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Original article

Safety and efficacy of maxillary labial frenectomy in children: A retrospective comparative cohort study

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Summary

Background > Maxillary frenectomy in children is a common procedure, but concerns about scar tissue affecting diastema closure prevent many clinicians from treating prior to orthodontics.
Objectives > To determine if maxillary frenectomy is safe and if diastema size is affected by early treatment.
Materials and methods > Paediatric patients with hypertrophic maxillary frena were treated under local anaesthesia with diode laser and CO_2 laser. Diastema width was compared by calibrating and digitally measuring initial and postoperative intraoral photographs.
Results > In total, 109 patients were included: 95 patients with primary dentition (39% male; mean age 1.9 years $\pm$ 1.5 years) and 14 with mixed dentition (43% male; mean age 8.1 $\pm$ 1.3 years) with a mean follow-up of 18.0 $\pm$ 13.2 months. No adverse outcomes were noted other than minor pain and swelling. In the primary dentition, a decrease in diastema width was observed in 94.7% with a mean closure of -1.4 ± 1.0 mm (range +0.7 to -5.1 mm). In the mixed dentition, a decrease in diastema width was observed in 92.9% with a mean closure of -1.8 ± 0.8 mm (range 0 to -3.5 mm). 74.5% of patients in the primary dentition and 75% of patients in the mixed dentition with preoperative diastema > 2 mm improved to < 2 mm width postoperatively.
Conclusions > Frenectomy is associated with cosmetic and oral hygiene benefits and when performed properly, does not impede diastema closure and may aid closure. Technique and case selection are critical to successful outcomes. IRB ethics approval was obtained from Solutions IRB protocol #2018/12/8, and this investigation was self-funded.

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Introduction

Historically, variations in the maxillary midline frenum and associated diastema have been considered normal anatomy, a symbol of beauty in some cultures, and pathologic in certain circumstances [1,2]. At birth, infants routinely have frena that insert near the papillae, or almost to the alveolar ridge [3], but in some infants, restricted maxillary frena can cause difficulty with breastfeeding and bottle-feeding [4–6]. Since most babies have low frena, blanching of the tissue, distress when lifting, and difficulty flanging the lip for feeding are the main reasons to treat restricted maxillary frena in babies [7].

As a child grows, the relative height of the frenum often recedes due to growth and remodelling of the maxilla, so it appears to be smaller and higher up on the gingiva than it does on a newborn [1,2]. Despite these changes, many children have persistent diastemas and thick maxillary frena until the permanent canines erupt. The causes of diastemas are multifactorial, but many times, hypertrophic frena are to blame [2,8]. After the eruption of the permanent canines, a child's diastema often persists and orthodontic treatment is necessary to close the space. Diastemas wider than 2 mm are thought to rarely close spontaneously, either from mesial migration or eruption of the canines [2,9]. The orthodontically closed gap will almost always need to be maintained with a fixed retainer since the cause of the diastema was not addressed surgically [8].

Common indications for removal of maxillary frena in children include difficulty performing oral hygiene, oral incompetence resulting in difficulty producing bilabial speech sounds (/b/,/p/,/m/,/w/), difficulty removing food from a spoon, habitual open mouth breathing, improving the cosmetic appearance of the smile line, lip fullness, and diastema closure [2,7,10]. In the early days of orthodontics, Angle proposed removing abnormal frenal tissue with cautery first and then closing the space orthodontically [11]. In the mid-1900s, this treatment fell out of favour, and practitioners were counselled that if a diastema was present, it was best to wait until after orthodontic closure to release the tight maxillary frenum. This sequence was thought to prevent the formation of "scar tissue'' and a persistent diastema [1]. Bergström et al. studied frenectomy and control groups and found the diastema closed rapidly after frenectomy, and the difference remained at one, two, and five years, but by ten years, many of the control group had also closed [12], leading some to believe it was best to wait and see. Both groups, however, had initial mean diastema sizes of 1.6 mm which will tend to close spontaneously [2,9,12]. This advice of waiting until after orthodontics (age 13 or later) is still taught in dental and specialty training programs and is a common practice among oral surgeons, orthodontists, and paediatric dentists [13]. The article commonly cited for waiting until after orthodontics to prevent scar tissue, Bishara 1972, never once mentions scar tissue [14]. However, it does state that "every effort should be made to diagnose properly and remove the cause of the diastema or to avoid its occurrence whenever this is predictable and possible''[14]. In the current study, we sought to determine whether a contemporary laser frenectomy is safe and effective and concerning the primary safety concern of scar tissue, assessing whether frenum release impedes diastema closure in paediatric patients.

Materials and methods

Study Design

This cohort study examined patient records and treatment outcomes of 192 consecutively treated paediatric patients who underwent maxillary labial frenectomy in a private paediatric dentistry clinic from January 2015–May 2018. Initial photographs were taken of every patient before and after the procedure, and again when the patient returned for hygiene visits.

Patients referred to our office from outside our dental home were contacted multiple times by text, telephone, and email to return for a visit or submit a straight-on photo clearly demonstrating the maxillary teeth to gather as many images as possible to prevent bias. Any submitted photos were subject to the same quality standards for intraoral images and must have been close-up, straight-on images that were easily measured. The width between the maxillary central incisors was measured based on intraoral photographs taken immediately prior to the intervention and compared to photographs taken at a minimum follow-up of one month postoperatively. IRB ethics approval was obtained from Solutions IRB protocol #2018/12/8, and this investigation was self-funded.

Inclusion/Exclusion Criteria

Patients who underwent maxillary labial frenectomy with photo documentation of the maxillary diastema taken preoperatively and at least one month postoperatively were included in the study. Patients with any history of orthodontic treatment were excluded. Infants without erupted maxillary primary teeth were excluded. Postoperative images that were sent that were not of sufficient quality or off-angle were rejected.

Intraoral Photographs

Digital photographs of the maxillary labial frenum and central incisors were taken immediately prior to the intervention and obtained again at a follow-up visit at least 1 month after the procedure. Intraoral photographs were taken using a ProDent, PD740 intraoral camera (Venoka USA Inc, Windermere, FL) and analyzed with VixWin Platinum Software (Gendex, Kavo Dental, Brea, CA) to measure the width between the maxillary central incisors at baseline and at follow-up. To standardize and compare images, calibration of the software's measurement tool with the average mesiodistal width of a primary central incisor (6.5 mm) and permanent central incisor (8.5 mm) occurred prior

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to measuring each photograph (*figure 1*) to account for any angulation irregularities [15]. The space between the maxillary central incisors was measured digitally at the height of contour of the tooth, taking care to measure at the same location between images on each patient for the most accurate measurements. Measurements from digital images taken by intraoral cameras have been shown to be reliable previously [16,17].

Intervention

Maxillary labial frenectomy was performed using a diode or CO_2 laser. Informed consent was obtained after discussing risks and benefits. Topical anaesthetics were applied to the frenum, and cooperative children received injected lidocaine. Parents aided in passive restraint of their children by holding their hands. No general anaesthesia or sedation was utilized. All present donned laser safety glasses. Tension was applied to the maxillary labial frenulum by everting and elevating the upper lip. Diode or CO_2 laser was used to ablate and excise the mucosal and fascial fibers of the maxillary frenum, a frenectomy, beginning at the insertion of the frenum but not removing any palatal tissue, and removing tissue mesiodistally until reaching the height of the vestibule, taking care to avoid the teeth, avoiding heating the bone, and avoiding orbicularis oris muscle fibers (*figures 2 and 3*). A similar technique was utilized for both instruments, by the same operator (RB). Diode laser settings were 1.5 W avg. CP2 with an iLase (BIOLASE, Irvine, CA). The glass tip was initiated (charred) presurgery per manufacturer's instructions, to reach operating temperature (700–1,000 C) to thermally cut the tissue [18,19]. CO_2 laser settings of Non-Superpulse 3 W, 29 Hz, 72.5% duty (2.1avg. W), and 0.25 mm diameter focal spot were used with the LS-1005 (LightScalpel, Bothell WA). Minimal to no bleeding was present for all cases, and no sutures were placed. The average procedure time was 60 seconds with diode and 15 seconds with CO_2 laser. Postoperative wound care included elevating the area 2–3 times a day and massaging the wound with upward strokes for 3 weeks to prevent re-adhesion of the site and promote tissue healing in an apical location.

FIGURE 1

Diastema Measurement and Calibration. The diastema was measured after calibrating the measuring tool with the mesiodistal width of the central incisor. Periodontal probe to demonstrate measured amount equals 5 mm on both periodontal probe and measuring software for accuracy after calibration. This maxillary frenum was released with a CO_2 laser. Notice diamond shape with no bleeding and minimal charring

Statistical analysis

Measurements of maxillary central incisor width at baseline and follow-up along with demographic and treatment data (laser type, etc.) were input into a spreadsheet and analyzed with JMP Pro 14.1 (SAS Institute Inc., Cary, NC) statistical software. Continuous variables are summarized as mean (M) ± standard deviation (SD). Categorical variables are summarized as frequencies and percentages. Univariate analysis with ANOVA (continuous variables) was performed to assess for covariates of change in diastema width based on age, gender, frenum classification, dentition type, and type of laser used. Bonferroni correction was applied to the interpretation of statistical significance due to the testing of multiple variables for each outcome, such that a two-tailed P-value < 0.01 was required to achieve statistical significance. The sample size required to assess a 1 mm difference assuming a standard deviation of 1 mm with

FIGURE 2

Diastema Closure in Primary Dentition After Diode Laser Release. Thick and restrictive maxillary lip-tie released with diode laser. Follow-up images taken 12 months and 4 years postoperatively demonstrating diastema closure and more cosmetic appearance with higher lip elevation and facilitation of oral hygiene. Diode laser release is haemostatic but demonstrates more charring due to heat used to thermally remove tissue

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FIGURE 3

Diastema Closure in Mixed Dentition After CO_2 Laser Release. Maxillary frenum and diastema in mixed dentition released by CO_2 laser. Notice less charred appearance and no bleeding postoperatively. Diastema closure, more cosmetic appearance, and easier oral hygiene without orthodontic intervention. Postoperative picture taken at 3 years

alpha=0.01 was calculated as $n = 16$ for power of 80% and $n = 28$ for power of 99%.

Results

There was a 56.8% response rate from 192 consecutively treated patients who returned for routine dental care or submitted a follow-up photo after a minimum of one month after frenectomy. In total, 109 patients were included in the study including 95 patients in the primary dentition (58 females, 37 males; mean age 1.9 years ± 1.5 years) and 14 in the mixed dentition (8 females, 6 males; mean age 8.1 ± 1.3 years). The total age range of patients studied was 10 months to 11 years. Maxillary frena were classified as Kotlow Class 3 (inserting into papilla) in $n = 30|27.5\%$ and Kotlow Class 4 (wrapping around to the palate) in $n = 79|72.4\%$ of cases [20,21]. The procedure was initially performed with a diode laser for the first 57 patients included in the study; the surgeon (RB) switched to a CO_2 laser for the following 52 cases. No adverse outcomes or complications were noted other than minor swelling and discomfort of the upper lip for 2-3 days, and minor bleeding lasting not more than 10 minutes.

Of the 95 patients in the primary dentition included in the study, 51 | 53.6% presented with a diastema of ≥ 2 mm prior to release of the upper lip-tie. The overall mean ± SD of preoperative diastema width was 2.3 ± 1.2 mm (range 0 to 7.2 mm). Postoperatively, at a mean follow-up of 16.6 .0 ± 12.0 months (range 1 to 49 months), there were $n = 1$ |13.6% patients with a diastema of ≥2 mm after release of the upper lip-tie. Mean ± SD of postoperative diastema was 0.85 ± 0.86 mm (range 0 to 3.2 mm, $P < 0.0001$). The mean difference after the procedure was −1.4 ± 1.0 mm (range +0.7 to −5.1 mm). Two patients experienced a slight increase in diastema width and three patients had no change. A decrease in diastema width was documented in 90 | 94.7% of cases (*figure 4a*).

Of the 14 patients in the mixed dentition included in the study, 12|85.7% presented with a diastema of ≥2 mm prior to release of the upper lip-tie. The overall mean ± SD of preoperative diastema width was 3.1 ± 1.2 mm (range 1.7 to 5.8 mm). Postoperatively, at a mean follow-up of 27.1 ± 12.1 months (range 2 to 39 months), there were $n = 3|21.5\%$ patients with a diastema of ≥2 mm after release of the upper lip-tie. Mean ± SD of postoperative diastema was 1.3 ± 1.1 mm (range 0 to 3.3 mm, $P = 0.0028$). The mean difference after the procedure was −1.8 ± 0.9 mm (range 0 to −3.5 mm). A decrease in diastema width was documented in 13 | 92.9% of cases (*figure 4b*).

There was no statistically significant change in diastema width based on age (R2= 0.0001, $P = 0.88$), gender (male: −1.5 ± 0.8 mm vs. female: −1.5 ± 1.1 mm, $P = 0.8027$), or dentition type (primary: −1.4 ± 1.0 mm vs. vs. permanent −1.8 ± 0.90 mm, $P = 0.1632$).

There was a statistically significant difference in the change of diastema width based on the laser type used (diode: −1.3 ± 0.7 mm vs. CO_2: −1.7 ± 1.1 mm, $P = 0.0081$). However, this result was confounded by a greater severity of baseline diastema width in the CO_2 laser group (diode: 2.2 ± 0.92 mm vs. CO_2: 2.7 ± 1.4 mm, $P = 0.0171$), and similar post-op diastema measurements between the two treatment groups (diode: 0.87 ± 0.86 mm vs. CO_2: 0.94 ± 0.95 mm, $P = 0.6875$).

In addition, there was a trend towards significance for Kotlow Labial Frenum Classification with a greater degree of change associated with the release of more restrictive Class 4 labial frena (Class 3: −1.15 ± 0.86 mm vs Class 4: −1.61 ± 1.0 mm, $P = 0.0310$).

Discussion

Patients with restrictive labial frena often present with difficulty with oral hygiene and/or cosmetically concerning restrictive maxillary frena. Maxillary labial frenectomy safely and successfully reduced the size of the diastema to a clinically acceptable range (<2 mm) in the majority of cases (45/63, 71.4%) without the need for orthodontic intervention. A decrease in the width of the diastema was documented in 103 | 94.5% of cases, demonstrating little to no scar tissue formation affecting closure. Almost all parents reported high satisfaction with the procedure at follow-up visits in the study group and in clinical practice daily and especially noted the ease of oral hygiene and better cosmetic appearance of the smile with greater tooth visibility. No complications were noted other than minor bleeding not lasting more than a few minutes (rare), minor discomfort alleviated with acetaminophen or ibuprofen, and swelling of the upper lip for two or three days. Most procedures were completely bloodless.

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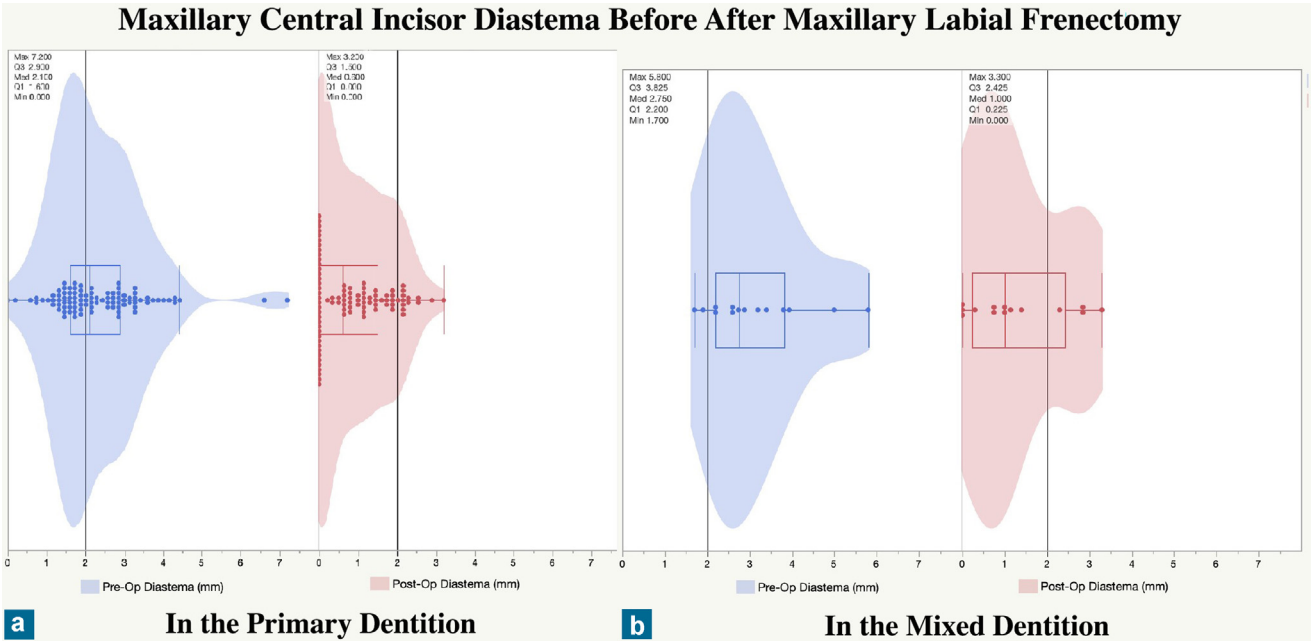

FIGURE 4

Box and whisker plot with contour map showing density distribution of the values for maxillary diastema widths before and after Labial Frenectomy. a: in the Primary Dentition, a decrease in the width of the diastema was observed in 94.7% (90/95) of cases. There were 74.5% (38/51) of patients with preoperative diastema > 2 mm that improved to < 2 mm width postoperatively. The mean difference from baseline to follow-up was −1.4 ± 1.0 mm (range +0.7 to −5.1 mm); b: in the Mixed Dentition, a decrease in the width of the diastema was observed in 92.9% (13/14) of cases. There were 75% (9/12) of patients with preoperative diastema > 2 mm that improved to < 2 mm width postoperatively. The mean difference from baseline to follow-up was −1.8 ± 0.8 mm (range 0 to −3.5 mm)

There were two patients who experienced a mild increase in the width of the diastema and four patients with no changes. The two cases that did not close but rather enlarged were documented in a 2-year-old boy (Δ +0.7 to post-op 1.4 mm) and a 4-year-old girl (Δ +0.4 to post-op 3.2 mm) in the primary dentition, released with CO_2 laser, and followed up 22 months and 12 months later, respectively. The increases in the diastemas are thought to have resulted from normal growth and development of the patients, as the arch width also increased in both, and more spacing was evident between other teeth as well. Arch width of the anterior maxillary segment increases in children over time [22,23]. Spacing is physiologic and helpful for permanent incisor eruption, but it should be distributed evenly, and not concentrated between the two central incisors [24]. Regarding the four cases with no changes, three were cases in the primary dentition without significant diastema at baseline (<2 mm), and the fourth a 12-year-old with a 2.8 mm diastema in the permanent dentition assessed 19 months postoperatively.

A statistically significant difference was present between laser types, but this result was confounded due to baseline differences. However, subjective reports from the operating surgeon and review of postoperative photographs suggest more complete and rapid release of restrictive tissues and less tissue charring, heat damage, and potential scarring with CO_2 compared to diode laser [7]. CO_2 laser has been shown previously to be less painful than a scalpel when performing a frenectomy [25].

The main safety concern we sought to address was the commonly held belief that it is best to wait until after orthodontic treatment to consider a maxillary frenectomy for diastema closure has been accepted for decades; indeed, since before the advent of evidence-based dentistry, and before the ubiquity of lasers in practice [1,14]. In Bishara 1972, (level 5, expert opinion) the article commonly cited for waiting until after orthodontics to treat a restrictive lip-tie states "every effort should be made to diagnose properly and remove the cause of the diastema or to avoid its occurrence whenever this is predictable and possible"[14]. The current study shows that it is possible and predictable in many cases to greatly reduce the size and impact of a diastema in the primary or permanent dentition while improving oral hygiene, through proper case selection and treatment. This study provides some of the first

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evidence of diastema closure, and thus a lack of harmful scar tissue when using contemporary tools and techniques. Palatal tissue was not removed in any of the cases to prevent a persistent black triangle as historically instructed, and the outcome of a persistent black triangle was not identified in any case [26]. With soft tissue lasers more accessible and available at a lower cost, this treatment modality should be offered by knowledgeable providers as an option to parents who experience difficulty with oral hygiene measures at home without the fear of scar tissue formation. The added benefits of likely diastema closure, a more cosmetic smile, and potentially less orthodontic burden in the future are also attractive [2].

Every day in private practice, paediatric dentists, general dentists, and orthodontists are asked about children's restrictive maxillary frena, as they are a common parent concern. Most often, advice such as "the child will likely fall and rip the tissue'' is given instead of parents being informed of an option to remove the tissue [2,27,28]. This advice likely stems from the belief that treating the tissue will impede diastema closure and impair future orthodontic treatment. This study adds to the evidence base in this area and provides assurance that maxillary labial frenectomy with appropriate aftercare can provide benefits without significant risk of injury or hindering future orthodontic closure. Additionally, advising a parent to wait for a baby or child to traumatically lacerate restrictive tissue may be considered insensitive and poor advice if a viable option to release the burden of the restricted tissue exists. Parents should be offered the options of watchful waiting vs. early intervention and allowed to make an informed decision.

Almost all parents of patients undergoing this procedure in our office chose a maxillary frenectomy due to difficulties with tooth brushing. Parents reported that children allowed them to brush posterior teeth, or mandibular teeth, but the maxillary anterior teeth caused frustration, fighting, and pain for the children. Raising the lip against the tension created by restricted maxillary labial frena, as well as brushing the sensitive mucosal tissue of the frenum between the teeth, is very uncomfortable [2,21,29]. After the 15-second procedure, near-universal improvement in ease of brushing was reported by parents in our chart review, with high satisfaction with the procedure and the improved cosmetic results reported at subsequent dental hygiene visits. Some diastemas in the present study were 2 mm or less which have been described in previous studies to be likely to spontaneously close over time [2,9]. In the present study, those diastemas closed within a matter of weeks to months instead of years. Parents reported the procedure was worthwhile for the ease of oral hygiene measures, with less fighting with the child and easier plaque removal. Caries can easily form in the presence of a tethered lip, which can trap food or milk and prevent proper cleaning of the area, especially the gingival margin (*figure 5*), [21].

Technique and case selection are critical to the success of treatment. Kotlow recommends the best time to treat a maxillary frenum for diastema closure is between 8 and 18 months of age, or later when the permanent central incisors are erupting in order to remove the restricted tissue before natural mesial migration of teeth takes place [20]. He also states that in over 30 years of treating this condition, no adverse scar tissue has formed to prevent gap closure [20]. If a patient's only orthodontic issue is a diastema, this procedure could prevent the need for orthodontic treatment in some [20]. In the present study, many of the children were younger than 18 months old when treated and saw significant closure of the diastema, agreeing with Kotlow's recommendations. Many others were in preschool

Figure 5

Example of Restricted Maxillary Frenum and Caries. Caries at the gingival margin for this patient were in part due to difficulty with oral hygiene from discomfort with lip elevation, as well as milk trapped by the frenum during frequent night feedings. The cause of caries is multifactorial and highly influenced by diet and frequency of carbohydrate consumption, including bottle-feeding or nursing without proper oral hygiene. The maxillary frenum was a contributing factor in this case and in many patients presenting with cervical decalcification and decay

or grade school and also experienced full or partial diastema closure. Treatment must be performed with the proper technique by excising the entire restricted tissue between the teeth and up into the vestibule (frenectomy), and the use of a laser allows a quick procedure with minimal risk, minimal to no bleeding, no sutures, and a quick recovery with little postoperative discomfort. The typical lasing time with the diode laser was 60 seconds for a full release (*figure 2*), and the average procedure time with a CO_2 laser was 15 seconds for a full release (*figure 3*). Both laser types allow precision in removing fascial fibers and tissue between the teeth and down to the periosteum with little difficulty. Some surgeons prefer to use scissors and placement of sutures for the frenectomy procedure, and treatment outcomes vary based upon the skill of the provider, and the amount of tissue removed. A snip of tissue in the middle of the frenum, called a frenotomy, is unlikely to yield changes in gap size, as insufficient tissue between the incisors is removed. Poor technique can also interfere with diastema closure. There can be heat injury (electrosurge or diode laser) or under-utilization of postoperative stretches (any technique) leading to reattachment and therefore no change in the diastema, and possible scar tissue formation that could impede closure.

As previously mentioned, the current dogma to support the non-treatment of a lip-tie due to the possibility of scar tissue is unsubstantiated in the evidence-based literature; the opinion that a child will likely fall and rip the tissue so it does not require treatment is a logical fallacy. This article seeks to provide an objective investigation of these issues. We understand that the present study has certain inherent limitations, including the absence of an untreated control group, however, we feel strongly that it is important for all research in the field of oral restrictions to be presented fairly and accurately, in order to inspire future research and provide the best available and most balanced information to patients and providers.

Limitations

This is a consecutive cohort study of a large number of patients treated by means of a specific surgical technique by a single surgeon. As with any highly skilled work, the outcome of the work is dependent upon the skill of the individual provider, and as such, there may be limited external generalizability across techniques and providers. The study was done retrospectively. We did not perform a written survey of parents and their reaction to the procedure, which would have been helpful. There is also a lack of an untreated control group, so closure of the diastema is possible, but not assured, as it could have occurred due to natural growth and development. Future studies, with randomization and a control group, would be helpful for further evaluation of diastema management.

Conclusions

Treatment of a diastema with proper technique and case selection is associated with diastema closure in 94.5% of cases and in our sample did not leave scar tissue that impedes orthodontic closure.

The frenectomy procedure has minimal risk and many potential benefits for the patient and family.

Maxillary frenectomy should be considered in patients with a hypertrophic maxillary frenum causing symptoms of difficulty with oral hygiene, cosmetic concerns, bilabial speech sounds, or anterior caries without the worry of scar tissue formation.

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