with the development of more sophisticated methods of controlling light, the laser has developed therapeutic benefits. The name of laser is related to its active medium, which includes the subatomic-particle that soak up and subsequently emit energy.⁴ The active medium is the material that is stimulated inside the laser in order to produce the photon beam. Lasers may be based on the solid, liquid, or gaseous (i.e. carbon dioxide [CO₂]) active media, or on electrical circuits, such as diode lasers.⁵ In certain tissues, the transferred light energy is absorbed and therapeutic effects are generated, whereas in other tissues, light is not absorbed and therapeutic benefits are not produced. This selective absorption is due to certain chromophores in the oral cavity, which are chemicals or molecules that absorb certain laser wavelengths more effectively.⁶ For example, water (CO₂ and erbium lasers) and haemoglobin (Hb) are chromophores (diodes and neodymium-doped yttrium aluminum garnet [Nd:YAG] lasers) present intra-orally i.e. CO₂ laser execute its therapeutic effects via evaporating water from the soft tissues.

After orthodontists decide to incorporate lasers into practice, they must invest in a laser that best serves their purpose. The two most common types of soft tissue lasers are CO₂ (10,600nm) and diode lasers⁷ (Table 1). There are

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Table-1: Soft tissue lasers most commonly employed with their wavelengths and chromophores.

Laser Types	Wavelengths	Chromophores	Uses
CO ₂ CO ₂	10,600 nm 9300/9600 nm	Water Water, Hydroxyapatite, Phosphate	<ul style="list-style-type: none"> • Soft tissue incision/ablation. • Frenectomy and gingivectomy • Gingival troughing. Aesthetic gingival contouring • De-epithelization of gingival tissue during periodontal procedures • Treatment of oral ulcers
Diodes	810/940/980/ 1064 nm	Melanin, Haemoglobin, Oxyhaemoglobin	<ul style="list-style-type: none"> • Soft tissue incision/ablation. • Frenectomy and gingivectomy • Gingival troughing. Aesthetic gingival contouring • De-epithelization of gingival tissue during periodontal procedures
Erbium	2740/2980 nm	Water, Hydroxyapatite	<ul style="list-style-type: none"> • Cavity preparation in both enamel and dentine • Laser activated irrigation and photoactivated disinfection
Nd.YAG	1064 nm	Melanin, Haemoglobin, Oxyhaemoglobin	Same as those for CO ₂ laser with the addition of the following: <ul style="list-style-type: none"> • Removal of incipient caries
Argon	457-502 nm	Melanin, Haemoglobin, Oxyhaemoglobin	<ul style="list-style-type: none"> • Resin curing • Tooth bleaching • Aesthetic gingival contouring • Frenectomy and gingivectomy • Treatment of ulcers

CO₂: Carbon dioxide, Nd.YAG: Neodymium-doped yttrium aluminum garnet, NM: Nanometre.

four wavelengths available in the family of diode lasers: 810nm, 940nm, 980nm, and 1064nm. More so than a wavelength, the ability to change operational factors, such as pulse duration, is a better predictor of therapeutic efficacy. This is simply one of the several reasons why training is a crucial aspect in determining which laser to use. The current narrative review was planned to provide an overview of soft-tissue laser applications in orthodontics.

Table-2: Benefits of laser-assisted soft tissue surgery.

Conventional soft tissue Surgery	Laser assisted soft tissue surgery
<ul style="list-style-type: none"> • Less precise • Delayed haemostasis • Distortion of the anatomical margin • Bleeding during surgery makes working field less visible • No thermal damage to tissue • Increased tactile sensitivity 	<ul style="list-style-type: none"> • More precise • Sufficient haemostasis • Precise incision margin • No bleeding during surgery • Feasibility issues with operatory and costs • Lack of swelling and pain and increased patient comfort

Conventional versus laser surgery

In comparison to conventional scalpel surgery, laser surgery has several benefits (Table 2). With a more precise excision of soft tissues compared to conventional scalpel excision, a soft-tissue laser also coagulates blood vessels, shuts the lymph, sterilises the cut and ensures that the operative area is clean and disinfected. Laser soft-tissue surgeries are often performed with just topical anaesthesia, which is very advantageous in orthodontic clinic both for the clinician and the patient. Significantly less bleeding occurs (especially during frenectomy), with limited oedema, and no irritating stitches or unattractive periodontal dressings are required. Various studies have reported that laser excisions result in less scar tissue than traditional knife surgery.⁸⁻¹⁰ Furthermore, laser assisted surgery results in soft tissue margins that remain stable over time. Recent clinical studies have compared different laser-assisted surgeries against conventional scalpel surgeries (Table 3).

Clinical considerations

After choosing a laser, the essential soft tissue aspects, such as attached gingiva, biological width and depth of the pocket, must be addressed while planning majority of reconstructive procedures.¹¹ The term “attached gingiva” refers to the thick, stippled, dense, keratinised gingiva extending from free gingival groove to mucogingival junction. It is firmly linked to the bone underneath and is generally resistant to trauma and recession caused by brushing.¹² Removal of this keratinised tissue enhances the possibility of gingival recession. To help mitigate this risk, it is generally recommended to leave at least 1.0-2.0mm of keratinised tissue after any gingival excision surgery.¹³

Uses of soft-tissue lasers in orthodontic practice

With the advent of new orthodontic technologies, patients now expect faster completion of the treatment and although the use of soft-tissue lasers does not enhance orthodontic tooth movement, it helps by enabling access to the teeth for adequate bonding by undergoing gingival excision surgery. Thus, early bonding of brackets to teeth in their ideal position increases the effectiveness of orthodontic treatment.

Furthermore, soft-tissue lasers can be used for the following purposes:

Surgical uncovering of partially erupted teeth

During orthodontic treatment, orthodontists usually face a scenario where they must wait for tooth eruption in order to bond a bracket on its optimal position. The tooth may

Table-3: Research comparing conventional with laser-assisted oral soft tissue surgery.

Author / Country / Year / Study Design / Sample Size	Objective	Laser type	Laser assisted versus conventional soft tissue surgery
Lione et al. ³⁰ / Italy / 2020 / RCT / 60	To compare the use of the diode laser with conventional surgery for gingivectomy procedure.	810 nm diode laser	To compare the use of the diode laser with conventional surgery for gingivectomy procedure.
Shalawe et al. ¹⁰ / Italy / 2012 / PC / 30	To compare diode laser incision with conventional blade incision wounds after oral soft tissue biopsy.	1064 nm diode laser	Required less anaesthesia; achieved better haemostasis; decreased need for suturing; minimal post-operative pain; less severe inflammatory response.
Ahn et al. ²⁸ / UK / 2021 / CS / 4	To demonstrate uses of diode laser therapy in four clinical cases of orthodontics.	Diode laser	Safe and effective.
Dalvi et al. ³¹ / UK / 2021 / CS / 3	To evaluate the efficacy of an 810 nm diode laser for the surgical management of oral soft tissues related to orthodontic treatment.	810 nm diode laser	Safe, effective and justifiable over the conventional scalpel technique; Must be performed by trained and experienced clinicians only.
Haytac et al. ³² / Turkey / 2006 / RCT / 40	To compare the degree of postoperative pain experienced by patients after conventional and laser assisted frenectomy.	CO ₂ laser	Decreased postoperative pain and functional complications (speech, chewing) compared to scalpel technique.
Ize-Iyamu et al. ³³ / Nigeria / 2013 / RCT / 23	To compare the use of the 810nm diode laser with conventional surgery in the management of soft tissue mucogingival problems associated with orthodontic treatment.	810 nm diode laser	Required less infiltration anaesthesia; decreased bleeding during and after surgery; elimination of the need for sutures; decreased post-operative discomfort.
Bhat et al. ³⁴ / India / 2015 / RCT / 20	To evaluate the stability of the soft tissue margins after excision either with a laser or scalpel.	940 nm diode laser	Soft tissue margins were more stable and stay at the point they were excised with lasers when compared with scalpel.
Karimi et al. ³⁵ / India / 2015 / RCT / 19	To assess the feasibility of utilizing CO ₂ laser in place of scalpel in surgical treatment of epulis fissuratum.	CO ₂ laser	Results in reduced surgery time; improved haemostasis during surgery; better re-epithelialization of the wound; decreased need for suturing.

RCT: Randomised controlled trial, PC: Prospective cohort, CS: Case series, CO₂: Carbon dioxide, NM: Nanometre.

be partially erupted or not yet erupted but is visible underneath the soft tissue. In scenarios involving partially erupted teeth, orthodontists usually have three options: wait for natural eruption and then bond; move the tooth using an orthodontic bracket/attachment on the visible surface and reposition the attachment after access to the ideal position has been achieved; at the same visit, expose and bond the tooth on its optimum position.

Not only would the latter option save weeks to months of waiting time compared to the other two, but it would also shorten total treatment duration and minimise patient fatigue. The procedure with soft-tissue lasers is reasonably fast and simple with appropriate training.⁵

Occasionally, a tooth that has not yet erupted can be seen just underneath the gingiva. This is most often seen with permanent maxillary canines. Typically, topical anaesthetic gel is adequate for soft tissue resection in these instances. The diode laser may be aimed directly towards the tooth in order to remove enough gingiva for bracket placement.

Soft tissue excision for a space maintainer

If a deciduous second molar cannot be recovered or saved and the only therapy available is extraction, removal of this tooth without adequate space maintenance will complicate the orthodontic treatment. Therefore, space

maintainers are often needed in this situation, prior to the emergence of the permanent first molar.¹⁴ If the first molar has not yet begun to erupt, soft-tissue lasers may be used to make a tiny incision for the insertion of a distal shoe, or to expose sufficient gingiva to permit attachment/band insertion around it after it has begun to emerge.

Circumferential supracrestal fiberotomy (CSF)

CSF is one of the methods to aid in stability after orthodontic treatment for an excessively rotated tooth.¹⁵ Conventional method of CSF consists of a procedure utilising a surgical blade in which scalpel is typically used to release the supracrestal attachments i.e. epithelial and periodontal trans-septal fibres. Due to the limitations of traditional soft tissue surgery, lasers may be utilised for this purpose. While this surgery is capable of being done using diode lasers, better results may be achieved using CO₂ lasers as diode lasers are nothing more than heated glass tips which can heat up the adjacent bone.¹⁶ Since CO₂ lasers are absorbed 1,000 times more efficiently in the oral soft tissues than diode lasers, the likelihood of a CO₂ laser causing an increase in the temperature of the adjacent bone is minuscule.⁵

Treatment of gingival hyperplasia

Certain individuals may have trouble maintaining proper

oral hygiene while undergoing orthodontic treatment. This may cause gingival hyperplasia, which makes oral hygiene maintenance considerably complicated.¹⁷ For such conditions, non-surgical periodontal therapy is the primary management strategy. If pseudo-pockets or firm fibrous tissue persist after treatment, then simple resection or gingivectomy may eliminate the superfluous tissue, making oral hygiene maintenance simpler. Gingivectomy in a simple or less severe gingival hyperplasia can be performed using diode or CO₂ laser, but in severe conditions only CO₂ should be attempted. Even though diode lasers are effective in melting tiny regions of gingiva, their slow cutting speed and method of action, which involves melting tissue at temperatures ranging from 750-1250° Celsius render the procedure inefficient and time-consuming.⁴ For a more extensive duration, in the mucous membrane, a CO₂ laser that melts the tissue at 100°C might be preferable.

Frenectomy

Modifying a frenum is a very straightforward soft tissue surgery that may significantly decrease or eliminate a variety of issues. When there is a low-level attachment of labial frenum i.e. near to the gingival margin, it may result in gingival recession and midline diastemas. By simply releasing the vexing frenum, pressure is relieved and natural gingival contours are restored.

Furthermore, if the gingival heights are adjusted, the frenal attachment may become low-level. Therefore, when performing gingival resection, take notice of adjacent frenum attachments and release them if required. Too often, maxillary midline diastema closure is hindered by the frenum, hence, bloodless frenectomy with soft-tissue lasers is the treatment of choice.

Laser ankyloglossia release

During the growth and development phase, lingual frenum migrates away from the dorsum tip of the tongue towards its ventral surface.¹⁸ But in a few instances, it fails to migrate distally and results in tongue-tie or ankyloglossia. The complications of tongue-tie include constricted upper jaw, constriction of nasal airway, leading to possible sleep apnoea and reduced oxygen supply which may result in deficient maxillomandibular growth.¹⁹ During the medieval period, a midwife finished the release of the ankylosed tongue by using a sharp fingernail. As infection control expertise increased and medicine grew into a profession, doctors employing blades/scissors/scalpels supplanted this practice. There are three different techniques available now for releasing a frenum: radiosurgery/electrosurgery

• ; blade with scalpel; and soft-tissue lasers.

The after-effects of former two procedures, i.e. bleeding, delayed healing and soft tissue burn, have made lasers the standard of care for this procedure.²⁰ Wigdor et al.²¹ demonstrated the benefits of lasers for ankyloglossia release which included surgery that is dry and bloodless, sterilisation of the operative site immediately, bacteraemia reduction, and minimal mechanical trauma.

Uvulopalatoplasty for obstructive sleep apnoea

Obstructive sleep apnoea (OSA) is a group of sleep disorders where upper airway constriction leads to decreased airflow to the lungs. Due to the repetitive constriction of the upper airway during sleep, this condition may result in abnormally slow or shallow breathing (hypopnoea) and temporary cessation of breathing (apnoea), depriving the body of adequate oxygen (hypoxia) and sleep fragmentation.²² This results in symptoms, such as excessive daytime drowsiness, difficulty to focus, and memory impairment, ultimately impairing one's quality of life.²³ OSA requires multidisciplinary management, which includes medical, behavioural and surgical options. Oral appliance (OA), such as continuous positive airway pressure (CPAP), is considered the gold standard choice of treatment for OSA.²⁴ However, soft tissue surgery, or uvulopalatoplasty, may be considered a secondary therapy when OA therapy fails to improve clinical results, or when the patient is intolerant to OA therapy. Soft tissue laser-assisted uvulopalatoplasty has been reported as efficacious in the management of OSA in literature.²⁵⁻²⁷

Discussion

The current narrative review has demonstrated that the proper use of new surgical technology, such as lasers for soft tissue treatment, may offer prospective benefits in orthodontics. Surgical soft-tissue resections, such as gingivectomies, tooth exposures, frenectomies, and excision of hyperplastic soft tissues, may be performed safely using lasers. Furthermore, there are many benefits in utilising soft-tissue lasers, including pain management and the possibility of decreasing postoperative bacterial contamination. Additionally, the diode laser's photochemical effect, bio-stimulation, may promote wound healing and reduce postoperative pain. Patients often need soft-tissue resection surgeries during their orthodontic treatment, for which they are usually referred to periodontists and oral and maxillofacial surgeons, which may delay or complicate orthodontic treatment.²⁸ Conventional soft tissue surgeries by oral surgeons require local infiltration anaesthesia and a longer time for healing. A study²⁹ comparing anaesthetic use between conventional scalpel and laser-assisted soft tissue surgeries demonstrated that only 9.1% patients in the laser group

required local anaesthesia. Whereas a majority of patients who underwent oral soft tissue surgeries with conventional scalpel required local anaesthesia infiltration. This prolonged and uncomfortable therapy may raise the risk of infection and reduce patient satisfaction, which may in turn have a negative impact on a practice's cost-effectiveness and productivity. Orthodontists may now plan and conduct soft-tissue resection surgery on their own in clinics using soft-tissue lasers. Because patients are better acquainted with their orthodontists, they feel more secure and get psychological support during soft-tissue surgeries performed independently by orthodontists in clinics.

Laser education, training and recommendations

The majority of orthodontists believe that soft tissue surgeries using lasers are acceptable.³⁰ Notwithstanding the potential advantages of soft tissue laser use, very few orthodontists appear to be using lasers for soft tissue treatment. Soft tissue laser use is not part of postgraduate orthodontic training programmes in most countries and orthodontic laser guidelines are not currently available. Furthermore, through direct or scattered irradiation, improper laser device handling may result in accidental damage to surrounding tissues. Therefore, standard operating procedures (SOPs) ensuring the highest degree of protection, including protective eyewear, surgical warning signs indicating the use of a laser, and adequate window covering are required to mitigate possible safety hazards.

Conclusion

The innovation of laser-assisted soft tissue surgery in orthodontics is believed to be effective and safe, which provides benefits over traditional soft tissue surgery, including better therapy results and management of patients. It is anticipated that this initiative would encourage more orthodontists to explore laser surgeries that were previously reserved for other dental specialists.

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