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ORIGINAL RESEARCH

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Evaluation of parental perceptions of lingual and labial frenectomy on their child: a comparison of CO_2 laser and conventional scalpel

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Abstract

To evaluate parental reports of postoperative pain, improvement and satisfaction following frenectomy with scalpel versus carbon dioxide (CO_2) laser treatment. Forty-nine patients aged 2–6 years with a short labial or lingual frenulum who required frenectomy were randomly assigned to undergo CO_2 laser or scalpel treatment. They were divided into a labial and a lingual frenulum group based on the severity of attachment. Frenectomy was performed using a scalpel or Pixel CO_2 10,600 nm laser (Alma Lasers Company, Caesarea, Israel). Postoperative follow-up was conducted *via* a mobile application where pain was evaluated daily using the visual analog scale (VAS) in the first 72 hours, and painkiller use was recorded. Improvement and satisfaction were evaluated at 1-month post-surgery and compared among the groups. Our results showed significant differences between the degree of clinical attachment of the frenulum, one-month postoperative improvement and satisfaction based on VAS scores ($p < 0.001$). Although the use of scalpel was associated with lower postoperative pain scores than the CO_2 groups, VAS scores of improvement and satisfaction after 1 month were higher in the CO_2 groups ($p < 0.05$). This study showed that although laser was associated with more postoperative pain, it showed greater improvement and higher satisfaction among patients' parents at 1 month post-surgery compared with scalpel.

Keywords

Frenectomy; LASER; Tongue-tie; Paediatric; Oral Surgery

1. Introduction

The frenulum was historically thought to be a mucosal fold, but recent studies showed it to be a complex structure containing connective tissues, fascia layers and even muscle fibers [1, 2]. Priyanka *et al.* [3] (2013) reported that the most notable frenal attachments in the oral cavity are the maxillary labial fraenum, mandibular labial fraenum and lingual fraenum. The maxillary and mandibular labial frenulum are composed of dense collagenous connective tissues that may frequently interact with surrounding muscles [1]. Observational studies have shown a wide variety of morphologic variations, and the lingual frenulum's structure has been described as a "midline fold" [4].

As described by Baxter *et al.* [5] (2022), a short maxillary frenulum can be problematic for oral hygiene as it can harm gingival health, cause speech (*i.e.*, when producing bilabial speech sounds) and eating (*i.e.*, when removing food from a spoon) difficulties, and may result in chronic open-mouth breathing, an uneven smile line, lip fullness and diastema formation. Kotlow classified labial fraenum attachment insertion into four classes. He proposed that a higher class was associated with greater severity of the tie and associated consequences [6]. Hand *et al.* [7] (2020) described a short lingual frenulum, also known as tongue-tie or ankyloglossia, as a congenital condition in which the lingual frenulum could be abnormally short, thick and restrict the tongue's mobility leading to impaired function. Ankyloglossia may be associated with other craniofacial abnormalities, although it is often an isolated anomaly [8]. In the early stages of embryological development, the tongue is anchored to the floor of the mouth; however, during embryonic development, some cells undergo apoptosis, making the tongue lose its initial anchorage. When this process does not occur, a tongue tie is formed. Kotlow [9] (1999) introduced a simple classification scale to measure the degree of "free tongue" for older patients and infants. The term "free tongue" is defined as the tongue's length from the insertion of the lingual fraenum into the tongue's base until its tip [10] (Fig. 1).

The reported prevalence of tongue-tie is 4%–10% [11–14] with a male-female ratio of 2.6:1.0 [13]. Treatment of a short frenulum can be done surgically by frenotomy or frenectomy. Frenotomy is a simple clipping of the frenulum, which usually can be performed with straight, blunt-ended scissors or a single

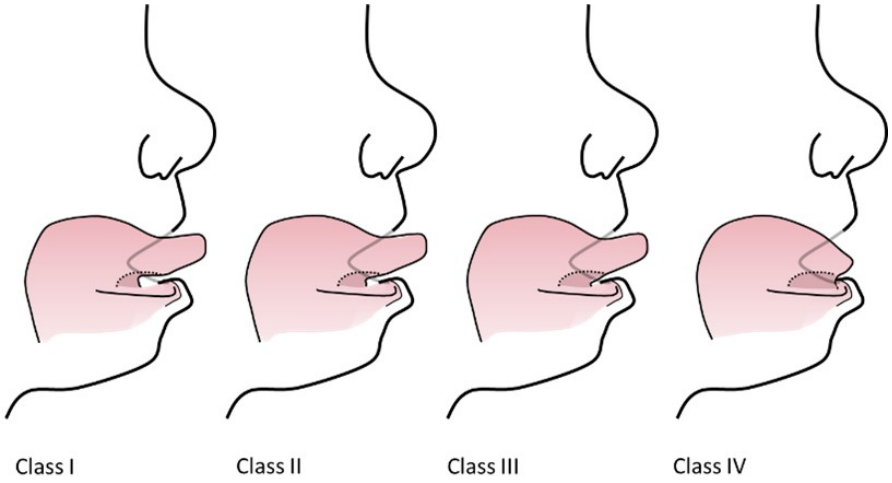

FIGURE 1. Classification of Ankyloglossia as per the Kotlow classification (1999).

incision by scalpel. Frenectomy is the excision of the entire frenulum and the release of its attachment. A frenectomy is considered the most straightforward procedure for correcting a short frenulum [11, 15, 16]. There are several techniques to perform the procedure. For instance, the conventional technique involves the excision of the fraenum using a scalpel [15]. The diode laser technique [17] and the CO_2 laser technique are more recent alternatives [18]. Laser technology is described in literature as an alternative to conventional techniques with several advantages, such as shorter procedural time, tissue cauterization and sterilization, hemostasis, less frequent requirement for local anesthesia and fewer postoperative complications (pain, swelling and infection) [19]. A meta-analysis of six studies comparing pain after frenectomy showed that frenectomy by laser was associated with lesser overall duration of pain compared to conventional scalpel [20].

Evaluating new methods for frenectomy is very important for the treatment of pediatrics. However, assessing postoperative parameters among young patients, especially preverbal children, is challenging as they cannot effectively communicate their discomfort; thus, the pain intensity of the children was evaluated in this study based on the parents' perceptions and observations of their children [21]. This study assessed the severity of the frenulum attachment, postoperative pain, pain improvement and treatment satisfaction of frenectomy performed with scalpel versus carbon dioxide (CO_2) laser to provide a reference for the clinical management of lingual frenulum in pediatrics.

2. Materials and methods

2.1 Study design and sampling

The work followed the CONSORT (**Supplementary material**) guidelines for controlled clinical trials. Inclusion criteria for participation were: (a) patients aged between 2 and 6 years, (b) the condition was classified as class III or IV by Kotlows classifications or class II with functional limitation.

The patients' demographic data, medical history, clinical signs and symptoms, and main complaints were obtained from their parents' reports. Frenulum classification was recorded for all patients. The labial frenulum was classified into four groups based on the Kotlow 1999 classification: class I—minimal visible attachment, class II—frenulum attached primarily to the gingival tissue, class III—frenulum inserts in front of the anterior papilla, and class IV—frenulum attached into the hard palate. The distance from the lingual frenulum attachment to the tip of the tongue was measured and classified by Kotlows 1999 classification as follow: class I—mild, distance of 12–16 mm; class II—moderate, distance of 8–11 mm; class III—sever, distance of 3–7 mm; and class IV—complete, <3 mm.

Exclusion criteria in the study were: (a) patients who were not in the scope of the age group at the day of the treatment, (b) patients that had previous treatments for frenectomy, and (c) had other concomitant diseases. The parents were given a link to a mobile phone app that guided them on measures before and after the surgical procedure, including instructional videos that emphasized the importance of performing stretches or exercises after a frenectomy. The app also provided a direct communication channel through which questionnaires were transmitted for follow-up. The phone application was launched as part of the study and was intended for a limited number of patients according to the criteria set out in the Helsinki approval to avoid leaking the patients' personal information. An experienced oral and maxillofacial surgeon examined all patients and made the final decision on whether the patient met the inclusion criteria or not.

2.2 Laser protocol

Pixel™CO_2 laser (CO_2LASER, Alma Lasers Company, Caesarea, Israel) was used at a wavelength of 10,600 nm and a continuous wave (CW) mode with power set at 1.5 W. The handpiece was set to a focal length of 100 mm with a spot size of 0.2 mm in noncontact conditions.

2.3 Surgical protocol

Surgery was conducted under intravenous sedation and local anesthesia using 2% lidocaine with epinephrine (dilution, 1:100,000). All the surgical interventions were done by a single clinician using the same laser settings, scalpel and sur-

gical protocols. The frenectomy procedure was performed in a randomized sequence using either a conventional scalpel No. 15 blade, considered the gold standard cutting tool for soft tissue in surgical procedures, or a CO_2 10,600 nm wavelength Pixel™CO_2 laser. As participants are recruited into the study, they are randomly assigned to either the laser group or the scalpel group. The randomization sequence determines the order in which participants receive their assigned treatment.

In the scalpel group, the fraenum was engaged with a hemostat inserted into the depth of the frenulum attachment, and incisions were done on the upper and under the surface of the hemostat. Blunt dissection was performed to relieve the fibrous attachment mid-way between the Wharton's duct and the base of the tongue. Lastly, the edges of the diamond-shaped wounds were sutured with interrupted sutures (resorbable 3-0 Vicryl Rapide).

In the laser group, the first incision was done in the vertical axis of the frenulum until the wound presented a linear shape. The laser was applied transversely at this point, and no suturing was performed in the laser group. In both the scalpel and the laser group, the lingual and labial frenectomies were conducted until the wound showed a diamond shape. The patients were instructed to maintain healthy oral hygiene throughout the postoperative period. Antibiotics were not prescribed to any patient.

2.4 Pain scoring

Pain Score (PS) was estimated using the Visual Analog Scale (VAS) based on the parents' rating of their child's experience. In the first 72 hours, daily postoperative pain scores of patients were reported based on their parents' subjective assessment. On the pain scale, the left endpoint indicated "no pain", whereas the right endpoint indicated "worst pain". The highest score in the first 72 hours was selected for each individual. In addition to pain scoring, parents also reported the use of any drugs used for pain relief.

2.5 Improvement and satisfaction scoring

One month after treatment, parents received a questionnaire to evaluate pain improvement and satisfaction following the procedure. Improvement Criteria (IC) referred to improvement postoperative depending on the reason for referral to our department. Satisfaction Criteria (SC) evaluated parents' satisfaction with the frenectomy procedure using a 0–10 scale, where "0" represented the lowest score and "10" the highest score.

2.6 Statistical analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) software, version 19 (IBM Corporation, Armonk, NY, USA). The Shapiro-Wilk Test was used to determine the normality of the data. Frenectomy perception was defined as the degree of frenulum attachment. The Kruskal-Wallis rank sum test was the nonparametric test chosen for non-parametrical variables. Kruskal-Wallis was used for comparisons between the groups, with the significance level set to 5% ($p < 0.05$). Analysis of pain, pain improvement and satisfaction were evaluated using the Wilcoxon signed-rank test. Results are represented as mean ± standard deviation, with $p < 0.05$ considered significant.

3. Results

Sixty patients were assessed for eligibility, of whom 6 did not meet the inclusion criteria, and another 5 were excluded due to incomplete follow-up. Thus, the parents of 49 patients completed the 1-month follow-up questionnaire using the mobile app. The patients' mean age was 3.6 years, ranging from 2 to 6 years. A short frenulum appeared at the lingual site in 29 patients, comprising 12 females and 17 males. Short labial frenulum appeared in 20 patients (females, 17 and males, 3). The severities of the short frenulum as per the combined Kotlow LA scale for lingual and labial frenulum were as follows: Class IV, 57% (n = 28), Class III, 31% (n = 15) and Class II, 12% (n = 6).

3.1 Frenectomy perception as a dependency of the degree of frenulum attachment

The comparisons of frenulum attachment severity and its effects on pain, pain improvement and satisfaction are shown in Table 1. No statistical differences were found between classification degree and reported pain levels as per the VAS pain scale (Fig. 2A and Table 1). The improvement levels were measured using the VAS scale, which revealed significant differences ($p < 0.001$) between the classes. Significant differences were detected between Class IV and Class III ($p = 0.004$) and between Class IV and Class II ($p = 0.002$), but no significant difference was observed between Class III and Class II ($p = 0.088$) (Fig. 2B). Satisfaction levels measured according to VAS scale revealed significant differences ($p = 0.019$) among the classes Significant differences were only detected between Class IV and Class II groups ($p = 0.009$). No significant differences were found between Class IV and III ($p = 0.159$) or Class III and II ($p = 0.058$) (Fig. 2C).

3.2 Lingual frenectomy

This group included 29 patients with a mean age of 3.5 years, ranging from 2 to 6 years. Short lingual frenulum appeared in 12 females and 17 males. The severity of the short frenulum, as per the Kotlow classification (1999), was distributed as follows: Class IV, 45% (n = 13), Class III, 38% (n = 11) and Class II, 17% (n = 5). Fig. 3 is a clinical photograph demonstrating attachment of a Class IV lingual frenulum, with the frenulum attached to the tip of the tongue (Fig. 3A). After frenectomy with CO_2, the same patient showed no bleeding and better lingual mobility or frenulum limitation (Fig. 3B). Analysis of the VAS score of pain (Fig. 3C) showed a significant difference ($p = 0.00006$) among patients who underwent frenectomy with a scalpel versus CO_2 laser. Of the patients who underwent lingual frenectomy with CO_2 laser, 60% took painkillers to manage their pain level. In the scalpel group, 21% of patients took painkillers to control their pain. Among patients who underwent lingual frenectomy, greater improvements in VAS scores were reported among patients treated with CO_2 laser compared with those in the scalpel group ($p = 0.002$) (Fig. 3D).

TABLE 1. Frenectomy perception as a dependency of the degree of frenulum attachment.

Variables	Class II	Class III	Class IV	*p*
Pain	5.0 ± 1.09	4.2 ± 1.26	4.2 ± 1.25	0.3
Improvement	7.6 ± 0.81▽	8.3 ± 0.72‡	9.1 ± 0.86	$p < 0.001$
Satisfaction	8.1 ± 0.7▽	8.8 ± 0.63	9.1 ± 0.72	0.01

‡: *significant difference between class III and IV, $p < 0.01$;* ▽: *significant difference between class II and IV, $p < 0.01$.*

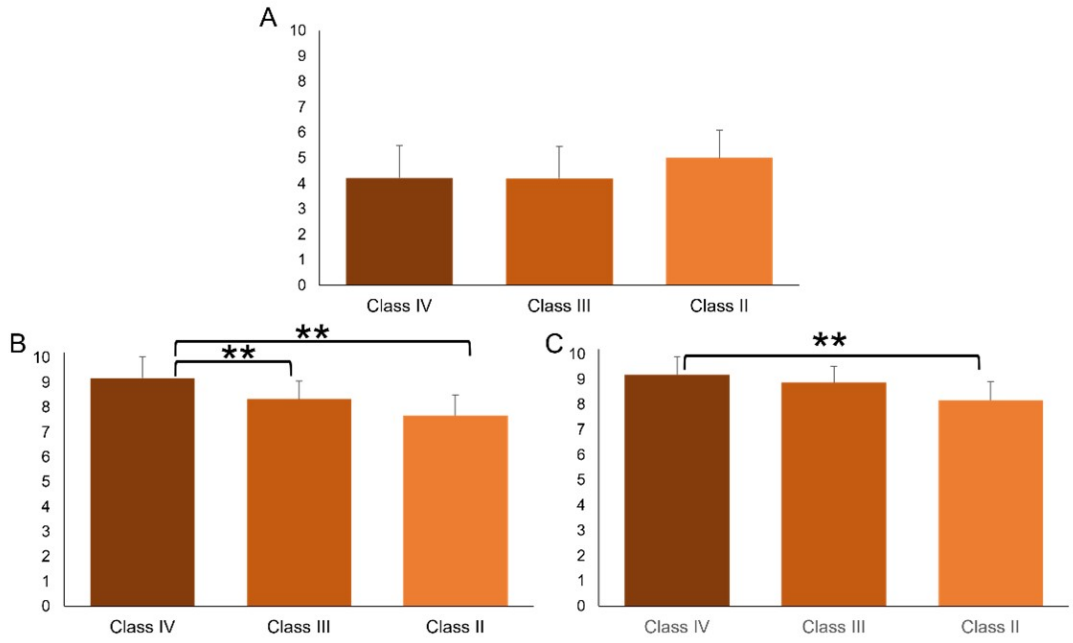

FIGURE 2. Frenectomy perception depending on the severity of attachment. (A) Pain score by VAS. (B) Improvement score by VAS. (C) Satisfaction score by VAS. $^{**}p < 0.01$.

Patients from the CO_2 laser group had significantly higher mean satisfaction scores compared to patients treated with a scalpel ($p = 0.0001$) (Fig. 3E).

3.3 Labial frenectomy

This group comprised 20 patients, with a mean age of 3.7 years, ranging from 2 to 6 years. Short labial frenulum appeared in 16 females and four males. The severity of the short frenulum as per the Kotlow classification (2004) was distributed as follows): Class IV, 75% (n = 15), Class III, 20% (n = 4) and Class II, 5% (n = 1). Fig. 4A is a clinical photograph demonstrating attachment of a Class IV labial frenulum with the frenulum attached to the anterior hard palatal area, and Fig. 4B shows the same patient after the frenectomy procedure with CO_2 laser, from which no bleeding and deep vestibulum could be observed. The analysis showed statistically significant differences in VAS scores for pain ($p = 0.0003$) among patients who underwent frenectomy with scalpel versus CO_2 laser. (Fig. 4C). Of the patients who underwent lingual frenectomy with CO_2 laser, 57% took painkillers to manage the pain, compared with 33% in the scalpel group. Among patients who underwent lingual frenectomy, the parents reported a greater improvement in VAS mean score among patients treated with CO_2 laser compared to patients treated with scalpel ($p = 0.002$) (Fig. 4D). The mean satisfaction score of patients who underwent lingual frenectomy with CO_2 laser was significantly higher than patients treated with scalpel ($p = 0.024$) (Fig. 4E).

4. Discussion

In the past decade, there has been an increasing number of research on tongue and lip ties, and we also observed more patients presenting with a short labial/lingual frenulum and related functional complains at our department. We assume this increase in awareness reflected that tongue and lip-ties anomalies vary in size and location of the frenulum, leading to many signs and symptoms besides those observed during breastfeeding.

While surgical treatment of frenectomy is more commonly done with a scalpel, lasers have become increasingly popular though there remain controversies regarding the advantages and disadvantages of scalpel versus different laser therapies [22]. This present study evaluated frenulum attachment severity, postoperative pain, pain improvement and satisfaction following frenectomy with scalpel versus CO_2 laser based on pediatric patients' parents' perceptions of their child during treatment.

Tongue and lip ties frenectomy are often considered an over-treatment. However, we agree with Olivi *et al.* [23] (2018), who emphasized the importance of intervention when it is associated with anatomical anomalies (*i.e.*, cases of Class III and IV as per Kotlows classification) and functional limitations

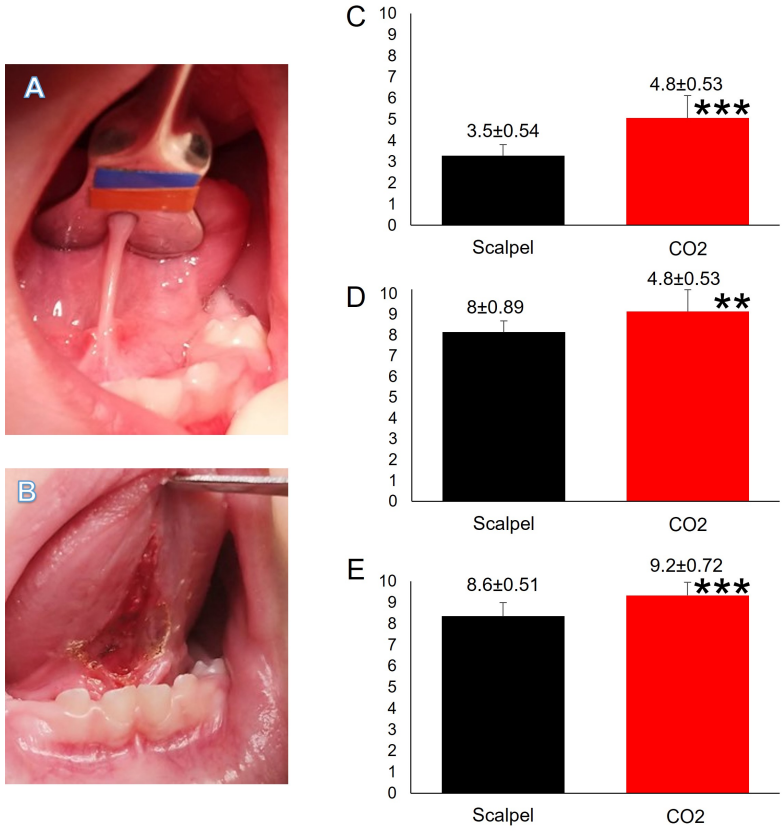

FIGURE 3. Lingual frenectomy evaluation of patient perception. (A) Clinical photography of a Class IV attached lingual frenulum. (B) Clinical photography immediately after surgery with CO_2 laser. (C) Pain score by VAS. (D) Improvement score by VAS. (E) Satisfaction score by VAS. $^{**}p < 0.01$, $^{***}p < 0.001$.

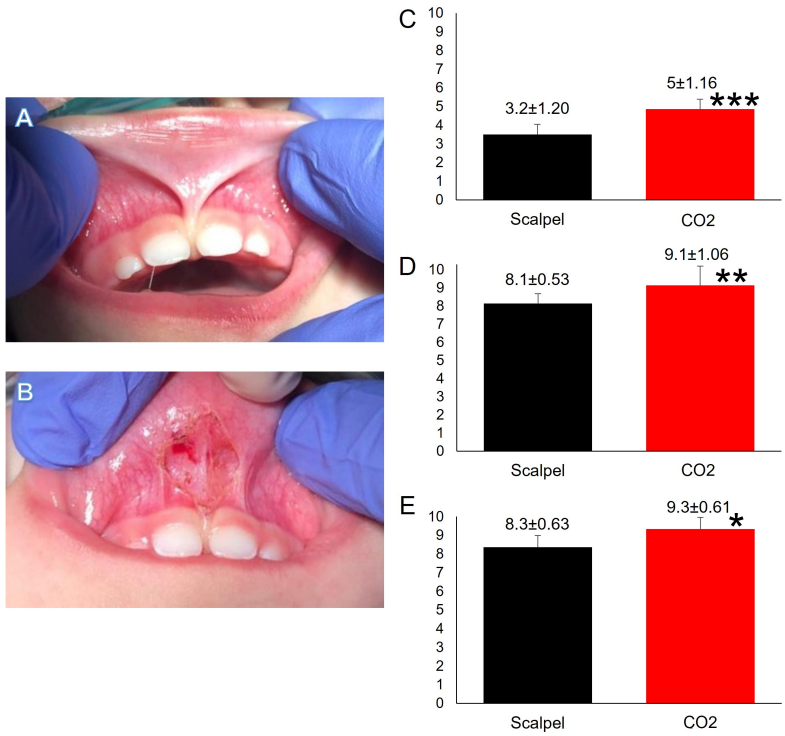

FIGURE 4. Labial frenectomy. Evaluation of patient perception. (A) Clinical photography of a Class IV attached labial frenulum. (B) Clinical photography immediately after surgery with CO_2 laser. (C) Pain score by VAS. (D) Improvement score by VAS. (E) Satisfaction score by VAS. $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

of tongue and lip frenulum. Although this was a randomized prospective clinical trial, some associated limitations were the small sample size in each group and that the pain scores were based on the parents' subjective perceptions, which could have been emotionally biased by not exactly representing the actual pain level of the child. There was a male-female dominance of 1.4:1 in the tongue tie group, which is supported by literature reporting a greater incidence in males [13]. On the other hand, there was a female dominance for short labial frenulum, with a female: male ratio of 5.6:1. To our best knowledge, there is currently no literature that has reported a male-to-female difference in this aspect; nevertheless, because of the small sample size no concrete conclusion could be made. Labial and lingual Class II, III or IV (Kotlow classifications) may provoke signs and symptoms; while symptoms and complications should be evaluated for possible treatment, while no intervention is usually required if this is caused by Class I attachment [22, 24]. Our results were concordant with the above statement, as our patients were mainly classified as Class IV or III, while patients classified as Class II were mainly referred to us by other experts due to functional difficulties such as aesthetic issues or more importantly, speech, eating and sleep difficulties.

To the best of our knowledge, no study has compared the attachment classes to pain levels or improvement and satisfaction levels after labial or lingual frenectomy. We found that the severity of the attachment did not affect the pain score after frenectomy, which could be due to the procedure and the wound size that was similar among the patients and was not related to the severity of the attachment. Regarding postoperative improvement levels after one month, we noticed that the improvement scores were highest among patients classified as Class IV compared with those with Class III and II attachments. Nevertheless, patients classified as Class III did not exhibit statistically significant differences compared with Class II patients. Considering the satisfaction criteria, patients classified as Class IV were more satisfied with the frenectomy procedure than patients classified as Class II. We can assume that the improvement and satisfaction levels of Class IV patients corresponded directly to patients' limitations and impacts on daily life, as this is classified as the highest degree of severity which probably limited mobility of the tongue or lip prior to the frenectomy. However, it is important to note that even though Class IV patients reported higher levels of improvement than Class III and II, the latter two groups still scored a mean improvement level of ~8 and total satisfaction of ~8.5 on the VAS scale.

Further, this is the first study to have evaluated and compared alternative techniques for pain, improvement and satisfaction with regard to the evaluation of patients' parents' perceptions of tongue or lip frenectomy using either scalpel or CO_2 laser. Postoperative pain scores in both tongue and lip frenectomy, and in both the scalpel and the laser group during the first 3 days after the procedure, were different from that reported in literature because patients treated with CO_2 laser reported higher pain levels than those treated with scalpel in our study, resulting in patients who underwent CO_2 laser to have greater use of painkillers. This might be explained by the thermal effect aiding coagulation with the CO_2 laser, which may produce postoperative pain and increase the possibility of altering laser parameters. Another explanation for postoperative pain in the laser group could be that scale primary healing, less nerve exposure and less pain. The results on CO_2 laser in postoperative pain levels vary in literature. Haytac *et al.* [25] (2006) reported that patients experienced less postoperative pain with CO_2 laser for frenectomy, while Tambuwala *et al.* [26] (2014) concluded that postoperative pain after laser excision was not significantly different compared with scalpel. Thus, further studies are still needed and should include a larger number of patients and a range of CO_2 parameters to determine the contribution of both treatments to postoperative pain.

Numerous articles have reported improvements after labial/lingual frenectomy [7, 22, 27], which significantly improved the children breastfeeding ability. Baxter *et al.* [28] (2020) reported that most children experienced functional improvements in speech, feeding and sleep after frenectomy. Nevertheless, Klockars *et al.* [29] (2009) reported that re-operation was required in up to 30% of frenectomies due to relapse or regrowth of the frenulum. Thus, further investigations with longer follow-ups are required to better understand the variations in improvement results following frenectomy that could contribute to a relapse.

Parents of patients who underwent frenectomy with CO_2 laser were more satisfied with the procedure. Hamilton *et al.* [30] (2013) reported that patients' satisfaction level was determined by their preoperative expectations, pain level, hospital experience and improvement compared to their preoperative state. In this present study, the high satisfaction scores reported by both groups reflected their corresponding pain scores and improvement scores. Given that all the conditions mentioned above, except for the surgical tool and sutures, were similar between both treatment groups, the higher satisfaction scores in the CO_2 laser group could be associated with improvement in the postoperative period. Yadav *et al.* [31] (2019) suggested that sutures after frenectomy might be a cause affecting oral hygiene at the surgical site and more postoperative pain and discomfort, leading to lower patient satisfaction. As a result, those patients might require a greater number and dosage of analgesics. In our study, the satisfaction score by VAS was highest for the laser group compared to the scalpel group. We assumed this could be partially due to the suture-related issues mentioned above. Nevertheless, the reported pain scores by VAS for the laser group in this study were higher than the scalpel group where suturing was used after frenectomy.

Even though the mobile application was "just" a tool for communication and follow-up, it is important to note that all the parents collaborated and actively participated through the mobile application. This increased our understanding of how parents interact in real-time with a mobile application designed to assist with their child's recovery after frenectomy, which was crucial in guiding them about pre- and postoperative instructions and completing the follow-up questionnaire. Thus, interdisciplinary collaboration to enhance the scope and quality of the mobile application in bigger and more diverse populations and interactions between healthcare workers and patients regarding the application are recommended future avenues. However, it should also be noted that the mobile

application lacked robust security guarantees for personal medical information. Therefore, at this stage, it has been approved for limited use only for research purposes and not as open access for the public. A further study with a larger number of patients and different parameters for the CO_2 laser settings is required to determine the effects of this technology on intra- and postoperative criteria. Histology analysis of the frenulum tissue post-operation may provide a better understanding of the advantages and disadvantages of these different excision tools.

5. Conclusions

This randomized prospective clinical study indicated that frenectomy with CO_2 laser without sutures had several advantages, including greater improvement and higher satisfaction among patients' parents, despite being more painful than scalpel and sutures. Considering the severity of the frenulum attachment, patients classified as class II may experience less improvement than those classified as class IV and might be relatively less satisfied with the procedure. Thus, it is essential to coordinate expectations among patients and parents, especially those who have less severe frenulum, as they may experience less improvement compared with patients with more severe frenulum attachment.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

OE, JGG, AB—designed the research study. JGG, OE and AB—performed the research. TC, SN, AB and AR—analyzed the data. AB, AR, EB, OE, CO and JGG—wrote the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Ethics Committee Approval was obtained from the Rambam Health Care Campus—Helsinki Committee of our institution (0119-20RMB). The patients' parents provided signed consent after clearly describing the clinical treatment plan and alternatives.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://oss.jocpd.com/files/article/1720313745075257344/attachment/Supplementary%20material.pdf.

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