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REVIEW ARTICLE

Therapeutic effect of laser on pediatric oral soft tissue problems: a systematic literature review

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Abstract
In recent years, extensive evidence has been published about usage of laser in oral lesions. The aim of the present study was to review the effectiveness of laser radiation in the treatment of pediatric oral soft tissue problems. The relevant keywords were searched in EBSCO, Medline (via Ovid), PubMed, Scopus, and Web of Science (WOS) databases. Then, eligible case series and controlled clinical trial studies, which published up to the end of 2018, were extracted and scrutinized. In this study, the age range of ≤ 21 years or the average age of ≤ 21 years was considered as the pediatric group. After limiting the search results, removing duplicate titles and eligibility evaluation, 17 papers were enrolled to the study (seven controlled clinical trials and ten case series). Er:YAG (2940 nm), CO_2 (10,600 nm), Er,Cr:YSGG (2780 nm), and diode (650, 660, and 975 nm) lasers indicated successful clinical results on mucocele excision, frenectomy, gingival incision and re-contouring, and treatment of vascular malformations. In addition, 660-nm diode laser radiation was an effective adjuvant treatment for halitosis and gingivitis induced by multi-bracket appliances. Reduction or absence of pain and bleeding, suitable homeostasis, reduction of operation time, less analgesic consumption, and antibacterial effect were among the advantages of the laser radiation in the studies. Laser as a main or adjuvant tool can have an effective role in surgical and non-surgical treatments of pediatric oral soft tissue problems. Conducting further randomized controlled trial studies on different soft tissue lesions can contribute to drawing better conclusions.

Keywords Laser · Oral · Soft tissue · Lesion · Disease · Children · Pediatric

Introduction

Hard tissue lesions, trauma, and congenital or acquired soft tissue lesions are the common problems of pediatric dentistry, respectively [1]. Oral soft tissue lesions claim 22% of pediatric referrals to dentists, among which aphthous ulcer, candidiasis and herpes infection, and traumatic damage to the mucosa are common [2, 3].

Dentistry interventions in children, especially due to their fears, have more complexity for the dentist [4]. In addition, limitations in taking therapeutic actions may lead to general anesthesia instead of local ones especially in younger ages, thereby further adding to the concern over complications caused by general anesthesia [4].

Management of pediatric' oral diseases with the approach of minimum invasion, shortest intervention time, and pain reduction alongside behavior guidance techniques can facilitate their treatments [5]. Accordingly, usage of adjuvant therapies can reduce the challenges of dentists when treating this group of patients.

Over the past two decades, great attempts have been made to investigate the effect of laser in treatment of oral diseases. Safety, low invasion, and minimal pain are among the characteristics of laser treatment. Further, shortening the time of surgical interventions and reducing excitability of pain terminals as well as the analgesic effect [6–8] can add to the advantages of laser. Regarding soft tissue, oral wound healing,

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antibacterial and antifungal effects, treatment of periodontitis, creating gingival re-contouring and mucosa incision, preparing biopsy, and regarding hard tissue, preparing access hole, endodontics treatment, and elevation of dentin hypersensitivity are among the applications of laser in dentistry [8, 9].

Clinical investigation of laser in pediatric dentistry has been performed less as compared with adults, and most available studies in pediatric are case studies and reporting their clinical usage [10, 11]. The aim of the present systematic review study was to investigate the effectiveness of laser in the treatment of pediatric oral soft tissue problems. In the review articles, which published on the present subject, limited results are available about the effects of laser. Furthermore, the characteristics of the studies such as type of study, number of subjects, radiation setting, and possible complications caused by laser have not been reported clearly in them [10, 11]. This study can reduce the deficiencies of previous studies by examining these characteristics. Also, the results of this study can be an introduction to conducting further randomized controlled trial studies in this regard.

Materials and methods

This systematic review was conducted and reported in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Checklist [12].

First, a list of pediatric oral soft tissue lesions [13–16] with a focus on its common cases was prepared, and the following keywords were extracted:

(laser OR phototherapy OR “photodynamic therapy”) AND (child OR children OR pediatric) AND (dentistry OR oral OR “oral lesion” OR “oral soft tissue” OR leukoedema OR “oral candidiasis” OR “angular cheilitis” OR “glossitis” OR “amalgam tattoo” OR mucocele OR “irritation fibroma” OR “pyogenic granuloma” OR “herpes labialis” OR “oral herpes” OR aphthous OR fibroma OR epulis OR “oral cyst” OR frenectomy OR gingivectomy OR gingivoplasty OR gingivostomatitis OR “oral ulcer” OR “oral trauma” OR “oral hemangioma” OR “oral lymphangioma” OR “oral vascular lesion” OR cheilitis OR stomatitis OR “oral wart” OR “oral papilloma”)

Then, the keywords were searched in five databases of EBSCO, Medline (via Ovid), PubMed, Scopus, and Web of Science (WOS). Next, the search results in each database were limited to English human clinical trials published up to the end of 2018 using the electronic items available in them. Thereafter, the remaining titles were transferred to Mendeley software (ver. 19.1). After integrating the titles of the mentioned databases, the repeated titles were removed and the remaining ones were submitted to three reviewers (A.S, F.K, M.F). The reviewers accessed the papers (abstract or text) in terms of study criteria.

The inclusion criteria were English papers, access to the full-text papers, human controlled clinical trial studies, case series studies with at least five similar patients, lip and oral soft tissue lesions, age ≤ 21 years or the mean age of ≤ 21 years, and laser intervention. The exclusion criteria included malignant lesions or chemotherapy or radiotherapy-induced lesions, having any underlying diseases, and lesions of other areas such as the skin, nose, larynx, and pharynx.

In this study, the age range or mean of ≤ 21 years was applied as the pediatric age groups [17]. Further, studies having at least five similar patients according to a recommendation were considered as case series studies [18] and studies with fewer than five patients or fewer than five similar patients were considered as case report [18, 19].

Next, the eligible papers were submitted to the third reviewer (F.K) in order to inspect them thoroughly. Out of the papers, the following information was extracted: type of study, number of patients, type of lesion and laser, wavelength, energy and power of laser radiation, clinical outcomes, and complications following laser treatment.

In cases with the control group, the therapeutic effect of laser was reported as effective (significant difference compared with the control group) and ineffective (no significant difference with the control group). Further, in case series studies, successful treatment of more than 90% of patients through laser therapy was regarded as effective outcome, while any need to pharmacotherapy or further operations to treat the lesions for more than 10% of patients was regarded as ineffective outcome. In addition, in some lesions such as vascular malformation, which may need several seasons of treatment, a reduction of 50% in their number or size was considered as an effective outcome.

Quality and risk of bias assessment

In order to evaluate the quality of the RCT studies, the CONSERT 2010 checklist was used [20], and for their risk of bias, a Cochrane Collaboration’s Tool was used [21]. The CONSERT checklist has 37 items. The positive items for each article were divided into 37 and expressed as percentage. The Cochrane Collaboration’s Tool divides the risk of bias into three grades of high (H), low (L), and unknown (U).

To check the quality of case series studies, the PROCESS checklist was used. This checklist contains 29 items. The number of positive items for each article was divided into 29 and expressed as a percentage. As we knew, there is no qualified checklist of risk of bias assessment for case series studies. However, a ROBINS-I tool (risk of bias in non-randomized studies of interventions) was used to assess risk of bias in case series studies, though it is more suitable for comparative studies. This checklist contains seven domains (Table 3), which divide risk of bias into five categories of mild, moderate, serious, critical, and no information on which to base a judgment [22]. The quality and risk of bias assessment was done by two reviewers and agreed together (M.F, S.E).

Results

Figure 1 demonstrates the flow diagram of the selection process for eligible papers. After electronic limiting of titles in each database, 3085 titles remained. By transferring the titles to Mendeley software and removing repeated titles, 2364 titles remained, which were transferred to three reviewers electronically. By investigating the titles, abstract, or text of papers, 2318 titles were removed by the reviewers. Figure 1 demonstrates the reasons of initial exclusion of papers. In item of "others" in Fig. 1, cases such as histological study, microbiology, and investigation of patient satisfaction were among the reasons of exclusion ($n = 11$). Eventually, 46 papers had the inclusion criteria. Among them, 29 papers were removed due to different reasons including not reporting the age of patients, unknown site of vascular lesions, phenytoin consumers who developed gingival hyperplasia, epidermolysis, malignancy, and mucositis caused by chemotherapy. In addition, two papers were clinical study protocol [23, 24], which one of them published its results [25]. Eventually, 17 eligible papers were thoroughly investigated by a reviewer. Table 1 shows a summary of the eligible papers.

Type of studies and number of patients

Five papers were randomized controlled trial (RCT) [25, 28, 31, 38, 40] and two were controlled clinical trial without randomization [27, 37]. One RCT study had a split-mouth design [40]. The 10 remaining papers were case series: five of them were prospective [29, 30, 34, 36, 38] and other were retrospective [26, 32, 33, 35, 41]. The number of all subjects in the studies was 914. Among them, 103 cases were in the control group of the controlled clinical trial studies. The control individuals underwent gingivitis treatment, frenectomy, or lingual scraper [25, 27, 28, 31, 37, 38, 40]. The maximum of average age of individuals was 20.9 years [33]. In four studies, the mean age of individuals had not been mentioned, but the subjects in them had an age range of 0–15 years [30, 34, 36, 41].

Type of lesions or problems

Laser radiation was used for treating vascular lesions in three studies [26, 29, 33], frenectomy in eight studies [27, 28, 30, 31, 34, 36, 37, 41], mucocele excision in four studies [30, 32, 34, 35], halitosis in two studies [25, 38], gingival incision and re-contouring in two studies [30, 34], gingivitis treatment induced by multi-bracket appliances in one study [40], and investigating the extent of healing and pain intensity following ranula and mucocele treatment in one study [39]. In two studies, different oral lesions underwent laser radiation [30, 34].

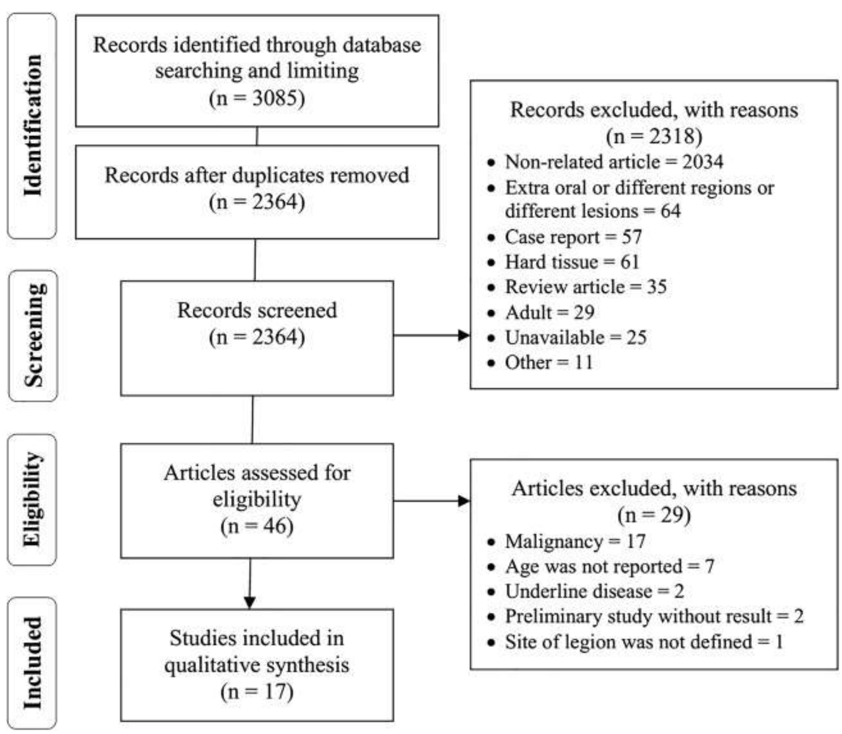

Fig. 1 PRISMA flow diagram of the articles selection process

Table 1 A summary of the articles. *R*, retrospective; *E*, effective; *Non-RCT*, non-randomized controlled trial; *RCT*, randomized controlled trial; *P*, prospective; *PDT*, photodynamic therapy

Reference	Author	Number of patients	Type of study	Age (year)	Type of lesion/surgery	Laser	Wavelength (nm)	Energy (J)	Power (W)	Result
[26]	Mungnirandr et al.	10	Case series (R)	7.3	Venous malformation	Nd:YAG	1064	–	3–50	E
[27]	Medeiros Júnior et al.	18	Non-RCT	21.2	Labial frenectomy	Nd:YAG	1064	40	4	E
		22		20.7		Surgery	–	–	–	
[28]	Kara	20	RCT	16.7	Labial frenectomy	Nd:YAG	1064	0.08	3.2	E
		20		16.2		Surgery	–	–	–	
[29]	Yang et al.	121	Case series (P)	19	Vascular malformation	Nd:YAG	1064	–	6.5	E
[30]	Hanna and Parker	51	Case series (P)	4–15	Frenectomy	CO_2	10,600	–	0.81	E
		40			Gingivectomy					
		5			Mucocele					
		4			Gingival re-contouring					
[31]	Pie-Sanchez et al.	25	RCT	11.3	Labial frenectomy	CO_2	10,600	–	5	E
		25				Er,Cr:YSGG	2780	–	1.5	
[32]	Wu et al.	30	Case series (R)	12.3	Mucocele	CO_2	10,600	–	–	E
		34				Surgery	–	–	–	
[33]	Glade and Buckmiller	17	Case series (R)	1–30.3	Lymphatic malformation	CO_2	10,600	–	30	E
[34]	Kato and Wijeyeweera	16	Case series (P)	0–15	Labial frenectomy	CO_2	10,600	–	3 or 4	E
		20			Lingual frenectomy					
		18			Mucocele					
		22			Gingival incision					
[35]	Huang et al.	82	Case series (R)	20.8	Mucocele	CO_2	–	–	5–8	E
[36]	Olivi et al.	143	Case series (P)	7–11	Labial frenectomy	Er,Cr:YSGG	2780	0.025,0.075	0.25–1.5	E
[37]	Stojanovska et al.	18	Non-RCT	10.6	Labial frenectomy	Diode	650	–	0.1	E
							975	–	6	
		18		15.6		Surgery	–	–	–	
[25]	Lopes et al.	16	RCT	13.5	Halitosis	Diode (PDT)	660	9	0.1	E
		15		14		Scraper				
		14		14.4		Scraper + Diode (PDT)				
[38]	Costa da Mota et al.	15	RCT	14.8	Halitosis	Diode (PDT)	660	9	0.1	E
		15				Scraper				
		16				Scraper + Diode (PDT)				
[39]	Amaral et al.	11	Case series (P)	17.4	Ranula and mucocele healing	Diode (InGaAsP)	660	3.2–5.4	0.1	E
[40]	Stein et al.	13	RCT (split-mouth)	16.2	Gingivitis	Diode	660	2	0.1	E
						Control	–	–	–	
[41]	Olivi et al.	20	Case series (R)	8–10	Labial frenectomy	Er:YAG	2940	0.15	2.25–3	E

Type of laser

Four studies used 1064-nm Nd:YAG laser [26–29]; five used 10,600-nm CO_2 laser [30–34]; two employed 2780-nm Er,Cr:YSGG laser [31, 36]; in four studies, 650-, 660-, and 975-nm diode lasers were radiated [25, 37–39]; and one study used 2940-nm Er:YAG laser [41]. Two studies used diode laser in combination with methylene blue as a photo synthesizer (photodynamic therapy = PDT) [25, 38]. Table 1 shows the mentioned wavelength, energy, and power of laser radiation in the studies. One study used combination of two wavelengths of diode laser (650 and 975 nm) [37].

Treatment outcomes

Laser in controlled trial studies had a better effect on frenectomy as compared with surgery [27, 28, 37], in combination with scraper on halitosis as compared with scraper [25, 38], and on gingivitis treatment induced by multi-bracket appliances as compared with laser in turn-off mode (placebo) [40]. In another study, CO_2 laser was preferred to Er,Cr:YSGG laser over the reducing operation time and a better homeostasis during frenectomy [31].

In case series studies, due to the reduction or absence of post-operative complications including bleeding, pain, better feelings of individuals, and less need to analgesics, laser indicated considerable advantages for treating oral soft tissue lesions including mucocele, pathologic frenulum, and vascular malformations. Further, in one study by a questionnaire, the patients had minor disability following the operation of vascular lesions [39]. Assuming treatment of $\geq 90\%$ of lesions by laser, need of further treatment or relapse less than 10% of cases, and at least a reduction of 50% in vascular malformation size, laser showed effective therapeutic role in all case series studies.

Vascular lesions

Vascular malformations affect about 1% of children in communities [42]. Some of these lesions, due to bulking effect, develop interference with the function of organs such as the eye and mouth. Some of them, through bleeding with different intensities, may be life-threatening. Further, aesthetic problems are among the other aspects of these malformations. Abnormalities of veins, arteries, capillaries, and lymphatic vessels can occur at different parts of the body [43]. Based on the site and size of lesions, different treatments are available. Corticosteroids, propranolol, interferon-2α, and interferon-2β are among the pharmacotherapies which relatively and gradually cause lesion shrinkage [36]. For lymphatic lesions, mostly surgery and sclerotherapy are used, and they have no specific pharmacotherapy [44, 45]. Today, lasers are considered as an effective therapeutic tool for these lesions [46].

Mungnirandr et al. in their retrospective study evaluated effect on 1064-nm Nd:YAG laser radiation on vascular malformation. They utilized 3–5 W power as an intra-tissue setting and 25–50 W as a non-contact radiation technique. Six of the patients (60%) received one session, and four patients received 2–5 sessions of laser radiation. According to the results, more than 50% reduction of color and size of lesions was observed in 70% and 60% of patients, respectively. Quasi-continuous wave as compared with continuous wave left less scar (5% vs 15%) and hypopigmentation (5% vs 10%) [26].

Yang et al. evaluated Nd:YAG laser radiation (power = 6.5 W) on oral vascular lesions. Laser radiation for lesions smaller than 3 cm was performed during one session, while the larger lesions underwent 2–3 sessions. The patients were then followed up for 6–24 months. During the first 3 days, the vascular protrusion began to shrink. During the first 3 weeks, the smaller lesions were healed. This time for larger lesions was around 1 month. The patients had no post-operative bleeding or severe pain. Incidence of necrosis and ulcer occurred in two and three patients respectively, which treated with topical agents and antibiotic completely [29].

Glade and Buckmiller evaluated patients undergoing CO_2 laser (power = 30 W) treatment for intraoral or pharyngeal lymphatic vessels lesions through a questionnaire. The patients underwent three times of laser radiation on average. Among their complications of interest were re-hospitalization, infection, difficulty in swallowing, and respiratory distress. All of the patients stated that their symptoms including swelling, bleeding, vesicle formation, and pain had improved. Further, 29% of them were able to eat after laser radiation, and only one case (6%) remained dependent on gastric tube. No post-operative complications were reported in their study [33].

Mucocele

Oral mucocele is categorized into two groups: extravasation, which caused by mechanical damage to the salivary tracts and cells and secretion of mucin to the extracellular space and the less common, retention type caused by mucin retention because of obstruction of salivary ducts or acini. Although mucocele can develop in any part of the mouth, the common sites of extravasation type are the lower lip and the ventral surface of the tongue, and in the retention type are upper lip and floor of mouth. The second decade of life is the most common time of its incidence, whose size varies from some millimeters to several centimeters [47]. Mucocele, given its size and site of lesion, has different manifestations including being asymptomatic to feeling of discomfort, pain, and functional disorder of the mouth. Traditional treatment for smaller lesions is surgical excision, while for larger lesions is marsupialization. Usage of laser especially CO_2 laser is one of the good methods due to high absorption of its photons in water; intra-lesional corticosteroid injection, cryotherapy, and micro marsupialization are among therapeutic methods of mucocele with less available evidence [48–50].

Wu et al. in a retrospective study compared removal of mucocele using electrosurgery and CO_2 laser. During 1 month of follow-up, the relapse was not significantly different between laser and electrosurgery groups (6.67% and 5.88% respectively). The non-closed lesion and prolonged wound healing were reported for one and two cases of the surgery and laser groups, respectively [32].

Huang et al. examined CO_2 laser radiation (power = 5–8 W) on the treatment of lower lip mucocele. During the monitoring of days 1 and 7, the patients did not complain about pain or bleeding. Only incidence of temporary paresthesia was observed in one patient. Two patients experienced relapse in the 3-month follow-up, who improved with second-time laser treatment in one patient and electrosurgery in the other [35].

Amaral et al. evaluated the effect of addition of 660-nm diode laser (power = 0.1 W, power density = 03.53 W/cm_2, energy density = 141 J/cm^2) on pain and healing following micro marsupialization of ranula and oral mucocele surgeries. Laser radiation was performed immediately and 24, 48, and 72 h after the operation. They investigated pain intensity for individuals younger than 7 years of age through visual analog scale, while for older ages, they used numeric rating scale. Following the operation, the patient had no pain or mild pain. The lesions healed during 30 days. After 6–18 months of follow-up, no infection or relapse was observed in the patients [39].

Frenectomy

Frenulum is a connective tissue attaching the tongue and lips to the floor of the mouth, vestibule, gums, or dental papilla [51, 52]. Papillary frenulum and frenulum with creating functional disorders necessitates its correction [51]. The pathological frenulum interacts with the function of lips and tongue, talking, chewing, swallowing, dental prostheses, and growth of facial bones [52]. The main treatment of a pathological frenulum is excision [51, 53].

Junior et al. compared frenectomy through Nd:YAG laser radiation (power = 4 W, power density = 5 W/cm^2, energy density = 50 J/cm^2) and surgery. They assessed the patient immediately and after 3, 7, and 15 days after the operation in terms of pain, the extent of analgesics consuming, and discomfort caused by talking and chewing. In the results, reduction of operation time and no need to suture were the advantages of laser. The extent of analgesic consumption and discomfort during talking and chewing was not significant between the two groups. Incidence of post-operative bleeding in one patient of the surgery group and two cases of bone surface exposure in the laser group was the post-operative complications. Also, no infection was observed post-treatment. After 45 days of mouth washing with chlorhexidine (0.12%), the bone surface was covered [27].

Nd:YAG laser (power = 3.2 W, energy = 0.18 J) in the study by Kara, 3 h and 1 and 7 days after frenectomy in comparison to the surgical knife, caused significant reduction in pain intensity as well as the ability to speak and chew [28].

Pie-Sanchez et al. evaluated frenectomy outcome, which performed by CO_2 laser (power = 5 W, power density = 1000 W/cm^2) and Er,Cr:YSGG laser (power = 1.5 W, energy density = 26.54 J/cm^2,12% water, 8% air). Patients were followed up for 4 months. In the findings, CO_2 laser showed superior effects; it had a shorter duration of radiation (30.4 ± 8.9 s vs 77.4 ± 19 s) and less bleeding during operation. In each group, only one patient needed analgesic drug. Complete healing in the CO_2 and Er,Cr:YSGG laser groups occurred in 21 and 14 days, respectively [31].

Stojanovska et al. observed that the intensity of pain and discomfort following frenectomy was significantly lower in the 975-nm diode laser group as compared with the surgery group. Reduction of operation time, no need to suture, and no bleeding were among the advantages of laser in their study. The duration of healing period was shorter in the surgery group, although the prescription of analgesic drug was higher in the laser group (38.9% vs 22.2%), which its difference was not significant [37].

Olivi et al. evaluated the effect of Er,Cr:YSGG radiation on frenectomy. In their setting, gradual increase and decrease in energy, power, and frequency of radiation occurred. Lower power (0.25–0.5 W) was used to enhance the threshold of pain and homeostasis, after which higher powers (1.5 W, 15% air,10% water) were used for cutting. The patients were followed up 3, 7, 21, and 30 days as well as first, second, and third years after operation. After frenectomy, the patients did not complain about pain. Also, no post-operative bleeding was observed. The wounds closed gradually without leaving any scar. Thirteen (8.3%) cases experienced relapse 21–30 days after operation. Through second-time laser therapy, 11 cases improved and had no relapse again. Accordingly, the success rate of laser treatment was recorded as 98% [36].

Olivi et al. in a retrospective study and 4 years of follow-up evaluated outcome of maxillary labial frenectomy by Er-YAG laser radiation (power 2.25–3 W, energy 0.15 J, air/water spray 4/5, water flow 25 ml/min). Children had no pain or experienced slight discomfort after operation and there was no bleeding or recurrence. In addition, the wounds closed completely with forming a thin scar tissue on the mucogingival junction [41].

Combination of lesions

Kato et al. evaluated CO_2 laser radiation on mucocele excision, upper lip and tongue frenectomy, and gingival incision. For all patients, topical anesthesia was used. During and after the intervention, most patients were pain- and bleeding-free. Also, there was no need to suture and no infection was observed. Wound healing occurred well and with minimum scar during 2–3 weeks [34].

Hanna and Parker investigated the effect of 10,600-nm CO_2 laser (power = 0.81 W, power density = 88.04 W/cm^2, water = 12 ml/min, air = 20–25 ml/min) in treatment of different oral lesions including mucocele, frenulum, gingival recontouring, and gingival excision for removing impacted molars. Maximum duration of radiation was 2 min. The individuals were interviewed during, immediately, and the 1 day after intervention. In the findings, the patients required fewer analgesic drugs. Older ages and more invasion were associated with more need to consuming analgesics. At least 96.7% of patients had very good satisfaction after 2 weeks of follow-up. Following frenectomy, speaking and tongue movements had satisfactory results. The wounds healed considerably and no scar and relapse of mucocele were seen [30].

Gingivitis

Orthodontic treatment, especially with fixed appliances, may cause complications such as gingival overgrowth, recession, invagination, and inflammation (gingivitis) [54, 55]. In a study, 40% of people who received orthodontic treatment experienced gingivitis [56]. It seems accelerated dental plaque formation, which contains biofilms, is the main cause of gingivitis in orthodontic patients. However, hormonal changes such as puberty stage, smoking, and oral hygiene levels are of the risk factors of gingivitis [57, 58]. The severity of gingivitis differs from mild bulging to necrosis. In addition, it may progress to periodontitis [59]. Gingivitis treatments include maintaining good oral hygiene, removing dental plaques, using mouthwash, and, if necessary, using antibacterial drugs and mechanical debridement [57, 60, 61]. Lasers have the antibacterial role [62, 63]. However, the therapeutic effect of lasers in the periodontal disease is not well-defined [64].

Stein et al. evaluated the effect of a 660-nm diode laser radiation (power = 0.1 W, power density = 0.1 W/cm^2, energy density = 2 J/cm^2) on gingivitis induced by multi-bracket appliances in a split-mouth design. In one upper quadrant, gingiva was radiated by laser buccally and orally, and in the opposite upper quadrant, gingiva received same procedure without laser radiation. Before radiation and after bracket deboning and professional tooth cleaning (base time), the two groups did not differ significantly in terms of papilla bleeding index and bleeding on probing. Five days after the intervention, the two mentioned indexes in the laser group more decreased significantly [40].

Halitosis

Halitosis is one of the reasons of impaired social functioning and anxiety [65]. True halitosis can be categorized into physiological and pathological groups. The physiological causes are due to the function of bacteria on remnants of food and dead epithelial cells on the tongue surface, which is felt mostly in mornings. Pathological conditions are mostly caused by oral factors such as periodontal disease and mucous lesions and less commonly extraoral etiology such as respiratory tract infection and gastroesophageal reflux disease. Management of halitosis involves diagnosing and resolving the etiology and underlying pathology and rule out false cases. In the next step, considering a better oral and dental hygiene, tongue scraping, use of mouthwashes with antibacterial agents such as chlorhexidine, and usage of materials such as zinc-containing creams, chewing gum, and mouth deodorant breath freshener sprays are among the ways for reducing halitosis [66].

Lopes et al. evaluated 660-nm diode laser radiation (power = 0.1 W, power density = 3.5 W/cm^2, energy density = 317.4 J/cm^2) on controlling halitosis in teenagers. In their study, first, the tongue was smeared with methylene blue as a photosensitizer, then laser radiated on the tongue for 9 min. Reduction in H_2S level)the gas produced from the activity of bacteria and involved in bad breath) by 88.6%, 97%, and 100% was observed in the laser, scraper, and combination of laser and scraper groups, respectively [25].

Costa da Mota assigned 46 teenagers in three groups of 660-nm diode laser (power = 0.1 W, power density = 3.54 W/cm^2, energy density = 320 J/cm^2), scraper, and combination groups. Photodynamic therapy was performed after smearing the tongue with methylene blue for 9 min in one session. In the findings, the combination, laser, and scraper groups had the minimum level of H_2S after the intervention, respectively. However, after 1 week, no significant difference was observed between the three groups. In terms of reduction of colony, the best impact was yielded by laser radiation, combination group, and scraper, respectively. However, only the difference of colony reduction between laser and scraper groups was significant. They concluded that laser radiation can immediately cause diminished halitosis [38].

Quality and risk of bias

Table 2 shows the quality and risk of bias in the RCT studies. In these studies, 31 to 33 items out of the 37 items of Concert Checklist were consistent with them.

Table 2 The quality and risk of bias assessment of the RCT studies based on modified CONSORT 2010 statement and Cochrane Risk of Bias Tool

Study	Medeiros Júnior et al. [27]	Stojanovska et al. [37]	Lopes et al. [25]	Costa da Mota et al. [38]	Kara [28]	Pie-Sanchez et al. [31]	Stein et al. [40]
Quality							
No. positive items	25/33	21/33	30/31	25/31	24/31	18/31	27/32
%	75.6	63.6	96.8	80.7	77.4	58.1	84.4
Bias							
Random sequence generation	H	H	L	U	H	U	L
Allocation concealment	H	H	L	U	L	U	U
Blinding of participants and personnel	H	H	U	H	U	H	L
Blinding of outcome assessment	U	U	U	H	U	H	L
Incomplete outcome data	L	L	L	L	L	H	L
Other (follow-up)	L	L	H	L	L	L	H

For example, the item of "Why the trial ended or was stopped?" was not relevant for them and was removed. Accordingly, their quality varied from 51.8 to 96.8%. The most common causes of decrease in quality were lack of randomization or its process reporting, blinding, registration in RCT databases, access to study protocol, and lack of presenting study limitations. In terms of risk of bias, lack of randomization or report of its process, and blindness were the most biases of the studies.

Table 3 shows the results of the quality and risk of bias in case series studies. In the PROCESS checklist, the item of "Any changes in the interventions during the course" was not relevant to them. Accordingly, the quality items in these studies were divided into 28. In the results, their quality was estimated 67.9 to 85.7%. The decrease in quality in some of them was influenced by the retrospective nature. Failure to presenting patient selection criteria, pre-surgical examinations, such as coagulation status, and the lack of reporting of study limitation and registration in any databases were the most reasons of reduced quality of the studies. In terms of risk of bias, in some studies, the laser was the only method of treatment. Accordingly, the following items, which were suitable for comparative studies, did not fit for them: bias due to confounding, bias in classification of interventions, and bias due to deviations from intended interventions. The limitation in presenting patient selection criteria and clinical assessment was of the most important biases among them. For example, using telephone for the patient assessment and filling a questionnaire were important limitations in evaluating the outcome of the treatment(s) [30, 33].

Discussion

In 13 reviewed papers, surgical or high-power lasers (power > 0.5 W, Nd:YAG, Er:YAG, Er,Cr:YSGG, CO_2, diode) were effective on gingival incision, gingival re-contouring, removal of mucocele, pathologic frenulum, and vascular malformations.

The optimal laser for oral soft tissue surgeries is not well documented. Various factors affect the use of a laser for soft tissue ablation. Laser beam penetration is a key feature for their surgical appliance. Lasers with a wavelength of 532–1100 nm have a high penetration depth in the aquatic environment such as mucosa; in other word, soft tissue exhibits poor wave absorption performance against these wavelengths. KTP, diode, and especially Nd:YAG lasers are in this group, which create deeper cuts and a better homeostasis during surgery. CO_2, Er:YAG, and Er,Cr:YSGG lasers have a lower penetration depth (less than 0.3 mm) [67, 68]. Additionally, diode and Nd:YAG lasers have a higher absorption potential in the pigmented tissues, such as mucosa and vascular lesions, which can improve their performance during oral soft tissue surgery [69, 70].

Fortunately, lasers in dentistry are greatly tolerable and acceptable for children, which can improve the treatment outcomes and make surgery and recovery easier [28, 30, 41, 71, 72]. Absence [33] or minimum post-operative complications such as bleeding, scar, and infection [26, 27, 29–32, 34, 41]; suitable homeostasis due to thermocoagulation effect [27, 29, 31–34, 41]; no need to suture [27, 34, 41]; absence of pain [37] or similar pain

Table 3 The quality and risk of bias of the case series studies based on PROCESS and ROBINS-I checklists

Study	Mungnirandr et al. [26]	Yang et al. [29]	Hanna and Parker [30]	Wu et al. [32]	Glade and Buckmiller, [33]	Kato and Wijeyeweera [34]	Huang et al. [35]	Olivi et al. [36]	Amaral et al. [39]	Olivi et al. [41]
Quality										
No. positive items	21/28	22/28	24/28	21/28	19/28	19/28	21/28	21/28	24/28	19/28
%	75	78.6	85.7	75	67.9	67.9	75	75	85.7	67.9
Bias										
Bias due to confounding	Moderate	–	Mild	Mild	–	–	–	–	–	–
Bias in selection of participants into the study	Mild	Serious	Serious	Mild	Serious	Serious	Serious	Serious	Mild	Serious
Bias in classification of interventions	Mild	–	Serious	Mild	–	–	–	–	–	–
Bias due to deviations from intended interventions	Mild	–	Mild	Mild	–	–	–	–	–	–
Bias due to missing data	Moderate	Serious	Mild	Moderate	Mild	Mild	Critical	Critical	Mild	Serious
Bias in measurement of outcomes	Moderate	Serious	Serious	Serious	Serious	Serious	Critical	Critical	Mild	Critical
Bias in selection of the reported result	Moderate	Moderate	Mild	Mild	Mild	Mild	Mild	Mild	Mild	Serious
Overall	Mild to moderate	Mild to serious	Mild to serious	Mild to serious	Mild to serious	Mild to serious	Mild to critical	Mild to critical	Mild	Serious to critical

with surgical procedure [27, 29, 31, 37]; and reduction of operation time [31, 41] added to the advantages of laser treatment.

In a study, bone surface exposed after a frenectomy by Nd:YAG laser radiation [27]. The incidence of these types of complications is not expected; accordingly, the dentist or physician's skill in using the deep-penetration laser can prevent over-removal of the tissues around the lesion.

In four out of 17 reviewed papers, biostimulator or low-power lasers (power ≤ 0.5 W, diode) tended to gingivitis treatment, control of pain, promote healing following marsupialization of ranula and mucocele [39, 40], and relief of halitosis under the photodynamic therapy protocol [25, 38]. Anti-inflammatory effect, accumulation of healing cells such as fibroblast, and collagen formation can accelerate tissue repair by laser radiation [73]. Modulating inflammatory response [74] and increase in the pain perception threshold by decreasing nerve impulse transmission [75] can explain analgesic effect of the low-power laser. Antibacterial effect of laser is a key mechanism [38, 62, 63], which confronts with halitosis.

Lack of randomized clinical trial studies in order to achieve a better understanding of the effect of laser radiation on pediatric oral lesions, lack of reporting of the method with further details, and the lack of precise definition of the clinical assessment of patients, as well as the retrospective nature of some studies, were the limitations among reviewed studies. Also, treatment of infectious lesions such as herpes and candidiasis as common pediatric oral lesions [2, 3] can be considered in future studies.

In summary, the findings of this study indicated that laser in both high- and low-power settings can be a safe and effective tool for treating some oral soft tissue lesions, and halitosis in pediatric. In addition, gingivectomy is a common procedure for exposing tooth, treatment gum hypertrophy, delayed tooth eruption, and cosmetic problems [76], which can facilitate by laser, as a hemostatic surgical blade, in comparison with conventional surgery. For a better comprehensive conclusion, more RCT studies on different oral lesions are required.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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