Reviews

Contemporary methods of treating venous lake lesions on the oral mucosa: A literature review

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Abstract

A venous lake (VL) is a vascular lesion arising from dilated venous vessels surrounded by thick fibrous tissue, located in the upper layers of the dermis. It can also appear in the oral cavity, especially on the lips, buccal mucosa and tongue. Recurrent bleeding or aesthetic complaints are the most common reasons for the treatment of these lesions. This review aims to present the current state of knowledge regarding the treatment of VL lesions in the oral cavity. PRISMA guidelines were followed. Articles were searched in the following databases: Pubmed, Medline and Scopus. The authors of this study analyzed scientific works concerning VL treatment. Keywords searched included "venous lake", "venous lake treatment", "sclerotherapy", "laser", "laser photocoagulation", "infrared coagulation", and "diathermocoagulation". Two articles described electrocoagulation, 10 articles focused on photocoagulation using laser devices, 2 articles studied photocoagulation with infrared, and 4 articles described sclerotherapy for the treatment of VL lesions. The most effective therapeutic options were electrocoagulation, 808 nm diode laser photocoagulation and 1064 nm Nd:YAG.

Key words: electrocoagulation, oral mucosa, sclerotherapy, laser photocoagulation, venous lake

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Introduction

A venous lake (VL) is a vascular lesion arising from dilated venous vessels surrounded by thick fibrous tissue, located in the superficial layers of the dermis.[1] It was first described in 1956 by Bean and Walsh.[2] It occurs most frequently in older people in areas of the body exposed to direct sunlight, such as the ears, face, hands, and lips.[3] Another location of these lesions is within the oral cavity with involvement of the labia, buccal mucosa and tongue. In the oral cavity, they manifest as well-defined, painless, navy blue or purple, usually single, convex lumps, ranging from a few to a dozen millimeters in diameter, and have a positive diascopic effect.[4] The characteristic clinical appearance is sufficient to make a diagnosis; therefore, collecting specimens for histopathological examination is usually not necessary. Research by Tobouti et al. reported that a VL is the 2nd most common vascular lesion in the oral cavity after pyogenic granuloma.[5] Recurrent bleeding or aesthetic complaints are the most common reasons for the treatment of these lesions.[6] An additional factor encouraging patients to undergo therapy is the fear of cancer transformation.[7]

Current methods of treating these lesions include surgical excision, cryosurgery using liquid nitrogen, electrocoagulation, infrared photocoagulation, laser photocoagulation, and sclerotherapy.[8–12] For the treatment of lesions located in the oral cavity, laser photocoagulation, infrared photocoagulation, electrocoagulation, and sclerotherapy are most often used. However, there is still no consensus which of these methods is the most effective. The gold standard is surgical excision, which has the lowest recurrence rate. However, it is associated with a longer recovery and more pain and scarring. These lesions are often located in aesthetically sensitive areas, which is a driving factor for the use of minimally invasive or selective treatment methods, free from the complications associated with surgical excision. Therefore, further research to standardize the treatment of VL lesions in the oral cavity using minimally invasive methods, considering the above facts, is justified.

There are few studies and articles in the scientific literature concerning the treatment of VLs in the oral cavity. Since this is a common clinical problem, especially in patients over 50 years of age, knowledge of treatment techniques is essential to improve this area of oral surgery.

Objectives

This review aims to present the current state of knowledge regarding the treatment of VLs in the oral cavity.

Materials and methods

This review aims to discuss the current treatment methods and the research conducted. The literature review was conducted in October 2023. It included publications from 1987–2023. Articles were searched in the following databases: PubMed, Medline and Scopus. The authors analyzed scientific works, especially in terms of innovative and minimally invasive approaches for the treatment of VL lesions. Key words searched included "venous lake", "venous lake treatment", "sclerotherapy", "laser", "laser photocoagulation", "infrared coagulation", and "diathermocoagulation". The inclusion criteria were full text articles in English published in peer-reviewed journals describing the treatment of VLs located exclusively within the oral cavity (case reports, case series and clinical trials). Letters to the editor, editorial comments and congress speeches were not analyzed in this study. Furthermore, articles that focused on the treatment of VLs located outside the oral cavity were not included in the analysis. Emphasis was placed on papers presenting unique information, expanding the review to include rarely published articles and innovative methods of treating VLs. Selected treatment methods were described, along with a discussion of the studies in which they were used.

Data selection

A total of 68 potentially relevant papers were found. Fifty publications were excluded due to a lack of a full text or duplications in the databases; those that were not relevant or included VL locations outside the oral cavity were also ommitted. Ultimately, 18 articles were included in the analysis (for most of the articles, PubMed and Medline gave similar results – we found 12 articles in the mentioned databases and 6 articles in Scopus). A workflow diagram of article selection is shown in Fig. 1.

Data collection

The collected data are presented in Table 1,[4,10,11,13–27] according to parameters such as authors, year of publication, number of lesions covered by the study, treatment method, healing period, results/conclusions, and post-treatment complications. We found 2 articles describing electrocoagulation, 10 articles focusing on photocoagulation using laser devices, 2 articles presenting photocoagulation with infrared lasers, and 4 articles describing sclerotherapy.

Results

Electrocoagulation

This method uses high-frequency electric current, causing a dramatic increase in the temperature of the tissues exposed to it.[28,29] It can be used to cut or burn soft tissue structures. The indisputable advantage of this method is the simultaneous coagulation of blood vessels that minimizes intraprocedural bleeding, which is highly desirable in the case of VLs. The technical approach to VLs may be the excision of these lesions or their coagulation. However, only the 2nd option is found in the literature for the treatment of oral VLs.

Poonia et al. performed electrocoagulation of a VL located on the lower lip using monopolar coagulation in 1 patient.[11] A modification of this method consisted of introducing a 20 G needle into the lesion, to which a monopolar

Table 1. Summary of venous lake treatment methods

Author/year	Number of treated lesions	Number of treatment sessions	Treatment method		Healing period	Local anesthesia	Results	Adverse effects	Follow-up observation
Migliari et al. 2015[4]	16	1	laser type	Nd:Yag	2–4 weeks	absent	full recovery	swelling disappearing after 1–2 days	–
			λ	1,064 nm					
			mode	contactless					
			modulation	IMP					
			power	2 W					
			energy density	–					
			spot diameter	–					
Ah-Weng et al. 2004[10]	20	1 (85%) 2 (10%) 3 (5%)	photocoagulation with infrared light		–	applied	full recovery (80%), partial recovery with scar formation (20%)	post-procedural bleeding (15%)	1–6 months
			number of pulses	2–4 pulses					
			pulse length	1.0–1.5 s					
Poonia et al. 2019[11]	1	1	electrocoagulation inside the lesion		no data	applied	full recovery	absent	18 months
Weiss et al. 2014[13]	8	1	electrocoagulation inside the lesion		no data	applied	full recovery	absent	3 months
Azevedo et al. 2010[14]	17	1	laser type	laser diode	2–3 weeks	applied	full recovery	slight swelling resolved after 2 days, minimal post-procedure pain, 5.9% (1 patient required painkillers)	–
			λ	808 nm					
			mode	contactless					
			modulation	CW					
			power	power: 2–3 W					
			energy density	20 J/cm^2					
			fiber diameter	300 µm					
Voynov et al. 2016[15]	35	1	laser type	laser diode	2–4 weeks	applied	full recovery	moderate post-procedure pain/2.8% (1 patient) post-procedure bleeding	–
			λ	980 nm					
			mode	contactless mode					
			modulation	CW					
			power	power: 2–3 W					
			energy density	224 J/cm^2 334 J/cm^2					
			fiber diameter	optical fiber diameter: 300 µm					
Wang et al. 2021[16]	41	1 (90.24%) 2 (7.32%) 3 (2.44%)	laser type	alexandrite laser	–	–	80.49% full recovery, 19.51% partial recovery,	scar – 1 case	–
			λ	755 nm					
			mode	–					
			modulation	IMP: 3 ms					
			power	–					
			energy density	50–90 J/cm^2					
			spot diameter	8 mm					

Table 1. Summary of venous lake treatment methods – cont.

Author/year	Number of treated lesions	Number of treatment sessions	Treatment method		Healing period	Local anesthesia	Results	Adverse effects	Follow-up observation
Yang at al. 2017[17]	17	1–2 (82.4%) 1–3 (17.6%)	laser type	PDL – air cooling	4–16 weeks	optional	82.4% full recovery, 17.6% partial recovery, including (5.9%) no response to treatment – relapse after a year	swelling lasting 2–3 days	3 months –6 years
			λ	595 nm					
			mode	–					
			modulation	IMP: 2–10 ms					
			power	–					
			energy density	7–11 J/cm^2					
			spot diameter	7 mm					
			laser type	Nd:YAG – air cooling					
			λ	1,064 nm					
			mode	–					
			modulation	IMP: 15–40 ms					
			power	–					
			energy density	35–40 J/cm^2					
			spot diameter	–					
Roncero et al. 2009[18]	39	1 (89.25%) 2 (10.75%)	laser type	PDL	12–14 weeks	present in $^1/_3$ of patients	full recovery (95%)	5.12% scar	–
			λ	595 nm					
			mode	–					
			modulation	IMP: 20 ms					
			power	–					
			energy density	10 J/cm^2					
			spot diameter	–					
			laser type	Nd:Yag					
			λ	1,064 nm					
			mode	–					
			modulation	IMP: 20 ms					
			power	–					
			energy density	70 J/cm^2					
			spot diameter	–					
Armogida et al. 2023[19]	50	1	laser type	Nd:Yag	4 weeks	absent	full recovery	small scar (2%)	2 years
			λ	1,064 nm					
			mode	contactless					
			modulation	IMP					
			power	–					
			energy density	100 J/cm^2					
			spot diameter	2.5 mm					

Table 1. Summary of venous lake treatment methods – cont.

Author/year	Number of treated lesions	Number of treatment sessions	Treatment method	Healing period	Local anesthesia	Results	Adverse effects	Follow-up observation
Chenung and Lanigian 2007[20]	8	1 (12.5%) 2 (25%) 3 (50%) 5 (12.5%)	laser type: PDL λ: 595 nm mode: – modulation: – power: – energy density: 8.5–13 J/cm^2 spot diameter: 7 mm	–	–	full recovery (25%), partial recovery (12.5%, no response (62.5%)	absent	–
Neumann and Knobler 1990[21]	51	1 (76.4%) 2 (9.8%) 3 (7.8%) 4 (5.8%)	laser type: argon laser λ: – mode: – modulation: IMP: 300 ms power: 1.8–3 W energy density: – spot diameter: 1.5–2.0 mm	10–20 days	optional (5.9% of patients received anesthesia)	full recovery (98.04%), recurrence (1.96%)	scars 10%	18 months
Trafalski et al. 2021[22]	23	1 (83%) 2 (17%)	laser type: diode laser λ: 980 nm mode: contactless modulation: IMP: 100 ms, 50% duty cycle power: 6 W energy density: – spot diameter: –	4–12 weeks	applied	full recovery (83%), scarring (9%), partial recovery (4%), no response to treatment (4%)	scars (9%)	3–6 months
Colver and Hunter 1987[23]	10	1	photocoagulation with infrared light number of pulses: 1 pulse length: 1.125 s	2–3 weeks	applied	full recovery (100%)	slight recess (20%)	4 months
Fernandez et al. 2020[24]	33	1 (85%) 2 (15%)	sclerotherapy chemical compound: 5% ethanolamine oleate volume: 0.3–0.9 mL	2–6 weeks	applied	full recovery	swelling, redness, burning sensation, lasting 1–3 days	3–6 months
Kuo and Yang 2003[25]	2	2	sclerotherapy chemical compound: 1% polidocanol volume: 0.6–1.0 mL	4 weeks	applied	full recovery (100%)	slight scar, hyperpigmentation (50%)	6 months
Cebeci et al. 2021[26]	25	1 (32%) 2 (28%) 3 (24%) 4 (8%) 5 (8%)	sclerotherapy chemical compound: 1% polidocanol volume: volume calculated based on the diameter of the lesion (0.3 mL/3 mm diameter of the lesion)	8–16 weeks	applied	full recovery (100%)	angioedema (8%), slight scarring and discoloration (8%), pain during the procedure	6 months

Table 1. Summary of venous lake treatment methods – cont.

Author/year	Number of treated lesions	Number of treatment sessions	Treatment method		Healing period	Local anes-thesia	Results	Adverse effects	Follow-up observa-tion
Jung et al. 2008[27]	12	1 (38.46%) 2 (30.77%) 3 (15.38%) 4 (7.69%) 5 (7.69%)	sclerotherapy		2–12 weeks	applied	full recovery (100%)	pain and par-esthesia during injection	10–49 months
			chemical compound	0.5% STS					
			volume	0.05–0.2 mL					

"–" – no data; CW – continuous wave; IMP – pulse mode; STS – sodium tetradecyl sulfate.

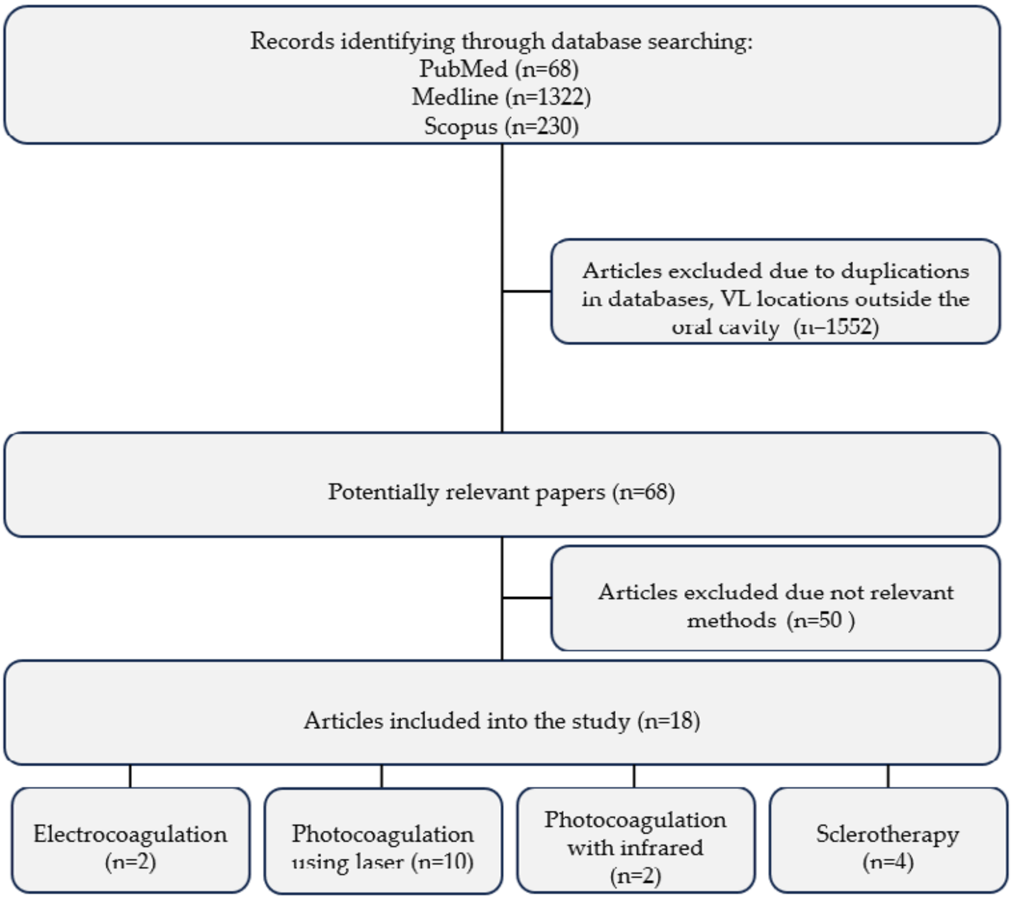

Fig.1. Workflow diagram of the articles selection

tip with an energy of 4 J was applied. Thanks to this solution, the energy was transferred directly to the inside of the lesion. The procedure was performed under local anesthesia. According to the researchers, the results were immediate, the healing process was uneventful, and full recovery was reached after 4 weeks. After 18 months, no recurrences were observed. This approach saves the mucous membrane overlying the lesion as well as the surrounding tissues, which proves the minimally invasive properties of this method.[11]

The same method of treating VLs was described by Weiss et al.[13] This study included 8 patients with lip lesions. The procedure was preceded by local anesthesia with 4% lidocaine. Through a 30 G injection needle inserted into the lesion, energy was delivered from a monopolar tip (McKesson 22-940™) with a power of 2 J. Immediate results were obtained with excellent cosmetic effects. After a 3-month observation period, full recovery of all lesions was observed and no side effects were detected. Researchers emphasize that this is a very effective and quick method for treating VLs with good aesthetic results. It also spares the mucosa overlying the lesion, proving the selectivity of this treatment option.[13]

Photocoagulation using laser devices

Lasers are a very attractive therapeutic option in the treatment of vascular lesions. Their operation is based on the theory of selective photothermolysis, described by Anderson and Parrish.[30] They proved that tissue chromophores can absorb specific wavelengths of light. Hemoglobin contained in the residual blood in the dilated vessels is 1 of the 4 tissue chromophores. Its largest absorption spectrum is in the range of 400–600 nm.

As the wavelength increases, its absorption decreases significantly, and it reaches another absorption peak, much weaker than the 1st one, which is in the range of 800–1,000 nm. The energy of the electromagnetic radiation is absorbed by the hemoglobin and is further transformed into thermal energy, causing blood coagulation and damage to the vessels, leading to their closure. The selection of laser devices in the treatment of VLs should consider the above properties of hemoglobin. Thanks to this, the impact of the laser beam is selective and limited mainly to the vascular lesion itself.[30]

Azevedo et al. researched a group of 17 patients using an 808 nm diode laser (Lasering 808; Revivre Italia SpA, Milan, Italy) to treat VLs of the oral cavity.[14] Exposure parameters were contactless mode, power of 2–3 W, optical fiber diameter of 300 µm, continuous wave operating mode, distance of the optical fiber from the lesion surface of 2–3 mm, average exposure time of 10 s, and an energy density of 20 J/cm^2. The procedure was preceded by local anesthesia and lasted until the lesion turned pale. If this result was not obtained, the procedure was repeated at 30-s intervals until successful to avoid overheating of the tissues. During the first 2 days after the procedure, participants observed slight swelling and minimal pain in the treated area. Only 1 patient required painkillers. After 2–3 weeks, all patients reached full recovery after only 1 session. Moreover, the recovery period was uneventful in all patients, without scarring or discoloration. The study authors emphasized that the contactless VL treatment technique using this laser is highly effective and simple.[14]

A different diode laser with a wavelength of 980 nm (LiteMedics, Milan, Italy) was used by Voynov et al., who included a group of 35 patients.[15] The procedure was preceded by superficial or infiltration anesthesia. The exposure was carried out in contactless mode with an optical fiber diameter of 300 µm, continuous mode and a power of 2–3 W. The exposure parameters and exposure time depended on the size of the VL and varied from 224 J/cm^2 at 2 W with a time of 20 s to 344 J/cm^2 at 3 W for 60 s. One session was sufficient for all patients to reach full recovery. Postoperative pain was minor, and 1 patient experienced transient bleeding. Recovery was reached within 2–4 weeks. The results of these studies also indicate that selective photocoagulation of VLs using a 980 nm diode laser is an effective and safe treatment method.[15]

Wang et al. used a 755 nm alexandrite laser (The Candela Gentle's Alexandrite Laser; Candela Medical, Marlborough, USA) to treat VL lesions on the lips in 41 patients.[16] The device was equipped with a Dynamic Cooling Device (DCD), and the area treated with the laser was covered with paper scarves with individually cut holes, exposing the lesion to avoid damaging adjacent tissues. The procedure was as follows: A spot width of 8 mm, pulse width of 3 ms and energy density of 50–90 J/cm^2. After the procedure, it was recommended to use erythromycin ointment for 3 days. Full recovery was reached in 80.49% of patients, and in 19.51% of patients, recovery was partial, with a reduction of the lesion in the range of 75–95%. Only 1 patient required 3 sessions, 3 patients required 2 sessions, and the remaining patients only required 1 session. One patient had a slight scar after treatment. Recovery was uneventful for all patients. The authors underscored the safety and efficacy of this method for the treatment of VLs. However, being aware of the use of many other types of lasers in the treatment of these lesions, they believe that the alexandrite laser requires comparison with other laser devices.[16]

A different approach was reported by Yang et al., who used 2 lasers emitting wavelengths of 595 and 1,064 nm.[17] The study included 15 Asians with skin phototype IV on the Fitzpatrick scale – a total of 17 VL lesions. Local anesthesia was used optionally before the procedure. First, a 595 nm pulse dye laser (PDL) was used, followed by a 1,064 nm Nd:YAG laser (Cynergy Multiplex; Cynosure Inc., Westford, USA). During exposure, continuous air cooling was used (Cryo 5a; Zimmer Medizinsysteme GmbH, Neu-Ulm, Germany). The exposure parameters were as follows for the PDL laser: A spot diameter of 7 mm, an energy density of 7–11.5 J/cm^2 and a pulse of 2–10 ms. For the Nd:YAG laser, an energy density of 35–40 J/cm^2 and a pulse of 15–40 ms was used. The authors reported that the selection of energy density was based on the color of the lesion, and the pulse width was based on the presumed diameter of the vessel. Applications of laser beams occurred consecutively without overlap. The treatments were repeated monthly until the changes disappeared completely. Post-treatment, it was recommended to use antibiotics (the study authors did not specify the type of antibiotic). After treatment, slight swelling was observed, which disappeared after 2–3 days. Full recovery was reached in 82.4% of patients after 1–2 sessions, while 17.6% reached partial recovery after 1–3 sessions. In 1 case, after 3 sessions, an improvement of 80% was achieved, with a recurrence of the lesion 1 year after the end of treatment. The authors explained this therapeutic approach by the fact that the absorption spectrum of hemoglobin coincided with the emission spectrum of both devices. However, a 596 nm PDL penetrates tissues to a depth of 1.5 mm, while the Nd:YAG 1,064 nm penetrates approx. 3.7–6.0 mm, which may result in the coagulation of vessels at various depths. The order in which the devices were used was because the PDL 595 nm transforms oxyhemoglobin into methemoglobin, which absorbs 1,064 nm Nd:YAG laser radiation 3 times more than oxyhemoglobin. Therefore, it is possible to use lower energy densities of the 1,064 nm Nd:YAG laser while maintaining its effectiveness and reducing side effects. The authors believe that this treatment method is effective and safe in Asians, although a lower energy density of the 1,064 nm Nd:YAG laser was used than in studies conducted on Caucasian patients.[17]

A similar therapeutic approach was characterized in the study by Roncero et al.[18] They used 2 PDL lasers: 595 nm and a Nd:YAG 1,064 nm laser (Cynergy Multiplex) to treat 39 VLs in 30 patients. Infiltration anesthesia was used in $^1/_3$ of patients (mepivacaine 2%). For irradiation, a PDL laser of 595 nm, 20 ms, and 10 J/cm^2 was used first, followed by a Nd:YAG laser of 1,064 nm, 20 ms and 70 J/cm^2. The spot width in both cases was 7 mm. The procedures were performed under air cooling. After the procedure, a 2% mupirocin ointment was applied topically. Response to treatment was assessed after 3 months. One therapeutic session was required in 89.75% of patients and 2 sessions in the remaining patients. Full recovery was reached in 95% of patients. Among the side effects, the formation of a slight scar in 2 cases (5.12%) was observed. Researchers believe that the use of 595 nm PDL and 1,064 nm Nd:YAG lasers provides a safe, rapid and effective treatment option for oral VLs. By using these lasers in succession, better coagulation is achieved, especially in the case of deeper lesions.[18]

A 1,064 nm Nd:YAG laser (Synchro FT Deka, MELA s.r.l., Calenzano, Italy) was also used in the study by Armogida et al.[19] They examined a group of 47 patients with 50 VL lesions. They carried out exposure to lesions in a contactless mode with exposure parameters of 100 J/cm^2, spot diameter of 2.5 mm and total emitted energy of 4.9 J using continuous operation mode. The procedure was not preceded by anesthesia. The exposure continued until the lesion turned gray, the exposure time ranging from 30 to 120 s. Only 1 treatment session was required for all patients. Full recovery was reached in 47% of cases after 7 days and after 30 days in all lesions. Patients rated periprocedural pain at 1.86 on a 4-point scale. However, after 24 h, the pain level was 0. No complications were observed, except for 1 case of small scar formation. The observation period was 2 years. This procedure was shown to be effective and safe as it did not require anesthesia and resulted in the complete healing of all lesions.[19]

A 1,064 nm Nd:YAG laser (Power Laser TM ST6; Lares Research®, San Clemente, USA) was also used in the study by Migliari et al.[4] The study included 16 patients. The procedure was preceded by local anesthesia. The operating parameters of the laser device were as follows: a power of 2W, pulse frequency of 50 Hz and exposure time of 10 s. Irradiation was performed in a contactless mode with a 320 μm diameter optical fiber placed at 2–3 mm from the lesion, using fast circular movements. The procedure was performed until the VL turned pale and decreased. If necessary, another cycle was performed after 30 s to prevent heat damage to the tissues. In all patients, 1 therapeutic session was enough to reach full recovery. In all cases after treatment, investigators only observed swelling of the treated area, which lasted 1–2 days. No pain or bleeding was observed in any of them. The healing period was 2–4 weeks. After healing, none of the typical side effects, such as scars, discoloration or hyperpigmentation, were observed. Researchers demonstrate that this technique provides safe and effective treatment of VLs in the oral cavity with clear results.[4]

Chenung and Lanigan used a PDL 595 nm laser (Candela Vbeam; Candela Medical).[20] They included 8 patients in their study. The operating parameters of the laser device were as follows: an energy density of 8.5–13.0 J/cm^2, a spot diameter of 7 mm and a pulse length of 1.5 ms. Additionally, they used cryogenic spray cooling. The number of therapeutic sessions ranged from 1 to 5. In subsequent treatment sessions, the energy density was increased by 0.5–1.0 J/cm^2. Only 2 patients had full recovery (25%), and 1 had partial recovery (12.5%). The remaining patients did not respond to treatment, or the response was unsatisfactory. No complications were reported during healing. Due to the unsatisfactory results, the researchers suggested pressing the lesion with a transparent glass during exposure to increase the depth of beam penetration, as well as extending the pulse width, which could improve clinical results.[20]

An argon laser (Coherent Medical Group, Palo Alto, USA) with blue and green light with a peak output power of 488 nm and 514 nm was used by Neumann and Knobler.[21] The study included 51 patients with lip lesions. No anesthesia was used before the procedure except for 3 patients. The exposure parameters used a power of 1.8–3.0 W, a spot diameter of 1.5–2.0 mm and a pulse width of 300 ms. The healing period ranged 1.5–12 weeks. Patients were followed up for 18 months. Full recovery was reached in 98.03% of patients. Among the side effects, they observed scar formation in 10% of cases. One therapy session was required in 76.4%, 2 in 9.8%, 3 in 7.8%, and 4 sessions in 5.8% of participants. After 18 months of follow-up, 1 patient experienced a recurrence. According to researchers, the argon laser is a safe and effective therapeutic option for the treatment of VLs.[21]

Further research using a 980 nm diode laser (Smart M; Lasotronix, Piaseczno, Poland) was conducted by Trafalski et al. This group included 23 patients.[22] The procedure was preceded by local anesthesia with 10% lidocaine. Exposure parameters were a pulse mode, an output power of 6 W, a pulse width of 100 ms, and a 50% duty cycle. In 83% of patients, 1 therapy session was required, and in 17%, 2 sessions were required. The modification of the method consisted of contactless exposure through a microscope slide placed with light pressure on the lesion to reduce its vertical dimension and penetrate the beam deeper into the lesion. The healing assessment was based on an innovative method of fractal dimension analysis (FDA), texture analysis (TA) and graphic images of these changes taken before treatment and 1 and 12 weeks after treatment. Full recovery was reached in 83% of patients and scar formation was observed in 9%. In the remaining 4%, partial recovery occurred, and in 4%, there was no response to treatment. Researchers reported no side effects. They emphasized that the use of a 980 nm diode laser is effective and safe in the treatment of VLs. Moreover, they reported that FDA and TA is a useful and objective method for assessing the effects of the treatment for these lesions using a diode laser.[22]

Photocoagulation with infrared light

This method uses an infrared coagulator that emits incoherent radiation in the range of 400–2,500 nm. The maximum output power of the device is in the infrared spectrum. The radiation is delivered through optical fibers to a quartz tip, which is applied directly to the lesion being treated, causing tissue heating and coagulation. The dose of emitted energy can be adjusted in terms of power and pulse length. Coagulators can typically generate pulses in the range of 0.5–3 s. The coagulation depth is several millimeters and is approximately equal to the pulse duration. However, pulses longer than 3 s cause charring and burning of tissues. This device provides excellent hemostasis without the release of gases that are present when using laser surgery or electrocoagulation. Infrared light photocoagulation is used to treat various lesions, such as hemorrhoids, condylomas and benign cervical lesions.[31,32] It is also a therapeutic option in the treatment of VLs located in the oral cavity.

Colver and Hunter treated 9 patients with a total of 10 VL lesions using an infrared coagulator (Model IRK 151, MBBAT; Lumatec GmbH, Deisenhofen, Germany) with a quartz tip diameter of 6 mm.[23] The therapy was preceded by local anesthesia in the form of 1% lidocaine hydrochloride. Before activation, the sapphire tip was applied with light pressure to the lesion to empty it of residual blood. The treatment was performed with 1 pulse lasting 1.125 s. After 2–3 weeks, full recovery of all lesions was observed, but in 2 patients, a small depression occurred in the treated area. After 4 months, no recurrences were noted. In all cases, only 1 treatment session was required. The authors suggested that in subsequent studies, the pulse duration should be shortened to 1 s to minimize the complications they noted in 2 cases. Researchers consider this method effective, quick and safe in the treatment of VLs.[23]

Ah-Weng et al. treated 18 patients with 20 VL lesions on the lips using an infrared coagulator (IRK151; Lumatec).[10] The procedure was preceded by local infiltration anesthesia with adrenaline, and the tip was placed with slight pressure on the lesions to empty them of residual blood. The number of pulses ranged from 2 to 4. The initial infrared pulse had a length of 1 s with subsequent pulses being increased by 0.125 s, reaching a maximum value of 1.5 s. The procedure continued until the lesion faded, along with a 2-mm margin around the VL. Patients were observed for 3–6 months after the end of treatment, with an average of 3 months. Full recovery was reached in 16 cases, and in 4 cases, partial recovery was reached with the formation of a slight scar at the treatment site. In 17 cases, 1 therapeutic session was sufficient, in 2 cases, 2 sessions, and in 1 case, 3 sessions were required. No healing complications were observed, except for 3 cases of postoperative bleeding. The observations of the authors of this study show that this method is effective, resulting in good therapeutic and cosmetic effects.[10]

Sclerotherapy

This is a therapeutic method that involves closing a fragment or longer section of a vein or artery by administering an appropriate substance causing obliteration. The mechanism of action of sclerosing substances is to react with the vascular endothelium, bringing about its destruction.[3,33] The effect on the endothelium additionally leads to the formation of a plug made of dead endothelial cells, fibrin and blood elements. The plug is firmly attached to the wall of the obliterated vessel, which prevents it from traveling along with the blood flow. As a result, the vessel lumen is closed and filled with fibrous connective tissue.[34,35] The most commonly used sclerosing agents include hypertonic glucose solution, alcohol (ethanol), ethanolamine oleate (EO), bleomycin, polidocanol, sodium tetradecyl sulfate (STS), and OK-432.[36] However, it is still unknown which sclerosing agent is best in terms of effectiveness and safety. Sclerotherapy is used primarily to treat venous and lymphatic diseases, telangiectasias, esophageal varices, hemorrhoids, and varicose veins.[36–39] It may also be considered a therapeutic option for VLs located in the oral cavity. Due to their low costs and satisfactory results, this therapeutic approach is widely practiced.

Fernadez et al. conducted a study on a group of 33 patients using 5% ethanolamine oleate (EO) (Ethamolin; Zest Pharma Ltda., Rio de Janeiro, Brazil).[24] The volume of the solution was calculated based on the diameter of the lesion: 0.1 mL/1 mm of lesion diameter. The total volume ranged from 0.3 mL to 0.9 mL. Before the procedure, infiltration anesthesia with a vasoconstrictor was used. One therapy session was required in 85% of patients, and in the remaining cases, 2 sessions were needed. The procedure was repeated after 3 weeks in cases where 1 session was insufficient to obtain satisfactory results. The size of the treated lesions ranged from 3 to 10 mm. Complications in the form of scarring and discoloration were not reported, but most patients reported some discomfort after the application of the sclerosing agent, such as pain, swelling, redness, and burning, which lasted from 1 to 3 days. Healing of the lesions occurred within 2–6 weeks. In all cases, there was a complete regression of the changes, and observations were carried out for 3–6 months after the procedure. The authors' conclusions support that sclerotherapy with EO is an effective, inexpensive and predictable method for the treatment of VLs on the lips in elderly patients.[24]

Kuo and Yang used 1% polidocanol in 2 patients with VLs on the upper lip.[25] They injected the sclerosing agent into the lesion using a needle and insulin syringe. The volume of sclerotization was 0.6–1.0 mL. The preparation was administered until the residual blood was removed from the lesion; then, the researchers applied 10 min of pressure to the treated area. The changes disappeared after 2 sclerotherapy sessions. The healing period was 4 weeks. In 1 case, an inconspicuous scar and hyperpigmentation occurred. The observation period was 6 months.

The authors believed that sclerotherapy with this agent is efficacious and represents a viable alternative to other therapeutic methods for treating VLs.[25]

Another group of 25 patients with lip lesions treated with 1% polidocanol was described by Cebeci et al.[26] The volume of the sclerosing agent was calculated based on the diameter of the lesion – 0.1 mm^3/1 mm of lesion diameter. The agent was administered using a syringe and insulin needle until the blood was emptied from the lesion. Then, pressure was applied for 5 min. All changes regressed completely. The healing period was 2–4 months. The follow-up period was 6 months from the last treatment. Only 1 session was required in 32% of patients, 2 sessions in 28%, 3 sessions in 24%, 4 sessions in 8%, and 5 sessions in 8%. The number of sessions depended on the size of the VL. In the case of a diameter not exceeding 3 mm, the number of sessions ranged from 1 to 2. For lesions with a diameter of 4–6 mm, the number of sessions ranged from 1 to 4. However, in the case of lesions with a diameter of 7–8 mm, 3–5 therapeutic sessions were required. The interval between subsequent sessions was 3 weeks. In 2 cases, minor scarring and discoloration occurred. The adverse effects included local angioedema in 2 cases. Cebeci et al. emphasized that this treatment method is both effective and simple, with excellent therapeutic and cosmetic results.[26]

Jung et al. included 12 patients with 13 lesions on the lips in a study using 0.5% STS.[27] The size of the lesions ranged from 2 to 10 mm. To establish the correct diagnosis, a 2 mm punch biopsy was performed before treatment. The biopsy material was assessed by histopathological examination. The sclerosing agent was injected slowly into the lesion using a needle and insulin syringe until it was emptied of residual blood. Then, alternating pressure was applied for 10 min. The volume of this agent was 0.05–0.20 mL. Patients were followed up after 2 weeks, and the treatment was repeated until the lesion disappeared completely. All patients reached full recovery. In 32% of patients, only 1 session was required. In 28% of patients, 2 sessions were sufficient. In 24% of patients, 3 sessions were necessary. Eight percent of patients required 4 sessions and 8% of patients required 5 sessions. The recovery period ranged between 2–12 weeks. The mean follow-up period was 29.58 months (10–49 months). No complications, such as necrosis, hyperpigmentation, swelling, or inflammation, were observed. Moderate pain and paresthesia during injection were observed in some patients but disappeared quickly. The authors emphasized that the above method was effective and acceptable to patients.[27]

Discussion

Therapeutic options for VLs that occur in aesthetically sensitive areas should primarily include a minimally invasive approach and highly cosmetic treatment results. Based on the data collected in this review, it can be concluded that the most frequently chosen therapeutic option for these lesions is photocoagulation using various laser devices. Their usefulness is supported by ease of use, good treatment results and a small number of adverse effects. The lasers used in this area included a PDL 595 nm, diode laser 980 nm, diode 808 nm, Nd:YAG 1,064 nm, alexandrite laser 755 nm, and argon laser with peak output powers of 488 nm and 514 nm. According to the theory of selective photothermolysis, their highly effective results are attributed to the perfect absorption of the emitted electromagnetic radiation by a tissue chromophore, which is hemoglobin.[30] It absorbs the laser energy and turns it into heat, which is then transferred to the walls of the vessels, causing them to coagulate and close. Thanks to this, laser surgery is becoming the gold standard for the treatment of minor vascular lesions. Due to the greatest absorption of radiation in the range of 400–600 nm by hemoglobin molecules, devices such as PDL 595 nm and argon lasers of 458 nm or 514 nm should be promoted.[40] However, the depth with which the beam of these devices penetrates the tissues is only 1.5–2.0 mm, covering only superficial changes. It should also be noted that this wavelength of light is absorbed by melanin much more strongly than near-infrared radiation. This is important when the treated lesions are on the verge of the lips and in patients with a dark complexion. This may result in a greater risk of skin damage if a VL is on the lips. Especially in these patients, devices emitting radiation in the near-infrared range should be preferred to limit epidermis damage and complications such as skin discoloration. It should be remembered that as the wavelength increases, the laser beam penetrates deeper into the tissues, which significantly improves the treatment of larger or deeper lesions. Therefore, diode lasers emitting radiation at 808 nm and 980 nm and Nd:YAG 1,064 nm, whose emission spectrum is less absorbed by hemoglobin than the emission spectrum of lasers emitting shorter wavelengths, provide better results in the treatment of VLs. An interesting solution is the use of lasers with different emitted wavelengths – PDL 595 nm with a Nd:YAG 1,064 nm laser. The justification for this method is the previously mentioned fact of a different depth of tissue penetration and the electromagnetic radiation emitted by them. In addition, the PDL 595 nm laser used as the first one converts oxyhemoglobin into methemoglobin, which has 3 times the absorption of 1,064 nm ND:YAG laser radiation than normal blood. This effect allows the use of lower energy densities of the 1,064 nm Nd:YAG laser, maintaining its effectiveness and reducing the risk of side effects.[41] However, the test results do not confirm that this option is significantly more effective than using only the 1,064 nm Nd:YAG laser.

Analyzing the treatment results, the best results were obtained using an 808 nm diode laser and a 1,064 nm Nd:YAG laser, reaching full recovery in all treated lesions.[4,14,19] The use of a 980 nm diode laser was characterized by full recovery in 83–100% of lesions,[15,22] an argon laser with a peak output power of 488 nm and 514 nm in 98.03%,[21] an alexandrite laser 755 nm in 80.49%,[16] and a PDL 595 nm in 25% of cases.[20] The use of a 595 nm PDL laser with a 1,064 nm Nd:YAG laser resulted in a full recovery rate of 82.4–95.0%.[17,18] The above data support a higher effectiveness of devices emitting radiation in the near-infrared range, even though hemoglobin is characterized by a lower absorption of radiation in this range. However, it is difficult to compare the results of studies conducted using different lasers. This is due to the different number of treated patients and the use of different radiation parameters. Moreover, the lesions treated varied in size, which may additionally influence the treatment results. Therefore, further research on the standardization of irradiation parameters of VLs is of key importance in this field.

The 2nd most common therapeutic option for the treatment of oral VLs is sclerotherapy. The most used agents are 1.0% polidocanol, 5.0% EO and 0.5% STS. The research results indicate that this is a simple, very effective and inexpensive treatment method. A VL is considered to be a low-flow lesion. Therefore, injecting a sclerosing agent inside the VL allows the achievement of a therapeutic concentration, resulting in an appropriate response to treatment. Sclerosing agents such as polidocanol, EO and STS are characterized by low toxicity. However, it should be remembered that when using them, side effects may occur, such as tissue necrosis, allergic reactions or discoloration. In studies using these agents, full recovery was reported in all cases, which is only possible when using a 1,064 nm Nd:YAG laser and an 808 nm diode laser and electrocoagulation. However, complications in the form of scaring and hyperpigmentation were more common than complications when using diode 808 nm lasers, Nd:YAG 1,064 nm lasers and electrocoagulation. Moreover, for sclerotherapy, the number of therapeutic sessions necessary to reach full recovery is much larger and ranges from 1 to 5. Therefore, this may encourage clinicians to use other, more effective methods that require fewer treatment sessions. This discrepancy is primarily due to the different sizes of the lesions treated and the agents used. Analyzing the results of sclerotherapy, it appears that as the size of the VL increases, the number of sessions needed to reach full recovery may increase. This is particularly visible in the cases using 1.0% polidocanol and 0.5% STS, where the number of sessions increased significantly with the increased size of the lesion and ranged from 1 to 5 sessions.[25–27] However, for 5% EO, the number of sessions ranged from 1 to 2, which indicates that the size of the treated lesions has a much smaller impact on this factor.[24] Therefore, the use of 5.0% EO is more beneficial than 1.0% polidocanol and 0.5% STS.

Another method, less frequently used, is photocoagulation with infrared light.[10,23] The emitted incoherent infrared radiation results in similar results to the use of laser devices. Full recovery in the analyzed studies was reached in 80–100% of cases. It is a contact technique, and an important element of it is compressing the lesion before irradiation to empty it of residual blood. This minimizes the energy needed to coagulate pathological vessels, thus increasing the precision of the procedure and preventing the formation of scars. Despite very good treatment results, it is difficult to consider it as the method of choice in the treatment of VLs in the oral cavity. This is because the number of therapy sessions needed to reach full recovery ranges from 1 to 3. Moreover, researchers using it have observed complications in the form of depressions at the treatment site, which is undesirable in the case of aesthetically sensitive areas. Clinicians using this method suggest shortening the pulse length to 1 s to improve its effectiveness and minimize side effects. Therefore, further research in this direction, especially on larger numbers of patients, should be conducted.

The least frequently used treatment method for oral VLs is electrocoagulation. In the analyzed studies, it was modified by introducing a needle into the lesion, to which an active monopolar diathermy electrode was applied.[11,13] Thanks to this, the energy of the device is transferred directly to the interior of the lesion, which provides the selective nature of this technique. This procedure allows you to save the surrounding mucosa, which is confirmed by the results of the conducted research. Moreover, using this method, it is possible to reach full recovery of lesions with only 1 therapeutic session. Such results were obtained only when using an 808 nm diode laser and a 1,064 nm Nd:YAG laser. Additionally, no side effects were observed using this technique. Therefore, this therapeutic option can be considered the method of choice in the treatment of VLs in the oral cavity. However, the small number of patients treated with this method does not allow us to clearly state that it is as effective as photocoagulation with an 808 nm diode laser and Nd:YAG.

It is also worth mentioning that the assessment of the results of the healing of VLs may be influenced by the bias of the researchers or the inaccuracy of the assessments. There are no qualitative and fully objective methods for assessing the healing of VLs. Subjective scar assessment scales are used, such as The Stony Brook Scar Evaluation Scale (SBSES), Manchester Scar Scale (MSS), Patient and Observer Scar Assessment Scale (POSAS), and Vancouver Scar Scale (VSS).[42,43] It is worth mentioning that Trafalski et al. took up such a challenge using TA and FDA on graphic images of the treated lesions.[22] They analyzed photographs of VLs before the procedure, 7 days, and 3 months after the procedure to monitor the healing process. Additionally, after 3 months, they compared the healed areas with the adjacent healthy mucosa, which served as a control group for the treated lesions. Their results were based on the mathematical analysis of digital images, which made them free from subjective assessment. The authors emphasize that FDA and TA are useful and objective methods for assessing the effects of diode laser treatment of VLs, which should encourage other clinicians to use it when evaluating other treatment options.

Analyzing the research results in this review, it was shown that the most effective therapeutic options for the treatment of VLs in the oral cavity are electrocoagulation, photocoagulation with an 808 nm diode laser, and Nd:YAG.[4,11,13,14,19] This is supported by reaching full recovery in all treated cases using only 1 therapeutic session. Another equally effective method is sclerotherapy using 1.0% polidocanol, 0.5% STS and 5.0% EO.[24–27] Full recovery was reached in all cases; however, the number of treatment sessions ranged from 1 to 5 for 1.0% polidocanol and 0.5% STS.[25–27] In contrast, 5.0% EO required only 1–2 therapeutic sessions.[24] Additionally, side effects in the form of scarring and discoloration are much more common than with other methods. This may make sclerotherapy less attractive compared to the previously mentioned options.

Considering the healing period of VLs treated with lasers, it ranged from 2 to 16 weeks. The shortest time was 2–3 weeks in the case of an 808 nm diode laser[14] and an argon laser with a peak output power of 488 nm and 514 nm.[21] For other devices, the healing period was as follows: for the 980 nm diode laser it was 2–12 weeks,[15,22] for the Nd:YAG 1064 nm it was 4 weeks,[4,19] and for the PDL 595 nm with Nd:YAG it was 4–16 weeks.[15,16] This is another factor that favors the greatest effectiveness of the 808 nm diode laser, the argon laser with a peak output power of 488 nm and 514 nm, and the Nd:YAG 1064 nm laser. However, in the case of the argon laser, the number of treatment sessions ranged from 1 to 5,[21] and for the 808 nm diode and Nd:YAG lasers, only 1 session was required.[4,14,19] Considering the ratio of full recovery to the number of necessary treatment sessions, the 808 nm diode laser and Nd:YAG are characterized by the highest effectiveness. Referring to other methods, the healing time is 2–16 weeks for sclerotherapy,[24–27] there is no data for electrocoagulation, and for photocoagulation with infrared light, it is 2–3 weeks, but no data were available in the analyzed studies.

The most common adverse effects of all laser devices included minor swelling that disappeared after 2–3 days, moderate pain after the procedure, bleeding, and the formation of minor scars at the treatment site. Lack of response to treatment was noted in the case of a diode laser 980 nm – 4%,[22] and a PDL 595 nm laser – 65%.[20] In 1 study, researchers employed photocoagulation with infrared light and reported a 20% complication rate in the form of depression at the surgical site.[23] In the case of sclerotherapy, the most common adverse effects are bleeding after the procedure, short-term pain and local swelling, but also angioedema. In the case of electrocoagulation, the authors did not identify any adverse effects.

Authors should discuss the results and how they can be interpreted from the perspective of previous studies and the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

There are few studies and articles in the scientific literature regarding the treatment of VLs in the oral cavity. Additionally, their treatment protocol has not been developed yet. Since this is not an uncommon clinical problem, knowledge of treatment techniques is essential to improve this area of oral surgery.

Limitations

The above publications are narrative in nature and may be characterized by the authors' bias. However, such reviews are of great value for the development of scientific and clinical concepts. Due to the small number of studies on the treatment of VLs located in the oral cavity, it is impossible to perform a reliable systematic review.

In the case of lesions treated with a laser, some of the publications do not describe all the parameters characterizing the laser beam, which makes it impossible to repeat the experiment and objectively compare the results.

The topic of the treatment of VLs located in the oral cavity is not widely described. There are only few studies on this topic written after 2020. In order to provide the most comprehensive account possible, we have drawn upon the existing literature on this subject.

Conclusions

Venous lakes in the oral cavity are mainly an aesthetic problem, negatively affecting the quality of life of patients. Modern methods of treating VLs of the oral cavity are characterized by low invasiveness and are safe and effective, which is why they are promoted among clinicians instead of surgical excision. Among modern methods of treating VL in the oral cavity, only sclerotherapy, electrocoagulation and photocoagulation with an 808 nm and Nd:YAG 1,064 nm diode laser are 100% effective. Regardless of the method chosen, patients should be informed about potential side effects associated with their use, such as slight postprocedural pain and swelling, bleeding and paresthesias. Additionally, the possibility of leaving scars should be considered.

In the opinion of the authors of this review, it cannot be clearly stated which method of treating VLs in the oral cavity is best due to the small number of publications on this topic. Research reports support the use of 808 nm and Nd:YAG 1,064 nm diode lasers and electrocoagulation. In these cases, the response to treatment reached 100% with only 1 treatment session. However, it should be mentioned that the cost of these devices may be a limitation and can encourage the selection of other cheaper methods. Therefore, sclerotherapy using 5% EO may be an attractive treatment option due to its low costs, 100% effectiveness and the small number of therapeutic sessions necessary to reach full recovery.

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