



Fractional CO₂ laser treatment for post-surgical lip scars in cleft lip and palate patients

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Abstract

Post-surgical scars of cleft lip patients can lead to abnormal lip activity, which causes deficient maxillary growth. The aim of the present study was to assess the effect of laser therapy on the appearance and electrical activity of the upper lip in cleft lip and palate patients. Twelve patients with cleft lip and palate participated in this study. All patients had surgically repaired the cleft lip at the age of about 3–6 months. The lip scars underwent five fractional CO₂ laser treatment sessions with a 4-week interval. Improvement of the quality of the skin texture was recorded according to quartile grading scale based on photographs taken before and 1 month after treatment. Patients' satisfaction survey was also recorded using Patient Scar Assessment Questionnaire (PSAQ) before and after laser therapy. Moreover, the EMG activity of the upper lip muscle was measured before and after treatment. According to dermatologists, the improvement of scar appearance ranged from 0.5 to 3, with a mean of 1.29 ± 0.86 . Mean scores of the scar appearance ($p < 0.001$), symptoms ($p = 0.003$), and scar consciousness ($p < 0.001$) subscales of the PSAQ questionnaire had significantly increased after treatment. The EMG recording of the upper lip had decreased significantly after laser treatment at rest ($p = 0.009$) and maximum lip compression ($p = 0.007$). The fractional CO₂ laser is an effective method for treating old scars of the cleft lip with a significant change in the opinion of patients about their scar appearance. Also, the therapy can help to reduce the EMG activity of the upper lip at rest.

Keywords Fractional carbon dioxide laser · Scar · Cleft lip · Electromyography

Introduction

Residual scars after primary lip surgery usually are accompanied with esthetic and functional problems in cleft lip and

palate patients. These mature post-surgical scars represent a major challenge in the treatment of these patients [1, 2]. In addition to the esthetic morbidity, the side effects and long-term courses of therapies place an additional burden on patients with cleft lip and palate patients. Besides, it has a negative effect on the psychology, self-esteem, and quality of life of these patients [1, 3, 4].

Scar revision with fractional CO₂ laser has received great attention in recent years. It helps to rebuild the collagenous fibers of the tissues and improves the appearance and also the function of the scars [5–8]. On the other hand, children with cleft lip and palate who have undergone surgical correction during childhood often exhibit severely deficient sagittal development in the midface. This is usually attributed to intrinsic developmental deficiencies as well as interferences with growth secondary to scar tissue contraction in the lip and palate following surgery [9, 10]. Thus, lip function seems to play an important role in the development of the maxilla. Moreover, abnormal lip activity during function represents an additional factor compromising the integrity of underlying

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dentofacial structures [11]. Therefore, it is essential to determine the function of the upper lip in patients with cleft lip and palate by means of electromyography (EMG).

The present study aimed to evaluate the effect of CO₂ laser therapy for the treatment of lip scars in cleft lip and palate patients based on dermatologists' and patients' opinion and to assess laser therapy on the electrical activity of the upper lip at rest and function.

Methods and material

Twelve female patients with Fitzpatrick skin phototype of III–IV and a mean age of 19.17 ± 3.21 years participated in this study. One patient had hypertrophic scars; two patients with somehow contracture scar and remaining normal fine line.

All patients had cleft lip and palate and were referred to cleft lip and palate department of University of Medical Sciences. All patients had surgically repaired the cleft lip at the age of about 3–6 months and the cleft palate at approximately 1 year of age. A written informed consent form was signed by the patients or their guardians. The protocol of this study was approved by the regional ethics committee. Patients who received any form of treatment including systemic retinoid within the past 6 months, with a previous history of adverse reaction to laser therapy, or with a contraindication to treatment with fractional CO₂ laser were excluded from the study.

Before starting the laser therapy, a standard photograph of the lips was taken. Initially, the patients' skin was cleaned with 70% ethyl alcohol and was anesthetized with lidocaine-prilocaine 5% (Xyla-P® cream 5% (Tehran Chemie, Iran)) for 30 min topically.

The target scars underwent five laser treatment sessions with a 4-week interval. Fractional CO₂ laser of 10,600 nm (eCO₂; Lutronic, Ilsan Techno Town, Korea) was used in this study. This device was used in the static mode, with a power of 30 W, for two passes. In the first pass, we used spot size of 120 μ , the density of 150 spots/cm², and fluency of 2×80 (double frequency of beam pattern) with a 4 mm in diameter quadrangular spot, and in second pass density of 200 spots/cm² and 40 mJ in our protocol. All patients were prescribed with 400-mg acyclovir tablet twice/day, 2 days before until 5 days after laser day. At the end of laser therapy at each session, the treated areas were cooled using ice packs for few minutes, then a combination of 1% hydrocortisone and zinc oxide cream was applied to the target area. Also, the topical application of post-laser repairing cream (Seagull, Akhavi Co., Iran), which includes 10% *Mimosa* extract, cottonseed extract, sucralfate, and allantoin as active ingredients, 4 times daily for 1 week was suggested [12]. Also, we advised all patients to avoid sun exposure and use a sunscreen with SPF 30–50.

One month after the termination of laser therapy, the patients were re-examined and post-treatment photographs were taken.

Improvement of the quality of the skin texture on photographs was rated by two blind dermatologists according to quartile grading scale [13–16] (Table 1).

Patients' satisfaction survey was also recorded using Patient Scar Assessment Questionnaire (PSAQ) before initiation of treatment and after laser therapy [17]. The questionnaire consisted of 3 subscales: appearance, symptoms, and scar consciousness.

Also, electromyography (EMG) activity of the orbicularis oris muscle was measured at the start of the study and 1 month after laser treatment. EMG was recorded using bipolar silver/silver chloride (Ag/AgCl) surface electrodes of Toennies electromyography (Eric Jaeger GmbH, Hoechberg, Germany). Two electrodes were attached to the upper lip with equal distance from the philtrum at the inter-electrode distance of 15 mm on a line running from the lip commissure to the subnasal point. A reference electrode was also attached to the forehead or cheeks of the patients. The electromyography activity of the muscle was recorded at rest and reciprocal compression of lips. Each process was repeated five times, and the peak electromyography value was recorded (Fig. 1).

During the EMG recording, the patients sat in the standard position in a dental chair without head support in the assumed natural head position. The patient's skin was cleaned with 70% ethyl alcohol to reduce skin impedance and dried before the placement of the electrodes. The electrodes were interfaced with a computer, which recorded the data for further analysis.

The paired sample *t* test was used for statistical comparison of the electromyographic activity of the upper lip as well as scores of the PSAQ subscales before and after laser therapy. $P < 0.05$ was set as significant.

Results

Improvement of the scare texture was rated by two independent dermatologists. Mean scores were recorded. According to the dermatologists, the improvement of scar appearance

Table 1 Assessment of the quality of the scar according to quartile grading scale

Score	Description
0	Less than 25% (minimal to no improvement)
1	25–50% (moderate improvement)
2	51–75% (marked improvement)
3	> 75% (near total improvement)

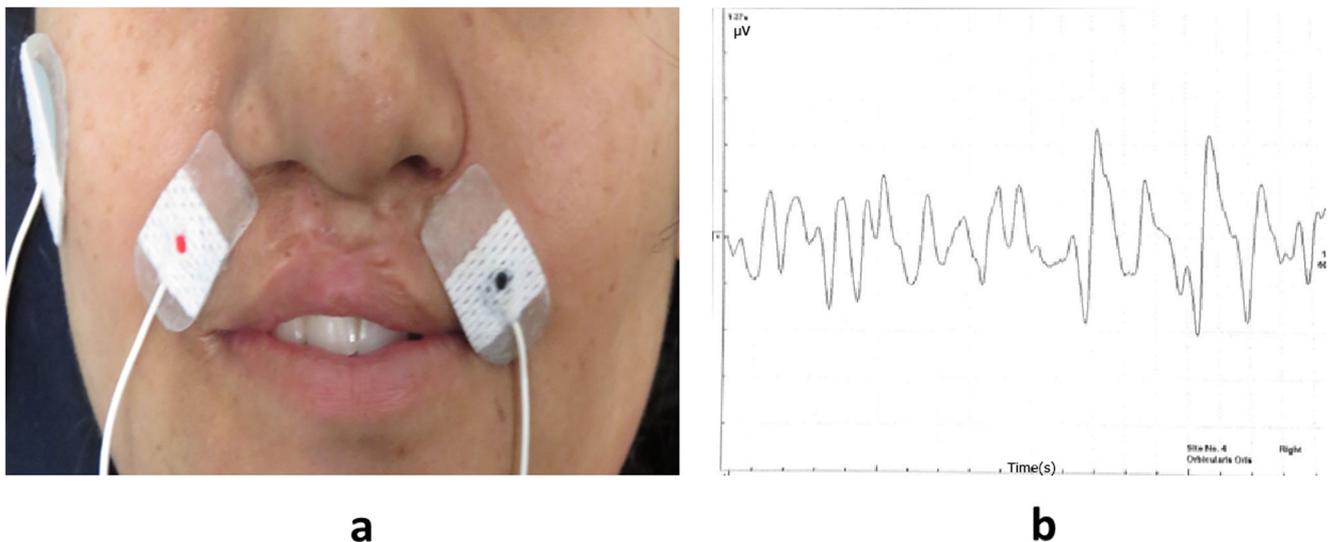


Fig. 1 **a** Position of the electrodes while recording the electromyographic activity of orbicularis oris muscle. **b** Electromyographic recordings of a patient at compression of the lips

ranged from 0.5 to 3, with a mean of 1.29 ± 0.86 and median of 1.25 ± 1.38 .

Table 2 shows the mean scores of the appearance, symptoms, and scar consciousness subscales before and after treatment. The table shows that all of the scores had significantly increased after treatment. Figure 2 also demonstrates the improvement of the appearance of scar tissue after laser therapy.

Table 3 shows the muscle electrical activity during rest and maximum lip compression before and after laser therapy. As is shown in the table, the EMG recording of the upper lip had decreased significantly after laser treatment at rest and maximum lip compression.

Discussion

Post-surgical scars after lip closure present challenging dermatological problems that usually require a multimodal approach to achieve desirable results. With the advent of new

treatment options, laser treatment is practiced recently by dermatologists to deliver effective treatment with minimal adverse side effects.

In the present study, we investigated the effect of fractional CO₂ laser therapy on the appearance of scars of cleft lip patient. Moreover, the electrical activity of the upper lip muscle was also measured using electromyography.

The appearance of the lip scar was assessed by two independent dermatologists using quartile grading scale. According to their opinion, laser therapy induced 25–50% improvement in the appearance of the lip scars (mean score of 1.29 ± 0.86).

We used the PSAQ to assess the patients' opinion about their scar tissue. According to the patients' opinion, the appearance of the scar tissue had improved significantly after laser therapy. In other words, they believed that the color, brightness, redness, texture, and prominence of the scar matched more likely with the surrounding normal skin after laser treatment. In terms of the size of the scar, the patients

Table 2 Mean scores of the appearance, symptoms, scar consciousness subscales, and total improvement of the scar before and after treatment

Variable	Time	Mean \pm SD	Minimum	Maximum	<i>P</i> value*
Appearance	B.T	16.75 ± 2.18	14	21	< 0.001
	A.T	23.75 ± 2.01	20	27	
Symptoms	B.T	31.00 ± 2.49	27	34	0.003
	A.T	32.83 ± 2.76	28	35	
Scar consciousness	B.T	7.92 ± 1.62	6	11	< 0.001
	A.T	12.42 ± 1.24	11	15	
Total improvement	B.T	55.67 ± 4.23	5	62	< 0.001
	A.T	69.00 ± 3.86	63	75	

*Paired sample *t* test

Fig. 2 Appearance of a lip scar **a** before and **b** after treatment



believed that in contrast to the length of the scar, the scar width had decreased significantly after treatment.

The patients' overall satisfaction with the appearance of the scar increased significantly after treatment. The symptoms of the scar including itching, pain, and loss of sensation did not seem to change significantly after laser therapy. Considering that all patients had old scars following post-surgical closure of the cleft lip soon after the birth, this finding was relatively expectable.

On the other hand, patients' consciousness of the scar revealed a significant improvement after treatment. In other words, patients believed that their scar had become less noticeable for themselves and others, and they tried less frequently to hide their scar after laser treatment.

Ryu et al. [18] evaluated the effect of fractional CO₂ laser treatment of caesarean section scars. Similar to our findings, photo-evaluation found that the laser-treated scars significantly improved. They believed that scar remodeling is initiated 1 month after laser treatment. However, the overall scar improvement is concealed until the color changed induced by laser resolves at 6 months.

The present study estimated the functional condition of the repaired cleft lip by electromyographic analysis. We used surface electrodes because they are noninvasive and are better accepted by the patients. Besides, there is no special advantage in using intramuscular electrodes when examining the muscles of the lip. We found that the electromyographic activity of the upper lip significantly decreased at rest and maximum compression after laser therapy. This could be due to the

decreased volume of the scar tissue following laser treatment. It seems that fractional CO₂ laser reinforces the normal surface reconstruction of the skin tissue.

Post-surgical scar after primary lip repair usually results in a certain degree of tension that is transferred to the underlying maxilla, which may significantly interfere with normal maxillary growth. The decrease of EMG activity of the upper lip at rest can probably diminish the negative effect of the scar tissue on the normal growth of the maxilla [9, 10]. However, EMG activity of the upper lip during maximum lip compression does not seem to significantly affect the normal jaw growth.

Fractional CO₂ laser therapy of the burn scars has been reported to change the upper dermis with newly formed dermal papilla, which is characterized by improvement in clinical surface smoothness and skin tension [19]. On the other hand, Karmisholt et al. [20] reported decreased thickness of the burn scar after fractional CO₂ laser treatment. In the present study, it was not possible to evaluate the histologic response of the scar tissue to laser therapy.

The results of the present study should be interpreted cautiously due to the small sample size. Further studies with larger sample size and longer follow-up visits are recommended.

Conclusion

The fractional CO₂ laser is an effective method for treating old scars of the cleft lip with a significant change in the opinion of patients about their scar appearance. Also, the therapy can

Table 3 Muscle electrical activity during rest and maximum lip compression before and after laser treatment

Position	Time	Mean ± SD	Minimum	Maximum	<i>P</i> value*
Rest	B.T	73.3 ± 26.8	25	120	<i>t</i> = 3.17
	A.T	48.7 ± 22.7	20	80	<i>P</i> = 0.009
Maximum compression	B.T	562.5 ± 152.4	300	850	<i>t</i> = 3.28
	A.T	445.8 ± 96.4	250	550	<i>P</i> = 0.007

*Paired sample *t* test

B.T., before treatment; A.T., after treatment

help reduce the EMG activity of the upper lip at rest which can probably decrease the inhibitory effect of the scar tissue on the maxillary growth in younger patients.

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Compliance with ethical standards

Conflict of interests Author A has received a research grant from the University of Medical Sciences. There are not any other conflicts of interests.

Ethical approval All procedures performed in this study were in accordance with the ethical standards of the institutional research committee of the University of Medical Sciences and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

References

- Eslami N, Majidi MR, Aliakbarian M, Hasanzadeh N (2013) Oral health-related quality of life in children with cleft lip and palate. *J Craniofac Surg* 24:e340–e343
- Li W, Lin J, Fu M (1998) Electromyographic investigation of masticatory muscles in unilateral cleft lip and palate patients with anterior crossbite. *Cleft Palate Craniofac* 35:415–418
- Konan P, Manosudprasit M, Pisek P, Pisek A, Wangsrimgkol T (2015) Oral health-related quality of life in children and young adolescent orthodontic cleft patients. *J Med Assoc Thai* 98(Suppl 7):S84–S91
- Antoun JS, Fowler PV, Jack HC, Farella M (2015) Oral health-related quality of life changes in standard, cleft, and surgery patients after orthodontic treatment. *Am J Orthod Dentofac Orthop* 148:568–575
- Hasegawa T, Matsukura T, Mizuno Y, Suga Y, Ogawa H, Ikeda S (2006) Clinical trial of a laser device called fractional photothermolysis system for acne scars. *J Dermatol* 33:623–627
- Behroozan DS, Goldberg LH, Dai T, Geronemus RG, Friedman PM (2006) Fractional photothermolysis for the treatment of surgical scars: a case report. *J Cosmetic Laser Ther* 8:35–38
- Waibel J, Beer K (2009) Ablative fractional laser resurfacing for the treatment of a third-degree burn. *J Drug Dermatol* 8:294–297
- Cervelli V, Gentile P, Spallone D, Nicoli F, Verardi S, Petrocelli M et al (2010) Ultrapulsed fractional CO2 laser for the treatment of post-traumatic and pathological scars. *J drug Dermatol* 9:1328–1331
- Liao Y-F, Mars M (2005) Long-term effects of palate repair on craniofacial morphology in patients with unilateral cleft lip and palate. *Cleft Palate Craniofac J* 42:594–600
- Doğan S, Öncüç G, Akin Y (2006) Craniofacial development in children with unilateral cleft lip and palate. *Br J Oral Maxillofac Surg* 44:28–33
- Szyszcza-Sommerfeld L, Woźniak K, Matthews-Brzozowska T, Kawala B, Mikulewicz M (2017) Electromyographic analysis of superior orbicularis oris muscle function in children surgically treated for unilateral complete cleft lip and palate. *Craniofacial Surg* 45:1547–1551
- Asilian A, Salimi E, Faghihi G, Dehghani F, Tajmirriahi N, Hosseini SM (2011) Comparison of Q-Switched 1064-nm Nd:YAG laser and fractional CO2 laser efficacies on improvement of atrophic facial acne scar. *J Res Med Sci* 16:1189
- Alster TS, Tanzi EL, Lazarus M (2007) The use of fractional laser photothermolysis for the treatment of atrophic scars. *Dermatol Surg* 33:295–299
- Lee SH, Zheng Z, Roh MR (2013) Early postoperative treatment of surgical scars using a fractional carbon dioxide laser: a split-scar, evaluator-blinded study. *Dermatol Surg* 39:1190–1196
- Tanzi EL, Alster TS (2004) Comparison of a 1450-nm diode laser and a 1320-nm Nd:YAG laser in the treatment of atrophic facial scars: a prospective clinical and histologic study. *Dermatol Surg* 30:152–157
- Tierney E, Mahmoud BH, Srivastava D, Ozog D, Kouba DJ (2009) Treatment of surgical scars with nonablative fractional laser versus pulsed dye laser: a randomized controlled trial. *Dermatol Surg* 35:1172–1180
- Mundy LR, Miller HC, Klassen AF, Cano SJ, Pusic AL (2016) Patient-reported outcome instruments for surgical and traumatic scars: a systematic review of their development, content, and psychometric validation. *Aesthet Plast Surg* 40:792–800
- Ryu HJ, Choi JE, Ahn HH, Kye YC, Seo SH (2014) A comparison of the scar prevention effect between carbon dioxide fractional laser and pulsed dye laser in surgical scars. *Dermatol Surg* 40:973–978
- Ha JM, Kim HS, Cho EB, Park GH, Park EJ, Kim KH et al (2014) Comparison of the effectiveness of nonablative fractional laser versus pulsed-dye laser in thyroidectomy scar prevention. *Ann Dermatol* 26:615–620
- Karmisholt KE, Taudorf EH, Wulff CB, Wenande E, Philipsen PA, Haedersdal M (2017) Fractional CO2 laser treatment of caesarean section scars—a randomized controlled split-scar trial with long term follow-up assessment. *Lasers Surg Med* 49:189–197

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