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Review Article

Dentistry Section

Efficacy of Carbon Dioxide Laser in Treating Oral Lichen Planus- A Scoping Review

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ABSTRACT

Introduction: Oral Lichen Planus (OLP) is a chronic disorder and its aetiology is multifactorial. Factors like local and systemic inducers of cell-mediated hypersensitivity, stress, autoimmune response and viral infection play a major role. Due to the varying aetiological factors, there are varying treatment modalities. With systemic medication, remission of the lesion is the most common side-effect.

Aim: To determine the efficacy of carbon dioxide laser in treating OLP.

Materials and Methods: In this systematic review, the study was done between January 2022 to April 2022 at Rajas Dental College and Hospital, Tamil Nadu. Search categories were specifically followed to databases like PubMed, PubMed Central, Cochrane, Medline, Embase and in Google Scholar. MeSH terms like CO_2 Laser, OLP, Carbondioxide Laser and Oral Premalignant Condition were used for searching the articles.

Results: A total of 942 articles had been collected. But after analysing the articles, only 16 articles based on the preformed inclusion and exclusion criteria had been selected. Out of these three were retrospective studies, five were prospective studies, one clinical trial, one observational study and one study was a Randomised Control Trial (RCT), one was a non RCT, one was a structured abstract, one was a single arm intervention study, one was a case series, and one was a case report.

Conclusion: Carbon dioxide laser was very efficient in treating larger size lesions. Recurrence rate of the lesions was very less when treated at an early stage.

Keywords: Autoimmunity, Gas, Lasers, Oral

INTRODUCTION

Lichen Planus (LP) was first described by Dr. Erasmus Wilson in 1869. It was originally named "Lichen Ruber Planus" and "Lichen Psoriasis". Oral Lichen Planus (OLP) is a chronic disorder with a primary role in the immune system [1-3]. Oral lesions may or may not manifest as skin lesions. OLP affects 0.5% to 2.2% of the population. The aetiology is still unknown. It has a female predilect. Middle-aged individuals are the most affected. The exact prevalence is unknown, but it has been estimated to be between 0.5% and 2.6% in various populations [4,5]. In most OLP cases, the patient is usually unaware of the oral condition. Patients may complain of roughness/burning in the lining of the mouth, red or white patches or ulceration [6,7]. Due to the unclear aetiology of OLP, the results of managing LP are also not satisfactory. Remission of the lesion is the main drawback. Carbon dioxide (CO_2) laser is one of the earliest gas lasers invented by Kumar Patel of Bell Labs in 1964. Because of its cutting efficiency, it remains a desirable choice in facial cosmetic surgeries [8]. Since they have less tactile sensation when compared to the other lasers, they are not preferred for hard-tissue procedures. They are mainly used for soft tissue surgical procedures [9]. In the 1980s, these lasers were used for the management of oral leukoplakia. Laser surgery is considered superior when compared to conventional systemic drug therapy, cold instrumentation, and electrocautery [10]. Since there was very few evidence-based information on the topic of treating OLP using CO_2 laser [2], the systematic review was aimed to find the efficacy of CO_2 laser in the treatment of OLP.

MATERIALS AND METHODS

The systematic review is registered in the PROSPERO with the registration Id CRD42022298392. The study was done between January 2022 to April 2022 at Rajas Dental College and Hospital, Tamil Nadu. A detailed systematic search of the literature was done from the databases of PubMed, PubMed Central, Cochrane Library, Medline, Embase and finally, a random search was also done in Google Scholar. The articles were searched between the timeline 1980 to 2022. The following MeSH keywords "OLP, oral premalignant condition, CO_2 laser, carbon dioxide laser" were used for the search in the above databases. The Boolean logic "AND" was used between CO_2 laser and OLP. It yielded more results than other keyword combinations in the database. MeSH terms like CO_2 laser AND OLP yielded 262 articles in PubMed, 257 articles in PubMed Central, and 83 articles in Cochrane.

From the systematic search, a total of 942 results were obtained from the above databases and the references to the above articles were also considered, if they were relevant to the review. Out of 942, 30 articles were also obtained from Google Scholar and back references.

Inclusion criteria: It included original articles, all clinical studies including RCT, cohorts, case-control, case reports, case series, systematic reviews, and free articles. In case where free articles were not available, the articles with structured abstracts were considered, articles about CO_2 laser in treating OLP, and articles that were only in English.

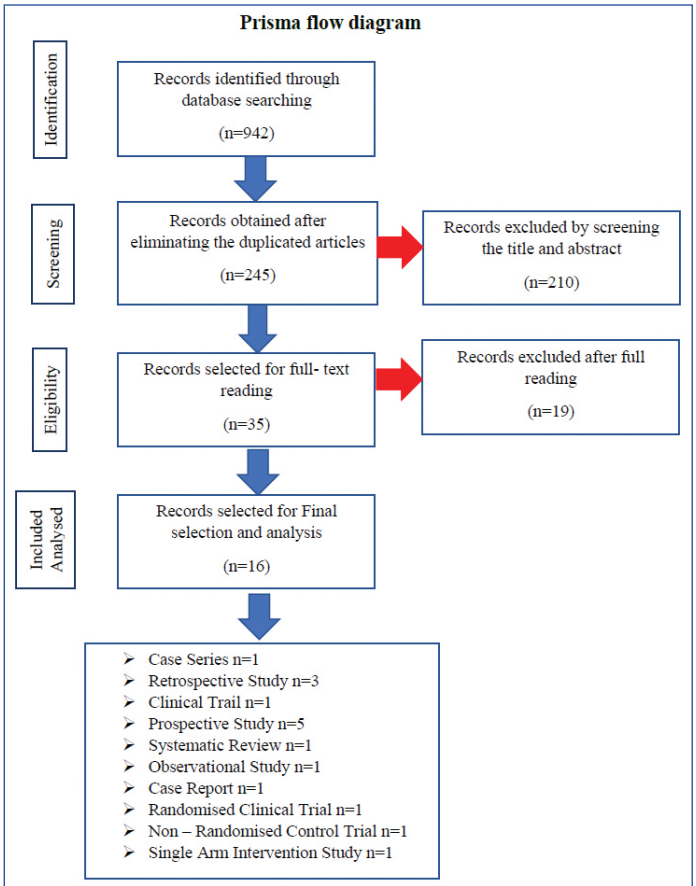
Exclusion criteria: Review articles about CO_2 laser in treating OLP and oral leukoplakia, newsletters, letters to the editor, articles with non structured abstracts, treatment of OLP and oral leukoplakia other than CO_2 lasers, and usage of CO_2 laser other than oral cavity.

Based on the above inclusion and exclusion criteria, the articles obtained were filtered. A total of 61 articles were relevant. On further analysing the articles, due to the irrelevant content, 15 full articles and one structured abstract were finally selected and rest were excluded. The articles were assessed using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) protocol in the systematic review. Three reviewers analysed every article. Blinding was not done. The conclusion was formulated after a detailed discussion with the panel of reviewers.

RESULTS

A total of 942 articles were identified by searching the databases like PubMed, Pubmed Central, Cochrane Library, Medline, Embase,

and Google Scholar. 697 articles were excluded after screening the title and 210 were excluded after reading the abstract due to their irrelevant nature. 19 articles were excluded after full reading because the content did not meet the inclusion criteria of the study [Table/Fig-1]. A total of 926 articles were excluded and therefore 16 articles [11-26] were selected for further analysis. This included one structured abstract, one clinical trial [11,12]; out of which three were retrospective studies [21,23,25], five were prospective studies [13,15,19,20,22], and other studies, like observational study [14], RCT [24], non RCT [18], single-arm intervention study [26], case series [16], and case report [17], which had one article each [Table/Fig-2] [11-26].



[Table/Fig-1]: PRISMA flow diagram.

Summary of benefits of using CO_2 laser: There was a significant reduction in pain and lesion size in subsequent follow-up periods [11]. The healing following laser removal progressed well [12]. After CO_2 laser therapy in the dorsum of the tongue, instead of a denuded tongue, the papilla started to reappear in the affected areas [13]. The re-epithelialisation was complete at all wound sites in 7-14 days and healing occurred without any complication [14]. The laser-treated mucosa returned to the same colour as the surrounding mucosa [15]. The case series concluded that the CO_2 laser was safe and more efficient to use against OLP but the cost of the CO_2 laser made it less affordable [16].

Summary of advantages of CO_2 laser over conventional scalpel treatment in treating OLP: The comparison of CO_2 laser and conventional scalpel procedure in treating OLP was studied in an animal model. The animal model had advantages like minimal damage to the adjacent tissues, less inflammatory reaction and fewer myofibroblasts, which resulted in little wound contraction. It was more efficient when compared to a scalpel in terms of the large lesion due to the bloodless field [17,27].

The postoperative effects on pain, bleeding and swelling were reduced when compared to the conventional scalpel. Since the lesions were subepithelial, the depth of invasion to eradicate the lesion was sufficient in the vaporisation technique. The immunologic status was altered for the better of the patient [18,28]. The case report reported that the amount of myofibroblasts was more in the case of CO_2 laser treatment when compared to scalpel excision [19].

Summary of advantages of CO_2 laser over systemic and topical corticosteroids: The size of the lesion and pain level showed no changes in both the groups of corticosteroids and CO_2 laser. But at the end of the study, the efficiency level of laser therapy was higher than that of systemic corticosteroids. The size of the lesion and the pain level decreased in the case of CO_2 laser therapy [20].

Summary of modes of CO_2 lasers: The total number of articles included in this category was two. Three different modes of CO_2 laser were used in the vaporisation of premalignant lesions. The modes were Continuous Wave (CW) defocussed, CW scanner, and Super Pulse (SP) scanner. Studies have proved that CW defocussed mode was found effective in treating a premalignant lesion in recurrent cases and long-term follow-up was also found successful [21,22].

Summary of rate of recurrence of OLP when treated with CO_2 laser: The rate of recurrence was high when treated with a CO_2 laser because only the recalcitrant cases were treated with a CO_2 laser. But the rate of malignant transformation was less [23]. The patients who were treated with the defocussed mode in CO_2 laser therapy showed a lesser recurrence rate and lower malignant transformation when compared to patients who received analgesics and steroids [24].

S. No.	About the journal	Aim	Objectives	Population	Intervention	Comparison	Outcome	Conclusion
1.	Use of the CO_2 laser in the management of premalignant lesions of the oral mucosa [12] Frame JW et al., 1984 Clinical Trial	To determine the advantage of using CO_2 laser in premalignant lesions of the oral mucosa	The CO_2 laser appears to possess many advantages over conventional techniques for removing oral premalignant lesion	34 patients 51 lesions Out of 51 lesions 3-Erosive LP 4-Candidal leukoplakia 44-Leukoplakia	Treating with CO_2 laser Laser machine-Coherent 450 or Sharplan 733 Follow-up period-4 to 24 months	No group	Out of 3, 2 Erosive LP recurred. But the patient reported less pain when compared to before treatment. Malignant change was not noticed	The CO_2 laser had certain advantages over the scalpel and cryoprobe in the management of oral premalignant disease. CO_2 laser was not superior in treating the premalignant disease but gave better healing to the patients when compared to other modalities
2.	A clinical investigation of the management of OLP with CO_2 laser surgery [13] Loh HS, 1992 Prospective Clinal study	To evaluate the effectiveness of the CO_2 laser in the management of OLP and compare it with current modalities	To evaluate the effectiveness of the CO_2 laser in the management of OLP and follow-up period-6 months to 4 years	10 Singaporean patients 5-Erosive LP 4-Reticular LP 1-Plaque like OLP	Patient accepted the use and effects of CO_2 laser 20 W machine Sharplan 1020, Israel Removal-Vaporisation of tissues Follow-up-6 months to 4 years at regular intervals	No comparison group	Immediate relief of burning sensation. Tolerance to hot and spicy foods. Re-epithelialisation produced little visible scarring. Alteration in the immunologic status were implicated	Patient's response to the treatment was favourable. The new LP occurred in untreated or unaffected areas. Immunological and long-term studies are suggested

3.	Experience with a CO_2 laser for removal of benign oral soft-tissue lesions [14] Luomanen M, 1992 Observational Study	Describes the use of CO_2 laser for various benign oral soft tissue lesions	With CO_2 laser it is possible to obtain specimens for histopathological examination with minimal tissue damage or production of artefacts	56 patients 4 LP patients with 8 lesions 3 women and 1 man Other mucosal lesions were also considered	Soft tissue lesions were removed by using CO_2 laser defocused mode Lasermatic CO_2 (Lasermatic Ltd., Helsinki, Finland) or Niic Model-IR 103CO_2 Surgical laser system (Nippon Infrared Industries Co., Tokyo, Japan)	No comparison group	No bleeding occurred from the tissues during or after operation. No sutures were needed. Recurrence was seen in one man and one woman. But the recurrence was smaller in size and more diffuse than the initial lesions	The removal of selected benign oral soft tissue lesions was precise and rapid and it gave good result. It also gave good visibility while doing surgery. There would be a place for use of CO_2 lasers in surgical management of oral soft tissues
4.	Nd: YAG and CO_2 laser therapy of oral mucosal lesions [23] White JM et al., 1998 Retrospective Clinical Study	To evaluate the specific indication for use of laser energy (Nd: YAG and CO_2 laser) as a surgical modality in the management of oral soft tissue lesions	To identify the usage of laser energies	64 patients Male-27 Female-37 1 LP case was seen in CO_2 laser group and Nd: YAG laser group CO_2 laser was used for more extensive lesions due to its larger spot size and continuous mode Nd:YAG laser was used in lesions adjacent to hard tissue because of its smaller spot size	Lesions were treated with Nd: YAG and CO_2 laser Nd: YAG laser-Two pulsed fiberoptic 1) dLase300 (manufactured for American Dental Laser of Troy, MI by Sunrise Technologies, Inc., Fremont, CA) Power Range: 0.3-3 W Repetition Rate 10-30 Hz 2) Sunlase Master (Sunrise Technologies, Inc., Fremont, CA) Power Range: 0.3-10 W Repetition Rate: 10-100 Hz CO_2 laser-Xanar (Coherent Medical Group, Palo Alto, CA) Power range: 1-20 W (CW) beam diameter: 0.8-1.5 mm	Nd: YAG laser group	The lesion treated with Nd: YAG laser didn't recur whereas the lesion treated with CO_2 laser recurred. This might be due to long-term standing of the lesion and inadequate excision of the lesion	Both the laser devices were effective in the management of oral benign soft tissue lesions. Nd: YAG laser had more precision in a contact mode of delivery in soft tissue area adjacent to tissues. The CO_2 laser had wider beam delivery and CW mode for larger surface area lesions. Both lasers function with minimum postoperative pain and successful postoperative healing
5.	The effects of CO_2 laser on OLP and lichenoid reactions [15] Kok TC and Ong ST, 2001 Prospective Study	To assess the effectiveness of CO_2 laser in relieving symptoms associated with OLP	To relieve symptoms associated with OLP by using CO_2 laser. Level of pain was recorded in Verbal Rating Scale (VRS) and Visual Analogue Scale (VAS)	6 patients LP-5 Lichenoid reaction-1 Reticular LP-4 Plaque like LP-1	Excision was done by CO_2 laser. Luxar LX-20 at the setting of 10 W continuous mode. Follow-up period-1 week, 2 weeks, 1,3 and 6 months	No comparison group	After treatment 5 patients reported no pain. 1 patient reported no improvement. Pain started on 3rd day which could be managed by using mild analgesics. In the follow-up period 5 of 6 patients did not show recurrence. One patient with plaque like OLP showed recurrence. In case of extensive involvement, laser treatment was given twice	In the present study, length of follow-up period was very less. Systematic health must be considered before treatment. Laser showed minimal morbidity, and satisfactory healing. Reduction of pain was also evident. Laser safety should be considered. Class IV category posed significant risks to unprotected eyes and skin and also fire hazard
6.	Recurrence rates of premalignant lesions after CO_2 laser vaporisation [20] Deppe H et al., 2004 Prospective Study	Prospective evaluation of the recurrence rate resulting from different methods of CO_2 laser vaporisation	Comparison of different modes, taking into consideration the variability of each mode	56 patients with LP and other lesions Defocused mode-2 lesions Scanner with additional parameters-2 lesions SP-mode-3 lesions	CO_2 laser-20C manufactured by Lumenis Omnilas GBL (Lammgasse 29, 73547 Lorch, Germany) Laser emitted a monochromatic light with a wavelength of 10.6 µm. 20 C power output range from 1 to 20 watts. Defocussed laser-CW, 15 W, 5-15 s, Mean output-2.12 Wcm^{-2} Scanner with additional parameters-Mean output 212.4 Wcm^{-2} SP-mode-Pulse duration-80 µs Pulse energy-20 mJ Mean output-228 Wcm^{-2}	Comparison was done between 3 groups of laser energies	Defocussed vaporisation-2 LP showed recurrence CW scanner-mode-1 of 2 LP recurred SP-mode-1 of 3 LP recurred	The defocussed mode showed better results than the other two modes due to the lesser degree of deep penetration

7.	CO_2 laser evaporation of OLP [25] Van der Hem PS et al., 2008 Retrospective Study	Retrospective evaluation of the effectiveness of CO_2 laser in the management of OLP in patients with complaint of pain, and evaluation of the recurrence rate compared with other treatment modalities according to literature	The objective of the study was to evaluate the effectiveness of CO_2 laser in the management of OLP	Period 1975-2003 Population-21 patients with 39 lesions 13-Erosive/ ulcerative 16-Reticular 6-Plaque like lesion 4-Classification unknown	CO_2 laser evaporation Sharplan 791, Cavitron and Sharplan 40C Output power-15-20 W Energy-1.5-2.0 J/mm^2 Follow-up-6 weeks, 3 months and 6 months	Comparison with other treatment modalities according to literature	Mean follow-up-8 years 24 lesions-No recurrence and no pain 15 lesions-Recurrence and pain 9 lesions-No pain Recurrence was seen in untreated regions	When there was no further improvement with steroids and taking into account the side-effects, CO_2 laser evaporation seemed to be a good treatment option
8.	Comparative evaluation of low-level laser and CO_2 laser in treatment of patients with OLP [24] Agha-Hosseini F et al., 2012 Randomised Controlled Trial (RCT)	Comparison of the efficacy of low-level laser treatment with CO_2 laser surgery in the treatment of OLP	The objective of the study was to compare the efficacy of Low-Level Laser Therapy (LLLT) with CO_2 laser surgery in the treatment of OLP	28 patients with 57 lesions. One group-CO_2 laser:13 patients-27 lesions Other group-LLLT 15 patients-30 lesions	CO_2 laser-Deka, Italy, 10600nm, 3W LLLT using a diode laser-Mustang, Russia. Two probes infrared light Ga-As, 890nm, 0.3-0.5 J/cm^2 and red light 633nm, CW, 0.3-0.5 J/cm^2 Follow-up-2 weeks, 1,2 and 3 months. Response rates were assessed in reduction in pain and comfort (symptom) VAS Thongprasom Sign Score (TSS)	CO_2 laser was compared with LLLT in treating OLP	85% of the CO_2 laser surgery group experienced partial to complete clinical response, while 15% had no response. In LLLT group 100% demonstrated partial to complete improvement. Clinical improvements were significantly higher in the LLLT group in all follow-up stages	LLLT displayed better results than CO_2 laser therapy as alternative or additional therapy, but further investigations must be done with standard treatment modalities with the long follow-up period
9.	Different CO_2 laser vaporisation protocols for the therapy of oral precancerous lesions and precancerous conditions: A 10 year follow-up [19] Deppe H et al., 2012 Prospective Study	Evaluation of the long-term outcome resulting from different methods of CO_2 laser surgery in a prospective clinical study	Prospective evaluation of the long-term outcome of the energies of CO_2 laser in CW mode, CW-scanner and SP-mode in treating oral precancerous lesions and precancerous conditions	Patient sample-145 patients. Both non-homogeneous leukoplakias and erosive LP were considered. Group 1: 62 lesions-62 patients treated with the defocused CO_2 laser (CW, 15 W, 5-15s, mean output-2.12 Wcm^{-2} LP-23 Group 2: 45 lesions in 43 patients treated with CW scanner LP-15 Group 3: 41 lesions in 40 patients, with vaporisation carried out in the SP-mode (pulse duration-80 µs, Pulse energy-20 mJ, Mean output-228 Wcm^{-2} LP-12	CO_2 laser employed in 20C manufactured by the DEKA Company (Am Lohmuhlbach 12a, Freising, Germany) Wavelength-10.6 µm. 20C power output range from 1-20 W and can be operated in either a continuous, pulsed, or SP mode of laser beam delivery. Accessory system (Swiftlase-scanner DEKA, Am Lohmuhlbach 12a, Freising, Germany) 1. Defocussed laser beam delivery at 15 W. 2. Continuous laser beam delivery plus use of the scanner. 3. SP mode at 7 W along with scanner	Three methods of CO_2 laser energy were compared Follow-up period-day one, 2 weeks, 4 weeks. Mean duration of follow-up was 75 months	Loss of follow-up -26 patients. Final outcome 119 patients with a total of 120 lesions were available. Group 1 7/12 LP recurred. Group 2 6/9 LP recurred. Group 3 4/8 LP recurred	The CO_2 laser treatment was efficacious when used in defocussed mode. In terms of OLP, it can be used for pain relief
10.	A study of the effects of CO_2 laser therapy on OLP [18] Mozafari H et al., 2015 Non-Randomised Controlled Trial (RCT)	Evaluation of the therapeutic effects of CO_2 laser therapy on OLP	Evaluation of the therapeutic effects of CO_2 laser therapy on OLP	Patients-50 Group 1: Control group-Retreatment with local corticosteroid Group 2: Experimental group-Laser therapy	Laser Machine Spectra Dental Korea 2007 with wavelength of 10600 nm with maximum power 2 W Size of the lesion and pain acuity which is measured in the beginning of the study, 15 days, one month, 3 months, 6 months after the study	Compared with patients who were under retreatment with local corticosteroid	There was a significant difference in the pain level and size of the lesion between the 2 groups. Pain level and the size of the lesion was significantly reduced in the experimental group when compared to the control group	The efficacy of treatment with laser showed a remarkably higher effect than corticosteroid
11.	Clinical trial analysing the impact of continuous defocused CO_2 laser vaporisation on the malignant transformation of erosive OLP [22] Mucke T et al., 2015 Prospective Study	Determination of the incidence of malignant transformation of erosive OLP into Squamous Cell Carcinoma (SCC) in patients undergoing symptomatic treatment and patients that were managed with a defocused continuous CO_2 laser beam	Determination of the incidence of malignant transformation of erosive OLP into SCC in patients undergoing symptomatic treatment and patients that were managed with a defocused continuous CO_2 laser beam	Patients-263 Exclusion-92 Duration of lesion:- <1 year in 53 patients 1-5 years in 115 patients >5 years in 3 patients Group 1-Symptomatic conservative treatment-103 patients Group II Defocused CO_2 laser-68 patients	Standard CO_2 laser (type 20C, DEKA, Freising, Germany) Power output range-1 to 2-W Focal Length-125 mm Spot diameter-200 µm Defocused beam delivery-15 W	CO_2 laser surgery treatment was compared with conservative symptomatic management.	26 patients showed recurrence after treating with continuous defocused CO_2 laser which included 2 SCC. 90 patients showed recurrence after treating with analgesics which included 14 SCC. Risk of SCC was more in patients treated with analgesics	CO_2 laser mode of treatment appeared to influence the recurrence rate of SCC

12.	Outcome of CO_2 vaporisation for Oral Potentially Malignant Disorders (OPMD) treatment [21] Cloitre A et al., 2018 Retrospective Study	Estimation of the recurrence and malignant transformation rates of OPMDs treated with CO_2 laser and identification of associated factors with recurrence or malignant transformation	Estimation of the recurrence and the malignant transformation rates of OPMDs treated with CO_2 laser, and identification of associated factors with recurrence or malignant transformation	Out of 46 patients, 21 were excluded. Total 25 patients. Out of 25, 3 OLP was identified	CO_2 laser system was a Lumenis Inc., CA, USA. Laser wavelength-10966 nm Focal Spot of beam-4 Power-10 to 20 W Non contact application		Out of 3 LP 1 LP recurred. This finding was related to other studies also	High recurrence rate of OMPDs was noted. This is due to the definition of recurrence which varies in every study. The definition must be determined before comparing with other studies
13	Clinical evaluation of CO_2 laser vaporisation therapy for OLP: A single-arm intervention study [26] Matsumoto K et al., 2019 Prospective Single Arm Intervention Study	Evaluation of the efficacy of CO_2 laser vaporisation therapy for OLP refractory to conservative treatments	Evaluation of the efficacy of CO_2 laser vaporisation therapy for OLP refractory to conservative treatments	Sample: 16 patients with 18 lesions Reticular lesion-10 sites Erosive type-2 sites Papular type-1 site Complex type-5 sites 9 patients with11 sites-CO_2 laser treatment 7 patients with 7 sites-Traditional treatment	CO_2 laser-Bell Laser; Takara Belmont Corp., Osaka, Japan CW mode 3W Depth ~1-2 mm Post-treatment evaluation: Numerical Rating Scale (NRS), TSS Follow-up-7 days, 1 month, 3 months, 6 months and 1 year	Compared with patients continuing traditional treatment	NRS score and TSS score showed a significant difference from 1 month to 1 year after irradiation. No patients with malignant transformation during the study period	CO_2 laser vaporisation therapy was more efficient than conservative treatment
14	Removal of refractory erosive atrophic LP by the CO_2 laser [11] Pakfetrat A et al., 2014 Structured Abstract	Investigation of the efficacy of CO_2 laser surgery for management of refractory erosive-atrophic OLP	Since the erosive-atrophic form of OLP is often associated with severe pain and burning sensation, this study investigated the efficacy of CO_2 laser surgery for management of refractory erosive-atrophic OLP	10 patients with 13 erosive-atrophic OLP resistant to standard therapy	CO_2 laser device 10,600 nm, CW, 5 W, slightly defocused. Follow-up -1 month, 3 months	No comparison groups	Significant reduction in pain and lesion size at 1-and 3-months following laser treatment. At the end of the follow-up period, 54% of the lesions showed 3 or 4 degrees of improvement in the clinical score and 23% improved 1 or 2 degrees, whereas 23% remained unchanged postoperatively compared to the pre-treatment evaluation	CO_2 laser surgery is an effective modality for management of erosive-atrophic OLP and can be considered as a suitable alternative to standard treatment

S. No.	Title	Population	Intervention	Outcome	Conclusion
15.	Erosive OLP and its Management: A Case Series [16] Sharma S et al., 2008	Total cases – 4 erosive OLP 2 patients treated with triamcinolone acetonide (0.1%) 2 patients treated with CO_2 laser	Triamcinolone acetonide followed by chlorhexidine mouthwash. CO_2 surgical laser – Luxar NOVA Pulse Lx-20 SP, Bothwell, Wash Non-contact focussed beam SP mode 10 watts, 0.8 mm spot size, 20 Hz, 10 milliseconds Near tooth 5 watts, 0.4 mm spot size	In 2 weeks recall there was mild pain and burning sensation in patients treated with triamcinolone acetonide, whereas CO_2 laser had no pain and burning sensation in 2 weeks recall. Lower risk was seen with CO_2 laser to the periosteum and the underlying bone	The use of CO_2 laser appeared to be a safe and effective alternative procedure for the treatment of Erosive OLP; However, its use is limited as it is quite expensive
16.	Removal of OLP by CO_2 laser [17] Magalhaes-Junior EB et al., 2011 Case Report	Total case-1	CO_2 laser-sharplan 20c; laser industries, Tel Aviv, Israel; Wavelength-10,600 nm; Φ=2 mm, CW/RSP Power output=10 W Laser is used in defocussed mode. Follow-up-1 week and 1 month	Mild discomfort was observed due to the removal of epithelial lining. Re-epithelialisation occurred within 3 weeks of removal. No signs of recurrence in the follow-up period	The amount of myofibroblasts on CO_2 laser wound was 3 times less than that found on scalpel wounds. No sutures were needed and healing occurred by secondary intention. The use of CO_2 laser was useful and effective in the treatment of OLP

[Table/Fig-2]: Overview of the processed studies for data extraction [11-26].

Summary of other lasers: The total number of articles collected under this category was 2. The other lasers like Nd: YAG and LLLT laser were also found to be effective in treating OLP.

The Nd: YAG laser shared many of the advantages of the CO_2 laser, but its unique feature was that it could be utilised in both a contact excision and non contact coagulation mode. Lesions with a small surface area were most efficiently treated with Nd: YAG laser as it has a very precise contact mode of delivery. The recurrence rate of OLP when treated with Nd: YAG laser was also very less when compared to CO_2 laser [25].

LLLT has a property called laser biomodulation. It can change the cell function, non thermally and non destructively. It has additional benefits when compared to CO_2 laser by simultaneously applying infra-red and red light to affect the surface and depth of the lesion. It has a low recurrence rate and is easier and less time-consuming [26].

DISCUSSION

LP is a common chronic inflammatory mucocutaneous disorder that typically affects the skin and mouth [29]. The major aetiological factors of OLP are local and systemic inducers of cell-mediated

hypersensitivity, stress, autoimmune response, and viral infections. The foremost treatment starts with topical and systemic corticosteroids. For biopsy purposes, incisional/excisional biopsy with a scalpel is performed under local anaesthesia to make a confirmatory final diagnosis [30].

In recent years, laser treatment has come into existence to give immediate symptomatic relief in patients with a burning sensation. Various lasers have been used in recent years, like CO_2 laser, Nd: YAG laser, LLLT, Argon laser, Diode laser, Ho: YAG laser, and Er: YAG laser. The choice of laser depends mainly upon the precision and depth of tissue ablation, haemostasis, effectiveness in a fluid-filled environment, and any preference for the pigmented surface [31].

The systematic review was made in such a way to prove the efficacy of the CO_2 laser in treating OLP. Initially, meta-analysis was also planned since we obtained heterogeneous types of studies, but was not performed. All the RCT and non RCT, observational clinical studies, case reports, cohort studies, prospective, and retrospective study were included and the review articles were excluded.

The heterogeneous nature of studies started from the size and duration of the lesion, follow-up period, a recalcitrant or fresh case of OLP, mode of CO_2 laser, the wavelength of CO_2 laser, duration of CO_2 laser contact with the tissue, and the brand of the laser machine. The patient's psychological status also paves a big path [20].

The CO_2 laser has two methods to remove the lesion. They are vaporisation of the surface mucosa and excision of the lesion. Vaporisation was done in inaccessible areas such as the floor of the mouth. Excision was done with the removal of soft tissue lesions with underlying tissues. This creates a slightly deeper wound. The CO_2 laser has a standard wavelength of 10,600 nm and for soft tissue surgeries it has another variant of 9300 nm. The CO_2 laser machine has 3 modes, defocussed mode, SP mode and scanner mode. The defocused mode shows great efficacy when compared to the other modes in treating OLP. In case of vaporisation, the beam will be in contact with the tissues for a minimum of 4 minutes. Keeping in contact with the tissues for a longer time would result in thermal injury and burrowing wounds [21,22].

The CO_2 laser has proved efficient when compared to conventional systemic and local corticosteroids and conventional scalpel excision of the lesion. The corticosteroids show remission of the lesion within a short period whereas the CO_2 laser in long-term follow-up doesn't show remission of the lesion [19]. CO_2 laser has few advantages over corticosteroids and conventional scalpel surgery. They can be used to excise larger lesions with the bloodless field of surgery and minimal wound contraction. Postoperatively they show less pain and a faster healing phase [19].

Studies have stated that the lesions occur in other areas which were not exposed to the laser tip [14]. Some cases show recurrence even after treatment with CO_2 laser because of the underlying systemic disorder.

Since the CO_2 laser has a non contact mode, they cannot refine the cutting areas. They also have a larger beam and it is cost-effective [21]. This is the major disadvantage of using CO_2 laser. To overcome these disadvantages Nd: YAG laser and LLLT laser came into existence. Nd: YAG laser has the additional advantage of using it as a non contact and contacts laser which is used in vaporisation and excision respectively [23]. LLLT has the advantage of dealing with smaller lesions particularly when the lesion is near the tooth surface area approximating gingiva since it has a smaller size beam. But still, long-term follow-up is necessary to prove the scenario [24].

Limitation(s)

Since, the articles which were included in the study were heterogeneous in nature (different varying data), the meta-analysis could not be performed. The lack of RCT clouds the result of this systematic review.

CONCLUSION(S)

The OLP is a chronic mucocutaneous disorder and it has a multifactorial aetiology. CO_2 laser is the best when large lesions are treated because of the large beam. Small lesions can also be treated but it affects the normal mucosa. The vaporisation technique proves effective in treating OLP. CO_2 laser proves efficient in treating recalcitrant cases when compared to systemic and topical corticosteroids and conventional scalpel surgery. Hence, CO_2 laser treatment can be given as a first line of therapy even before the use of corticosteroids. Additionally, treating the underlying systemic disorder and stress reduction may lead to the complete cure of the lesion.

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