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Original Research

Effect of Carbon Dioxide Laser on Increasing Vestibular Depth in Cleft Lip and Palate Patients

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Abstract

Background: Shallow upper buccal sulcus deformity in cleft lip and palate patients is one of the common secondary deformities after primary cleft lip and palate repair; this deformity may prevent or complicate orthodontic and prosthodontic procedures causing aesthetic and functional problems. A number of methods are described to increase the anterior maxillary sulcus in these patients. ***Purpose:*** This study assessed the use of a carbon dioxide laser (CO_2) to increase the sulcus depth. ***Method:*** Fifteen patients with cleft lip and palate (eight unilateral and seven bilateral) were studied. The surgical procedure was performed using CO_2 laser. The vestibular depth and lip length were measured at three time points namely before surgery (T0), 1 week following surgery (T1), and 4 months following surgery (T2). After data collection, statistical analyses were done using PASW® version 18 SPSS. ***Results:*** The mean values of vestibular depth were 9.46 ± 1.92, 13.83 ± 1.88, and 13.23 ± 1.76 mm for T0, T1, and T2, respectively. The vestibular depth significantly increased after 4 months of follow-up ($p = 0.001$). The mean amount of vestibular depth gain was not significantly different in unilateral and bilateral cleft groups ($p = 0.908$). The mean value of upper lip length increased by a mean of 1.23 mm and was statistically significant ($p = 0.001$). ***Conclusions:*** Upper buccal sulcus reconstruction with CO_2 laser provides successful and stable results. CO_2 laser application is suggested as an alternative to conventional vestibuloplasty.

Keywords: cleft lip and palate, CO_2 laser, vestibuloplasty

Introduction

Clefts of the lip and palate are among the most common deformities affecting the head and neck structures.[1] Blacks have the lowest incidence of clefts of the lip and palate.[2] The highest incidence rate was reported among Native Americans to be 3.74 per 1000.[3] These conditions affect 1 in every 700 children in the United States, with a slightly lower incidence rate of 1.3 per 1000.[4] The prevalence of this anomaly has been reported to be 0.86–1.09 in 1000 births in Iran.[5,6]

Surgical closure of clefts, prosthetic and orthodontic therapy, alveolar bone grafts, lip and nose revisions, and cosmetic surgeries are needed to correct secondary deformities which develop following primary interventions and treatment of the condition.[7]

Following the primary surgery to close the cleft, the buccal sulcus of the anterior maxillary region decreases in depth; this is an important secondary deformity that affects the esthetics and function of the lips and compromises the orthodontic and prosthetic treatment.[8] Various methods and techniques, including vestibuloplasty and different flap designs, have been developed to regain the depth of buccal vestibules and to overcome the functional limit of the upper lip.[9,10]

Vestibuloplasty was first introduced by Kazanjain in 1924.[11] This technique includes a horizontal incision along the alveolar crest and complete reflection of soft tissue and periosteum to reach the required depth for vestibule.[11] Since this surgery includes mechanical incision of attached muscles and periosteum, it causes patient discomfort and possibly delays wound healing.

Re-fusion of upper lip to gingiva in response to tension of the scar tissue may take place following vestibuloplasty. Reconstruction with skin grafts has been suggested to solve this problem. However, regardless of methods which are used, decrease of vestibular depth usually occurs[9] and along with pain and discomfort which accompany every surgical procedure, each technique has its own specific advantages and disadvantages.

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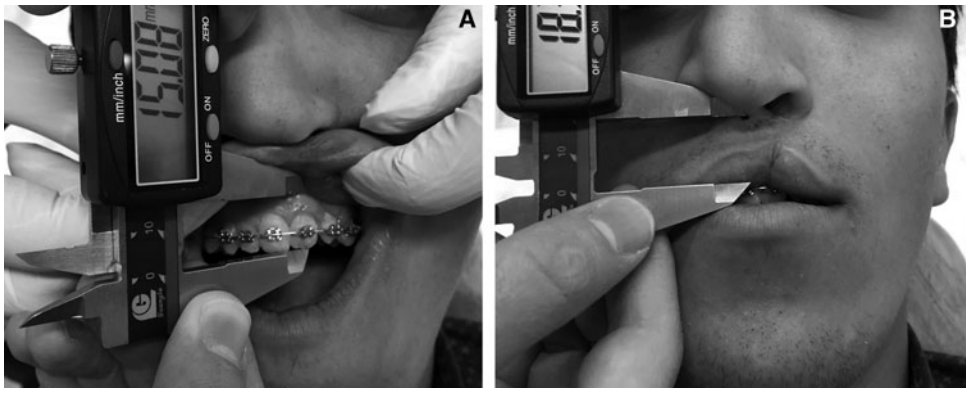

FIG. 1. Measurement of vestibular height and upper lip length using a digital caliper **(A, B).**

Use of polyglactin mesh[12] and skin grafts[13] for deepening the buccal vestibule usually makes it necessary to perform the surgery under general anesthesia. Again there is patient discomfort and pain following the procedure.

Surgery by means of laser is one of the methods used to perform soft tissue oral surgeries. This method offers advantages, including less pain and fear experienced by patients, excellent hemostasis, and decreased possibility of postsurgical infections.[14,15]

Laser was first introduced in 1970, and in 1980 it was used by periodontists and oral surgeons for oral soft tissue surgery. Now, different laser settings and systems are available; among them CO_2, Nd:YAG, and Er:YAG are the most common lasers used for dental applications.[14] CO_2 laser with a wavelength of 10.6 μm is highly absorbed by water. Thus, high water content of oral soft tissues makes this laser an appropriate choice for oral surgery.[15–17] Application of laser for surgical removal of epulis fissuratum[15] and mucoceles[18] and regaining the vestibular depth in edentulous patients[19] has been reported in the literature. There is a preliminary report regarding application of Er:YAG laser for lip skin scar revision following primary surgery which caused improvement in the clinical appearance of laser-treated scars.[20] However, we found no previous report using laser for vestibular deepening in cleft patients.

The aim of this study was to evaluate the efficacy of CO_2 laser for vestibuloplasty in the anterior region of the maxilla in cleft patients and to assess the recurrence of lip attachment to gingiva following surgery.

Materials and Methods

This study was verified by the ethics committee and the research vice chancellor of Shahid Sadoughi University of Medical Science by the P/17/1/17438 ethical code. All the patients or their parents signed informed consent forms. Cleft patients presenting to the Department of Orthodontics of Yazd University of Medical sciences who had vestibular depth loss in the anterior maxilla following primary cleft surgery were included in the study. Patients who had already underwent secondary surgery for vestibuloplasty and subjects with certain systemic problems such as heart disease (pacemaker), pregnancy, epileptic seizures, thyroid gland disease, and malignancies were excluded. A total of 15 subjects (8 females and 7 males) in age range of 9–20 years were included in the study. Eight subjects suffered from unilateral cleft lip while the remaining had bilateral clefts.

At the beginning of the trial (T0), the vestibular depth was measured using a digital caliper (Guilin Guanglu Measuring Instrument Co., P.R. China); the distance from the incisal edge of the tooth adjacent to the cleft site to the deepest point of the labial vestibule was measured. In addition, the length of the upper lip was measured from the subnasal point (Sn) to the inferior border of the upper lip using digital caliper (Fig. 1A, B).

Local anesthesia was administered with 4% articaine and 1/100,000 epinephrine (Septanest; Septodont, France) before surgery. Laser safety glasses were worn by the clinician, and a moist cotton gauze was placed on the patients' eyes to ensure safety.

The surgery was performed using CO_2 laser (Daeshin Enterprise, Seoul, Korea; DS-40UB, 1–30 W, continuous wave, 10.600 nm, gas laser) with output power of 5 W (E.D. = 442.477 W/cm^2). The application tip used was a needle with a beam with an inner diameter of 0.6 mm and a spot diameter of 0.1 mm (Table 1).

The upper lip in the cleft side was pulled outwards to maintain tension and facilitate soft-tissue incision. Ablation with the laser tip was initiated at the most inferior part of the attached tissue with a sweeping motion parallel to the bone, slowly relieving the mucosa and muscle fibers to the desired depth. The laser tip was maintained 1–2 mm away from the tissue and was moved at a ''hand speed'' of a few millimeters per second (Fig. 2). To find any remaining attached fibers, the perioral muscle was pulled one more time, and if any fibers were noticed, they were excised with the laser tip. Incision and

Table 1. Laser Characteristics and Parameters

Laser	
Laser type	CO_2 gas laser
Wave length	10,600 nm
Power	5 W
Tube length	830 mm
Working mode	Continuous wave
Focusing handpiece	
Spot size	0.1 mm
Beam diameter at source	2.5 mm
Dental tip	
Tip type	Needle
Tip diameter	0.6 mm
Area	0.0113 cm^2
Power density	442.477 W/cm^2

FIG. 2. The use CO_2 laser to increase the vestibule depth.

ablation were extended in the upper and two lateral borders, and laser surgery was continued until no adhesion was observed. The maximum time of laser surgical procedure was 10 min, and all surgical procedures were performed by the same surgeon. Patients were prescribed 325 mg acetaminophen four times a day for the first day. No antibiotic was prescribed. Patients were instructed to use Persica mouthwash (Poursina Co., Iran) for 1 week.

Recall measurements of vestibular depth and lip length were done after 1 week (T1) and 4 months (T2) using the exact same procedure as described earlier. All of the measurements were made by one of the authors and after data collection, statistical analysis was done using PASW® version 18 (SPSS, Chicago, IL). Wilcoxon signed-rank test was used to compare the vestibular depth and lip length, and the Mann–Whitney test was used to compare the vestibular depth in unilateral and bilateral cleft groups. A p value of less than 0.05 was considered to be statistically significant for all the tests.

Results

The patients were in the age range of 9–20 years (mean 12.73 ± 3.55 years). No intraoperative and postoperative complications, such as inflammation, hemorrhage, and infection, occurred. No lip adhesion to gingival tissues and no subsequent surgery were required, and initial healing in the area of operation was observed after 7–10 days. The mean recorded values of vestibular depth were 9.46 ± 1.92, 13.83 ± 1.88, and 13.23 ± 1.76 mm for T0, T1, and T2, respectively. The vestibular depth was regained by up to 100% by surgical intervention and reached the level of 86.33% by 4 months following surgery (Table 2). Table 3 shows that vestibular depth significantly increased after 4 months of follow-up ($p = 0.001$, Figs. 3 and 4). The mean value of vestibular depth gain was 3.85 and 3.69 mm for unilateral and bilateral cleft patients, respectively, which showed insignificant difference between the two groups ($p = 0.908$, Table 3). The mean value of presurgical upper lip length was 17.09 mm, which increased to 18.32 mm after 4 months following surgery. This increase was statistically significant ($p = 0.001$, Table 2).

Discussion

The technique of vestibuloplasty includes horizontal incision along the alveolar crest and reflection of periosteum and soft tissues to regain adequate depth of the vestibule.[11] To decrease the possibility of recurrence of lip attachment to the gingiva, different materials and techniques such as application of polyglactin mesh, skin, attached gingiva, and mucosal grafts are suggested.[10]

As previously mentioned, CO_2 laser is currently used for removal of oral lesions as epulis fissuratum, frenectomy, and vestibuloplasty in edentulous patients.[15,18,19] The reports of using laser for cleft patients are scarce in the literature. Application of Er:YAG laser for treatment of lip skin scars in 10 cleft patients showed improvement in clinical appearance of scars. The clinically observed improvement was seen after the first laser session and continued after the second session and was further corroborated by the patients who reported satisfaction with the results. Er:YAG laser irradiation can be an effective approach for correction of residual lip skin scars. Combined mechanisms of ablation/coagulation and shrinking of the skin are effective in this regard.[20]

CO_2 laser with a wavelength of 10.6 μm is highly absorbed by water and subsequently the soft tissues. The penetration depth of CO_2 laser waves is low and 99% of its energy is absorbed within 0.2 mm from the surface. The laser causes simultaneous coagulation and thus provides good visibility for the surgeon. There is no need for suturing the wound following the surgery.[21]

Er:YAG laser has very high affinity for water; nevertheless, Er:YAG absorption in water is about 15 times higher compared with CO_2 laser; therefore, the latter would be the laser of choice for hard tissue removal such as enamel and dentin in the oral cavity.[22] In addition, erbium laser can be used for soft tissue ablation; however, hemostasis is not as

TABLE 2. VESTIBULAR HEIGHT GAIN (MM) AND UPPER LIP LENGTH (MM) MEASURED IN TERMS OF MEAN AND STANDARD DEVIATION

Parameters	*Patients number*	*T0*	*T1*	*T2*	*T1 − T0*	*T2 − T1*	*T2 − T0*
Vestibular height	15	9.456 ± 1.92	13.832 ± 1.88	13.234 ± 1.76	4.376	0.595	3.778
	p	—	—	—	0.001	0.001	0.001
Upper lip length	15	17.088 ± 1.96	18.646 ± 2.49	18.323 ± 2.42	1.558	0.323	1.235
	p	—	—	—	0.001	0.001	0.001

T0, the measurement of vestibular height and upper lip length before CO_2 laser surgery; T1, the measurement of vestibular height and upper lip length a weak after CO_2 laser surgery; T2, The meaurement of vestibular height and upper lip length 4 months after CO_2 laser surgery.

Table 3. Vestibular Height Gain (mm) in Unilateral and Bilateral Cleft Groups in Terms of Mean and Standard Deviation

	Mean measurements			
Cleft type	*T0*	*T1*	*T2*	*T2 – T0*
Unilateral (8)	9.74 ± 2.24	14.04 ± 1.86	13.59 ± 1.82	3.85
Bilateral (7)	9.14 ± 1.59	13.60 ± 2.08	12.83 ± 1.74	3.69
p	—	—	—	0.908

T0, the measurement of vestibular height before CO_2 laser surgery; T1, the measurement of vestibular height a weak after CO_2 laser surgery; T2, the measurement of vestibular height 4 months after CO_2 laser surgery.

pronounced as would be seen with CO_2 laser ablation.[21] In addition, CO_2 laser causes superficial tissue burning and may prevent tissues from reattaching to each other. These characteristics were the reasons for selection of CO_2 laser for the current study.

Other advantages of the CO_2 laser surgery over the blade include the lower risk of damage to adjacent structures, providing a clean and blood-free surgical field, minimum swelling and pain following surgery, and low probability of wound contraction.[18] Our observations regarding the amount of pain and swelling and no need to prescribe antibiotics further confirm the abovementioned advantages and are in line with the findings of others.

Increased vestibular depth was observed in all patients after laser surgery (4-month follow-up). The increase in depth was 2.35 mm at the lowest point and 6.50 mm at the highest point, and we observed no lip adhesion to gingival tissues and no subsequent surgery was required.

Based on the study conducted by García-Ortiz de Zárate et al.[23] the power of 5–10 W is the setting used for soft tissue ablation. Using higher laser powers can lead to increased wound fibrosis and higher possibility of reattachment. Therefore, a power of 5 W was selected in this study.

The mean value of vestibular depth increase was 4.38 mm which decreased by 0.6 mm and reached the value of 3.77 mm at the end of follow-up period which corresponded to 13.67% decrease.

Using polyglactin mesh, Quarta and Koch in 1989[12] performed vestibuloplasty on 19 patients suffering from unilateral palatal clefts. The recurrence rate was 18% in their study. The vestibular depth increase was 5.2 mm mesial to and 7.7 mm distal to the target tooth. The vestibular depth increase in their study[12] was greater than that in our study. However, reattachment occurred less frequently compared to their study, which can be attributed to less wound contraction. Quarta and Koch[12] performed the operation under general anesthesia, while we conducted the procedure under local anesthesia and this can bring about higher patient satisfaction and comfort.

de Almeida et al.[10] compared the two vestibuloplasty techniques in cleft patients, including conventional method versus the fixing splint method. The vestibular depth increase for the conventional and fixing splint groups was 3.16 and 4.86 mm, respectively. They did not report the rate of

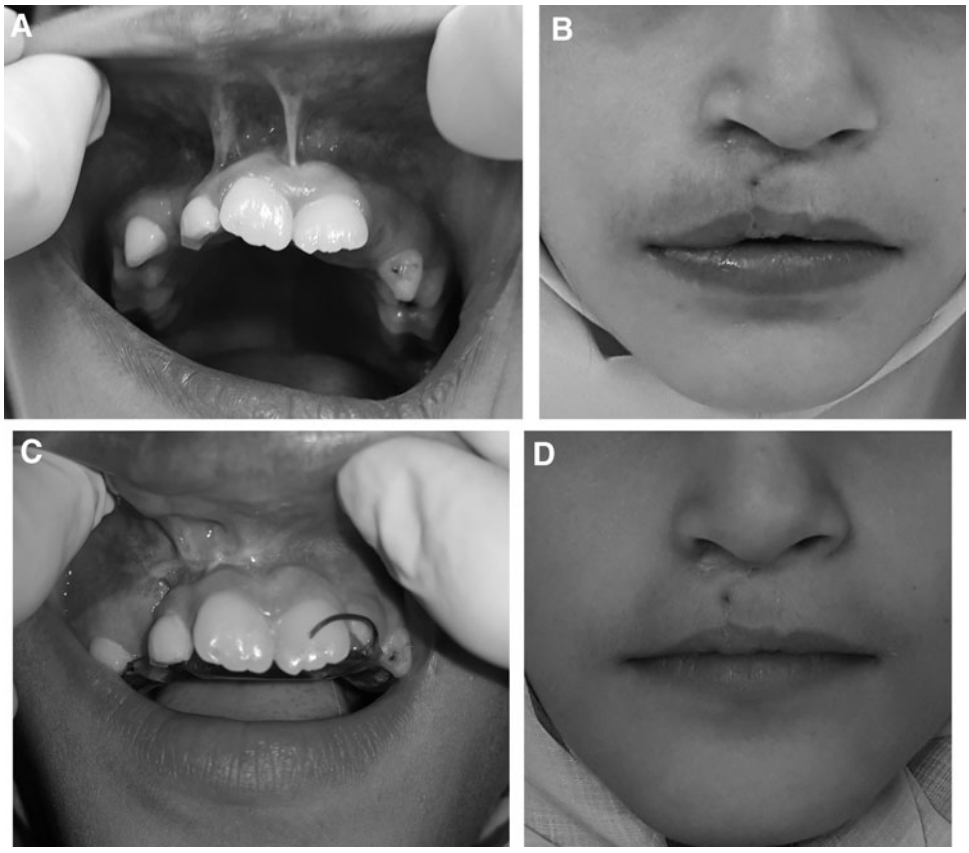

FIG. 3. Patient L.B. with unilateral cleft lip and palate. Extra and intraoral views before CO_2 laser surgery **(A, B)**, extra and intraoral views after CO_2 laser surgery **(C, D)**.

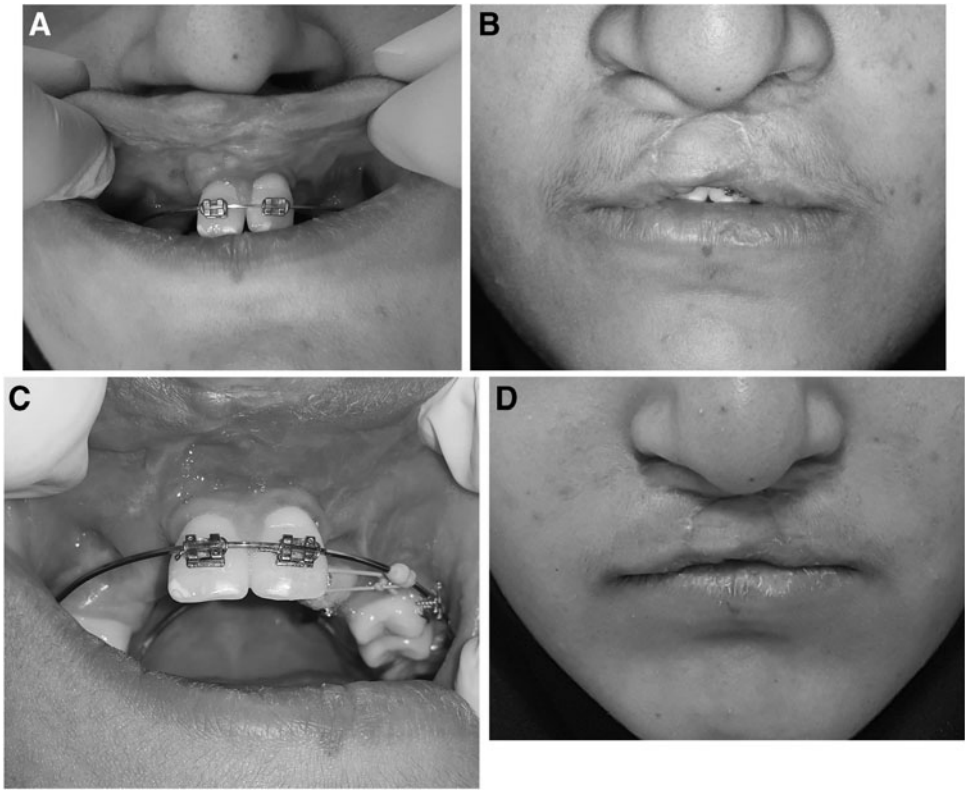

FIG. 4. Patient F.K. with bilateral cleft lip and palate. Extra and intraoral view before CO_2 laser surgery **(A, B)**, extra and intraoral view after CO_2 laser surgery **(C, D)**.

attachment recurrence. The vestibular depth increase in our study was in line with that reported by de Almeida et al.[10]

Upper lip length changes were evaluated at T0 and T2. The mean lip length increase following surgery was 1.33 mm. Lip function and movement following removal of attachment clinically improved.

As a suggestion for future research, simplicity of laser surgery makes it possible to repeat the procedure if needed to increase vestibular depth and also splints can be suitable for decreasing the possibility of attachment recurrence.[10]

Conclusions

Upper buccal sulcus deepening with CO_2 laser is successful and has good results. CO_2 laser application is suggested as an alternative to conventional surgery of oral soft tissues.

Author Disclosure Statement

No competing financial interests exist.

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