Short lingual frenum in infants, children and adolescents. Part 1: Breastfeeding and gastroesophageal reflux disease improvement after tethered oral tissues release

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Abstract

Aim This study aimed to determine the impact of laser surgical tongue-tie, lip-tie, buccal tie release on breastfeeding and Gastroesophageal Reflux Disease (GERD) in a prospective cohort study conducted from June 2019 to June 2020 in a private general dental practice.

Materials and methods Preoperative, one-week and one-month postoperative surveys were completed, consisting of Visual Analogue Scale (VAS) for nipple pain severity, Breastfeeding Self-Efficacy Scale Short Form (BSES-SF), and the Revised Infant Gastroesophageal Reflux Questionnaire (I-GERQ-R). All study participants were breastfeeding dyads (0–12 weeks of age) with untreated ankyloglossia and/or tethered maxillary/buccal frena. The laser surgery was completed using 2 different near-infrared diode lasers with 300µm diameter fibre: a 980 nm wavelength diode laser (Lasotronix Smart Pro, Piaseczno Poland) was used at 4.0 W, gated with 100 µs t/on and 100 µs t/off, and a 1470 nm wavelength diode laser (Pioon S1, Wuhan Pioon Tech Co Ltd., Wuhan, China), used at 3.5W, gated with 50 ms t/on and 50 ms t/off.

Results Statistically significant improvement was noted in VAS, I-GERQ-R and BSES-SF comparing preoperative scores to both one-week and one-month scores. The study had 132 breastfeeding dyads enrolled. Posterior tongue-tie was noted in 71% of this cohort.

Conclusion This study confirms the need for functional assessment of tongue and lip movement for this significantly affected cohort. Laser surgical release (frenotomy) of tongue-tie, lip-tie, buccal-tie resulted in significant improvement in breastfeeding outcomes. These improvements (VAS, I-GERQ-R and BSES-SF) in breastfeeding outcomes were found for cohorts of the classically recognised anterior tongue-tie and the less obvious (without functional assessment) submucosal tongue-tie were found.

KEYWORDS Breastfeeding; Laser frenotomy; Gastroesophageal reflux, Visual Analogue Scale; Ankyloglossia; Posterior tongue-tie; Lip-tie, Buccal-tie

Introduction

The effects of tongue-tie, lip-tie, and buccal-tie on newborn orofacial growth and development are well known and range from maternal discomfort during breastfeeding, infant poor weight gain, air induced reflux and associated symptoms, to orofacial growth retardation.

If health professionals fail to diagnose a short lingual frenum, the correlated impairment can lead to a cascade of several malfunctions, that starts in children with atypical swallowing, may lead to oral breathing and craniofacial growth impairment and may also lead to speech impediment and sleep disorder during childhood and adolescence. During life these alterations can be associated or cause other oral and/or general health problems, including postural modification [Olivi et al., 2012] and pulmonary hypertension [Demirgüneş et al., 2009]. Early detection and surgical intervention in newborns and infants may prevent this vicious cascade of functional impairments from happening. All of us are born with oral frena. Whether these frena are restricting movement of the tongue, lip or cheeks is the issue. If they are restrictive they may be described as ties, or more appropriately, restricitve tethered oral tissues (TOTs). When the mother and infant have been assessed appropriately and other conservative measures are not proving beneficial, there are many breastfeeding dyads that can, and should benefit by surgical intervention [O'Callaghan et al., 2013; Pransky et al., 2015; Ghaheri et al., 2017; Caloway et al., 2019]. This may be achieved by lingual frenotomy, with or without labial frenotomy and/or buccal frenotomy, dependent once again on a well diagnosed need for such intervention.

Breastfeeding is recognised as the optimum nutrition for infants and is beneficial for mothers and infants' health. This is based upon numerous studies that have identified the protective nutritional and health benefits of breastfeeding [Victora et al., 2016].

The current National Health and Medical Research Council infant-feeding guideline in Australia follows the WHO guidelines and recommends exclusive breast-feeding for infants up to around 6 months of age, and that breastfeeding should be continued until 12 months of age and beyond, for

as long as the mother and child desire [Infant Feeding Guidelines. National Health and Medical Research Council: Canberra, 2012., 2012]. The WHO reaffirmed this in 2018 in the Infant and Young Child Feeding resolution WHA 71.9 [WHO, 2018].

Although the percentage of Australian mothers who initiate breastfeeding has increased during the past few decades [Amir and Donath, 2008], it is well known that guidelines regarding the duration of breastfeeding are not followed by many women, for a wide variety of reasons [Colin and Scott, 2002].

The 2010 Australian National Infant Feeding Survey [Australian Institute of Health and Welfare, 2011] reported that, although breastfeeding was initiated in 96% of women surveyed, 40% of these women had completely stopped breastfeeding by 6 months of age. WHO figures worldwide show that 63% of women have stopped solely breastfeeding by the 6th month of age of their baby [Victora et al., 2016]. Moreover, only 15% of mothers had exclusively breastfed their infant until around 6 months of age, in line with National Health and Medical Research Council guidelines, and 42% were still breastfeeding between 7 and 12 months of age [Australian Institute of Health and Welfare, 2011].

Consensus in the literature and from clinical experience suggests that babies with limited tongue mobility due to ankyloglossia can have a shallow latch and poor oral seal around the nipple [Walsh and McKenna Benoit, 2019]. In a cohort of infants under 12 weeks of age, mothers ceased breastfeeding because nipples were sore, cracked or bleeding in 30.4% of cases and due to trouble suckling or latching on in 48.2% of cases [Newby and Davies, 2016].

Several studies reported that ankyloglossia (either classic anterior tongue-tie or submucosal restriction) [Geddes et al., 2008] and a tethered maxillary labial frenum (upper lip tie) cause altered latch and sucking mechanics [Ghaheri et al., 2017].

There are a wide variety of treatment options for breastfeeding difficulties in infants. Amongst these options are using a nipple shield, change in breastfeeding technique and position, chiropractic care, craniosacral therapy or osteopathic care. All of these treatment options have been seen as beneficial to improve breastfeeding outcomes with suspected ankyloglossia [Walsh and McKenna Benoit, 2019]. Frenotomy is effective at relieving nipple pain for breastfeeding women [Puapornpong et al., 2017]. Ankyloglossia also makes the transfer of milk less efficient, which can lead to a decrease in milk supply, poor infant weight gain, prolonged feedings, and failure to thrive [Walsh and McKenna Benoit, 2019]. The intermittent loss of the oral nipple seal also leads to a clicking sound and aerophagia that may contribute to symptomatic reflux in infants [Kotlow, 2011; Siegel, 2016].

In a Cochrane review of Frenotomy for tongue-tie in newborn infants in 2017 their conclusion was that the quality of the evidence was very low to moderate because only a small number of randomised controlled trial studies have looked at this condition [O'Shea et al., 2017].

Completing randomised controlled trials in this surgical field poses both an ethical and intellectual dilemma as completing a sham frenotomy for control infants is implausible. This prospective cohort study is a clinical endeavour to help answer the question of effectivity of frenotomy where indicated for tethered oral tissues, whether they are lingual, maxillary labial or buccal ties.

The first part of this study will present the role of surgical release of tethered oral tissues (TOTS) in infants to improve breastfeeding and gastroesophageal reflux disease (GERD).

A second part will investigate the possibility to intercept this condition, when the child is older and the diagnosis is made later. Health professionals including paediatricians, paediatric dentists, orthodontists, myofunctional and speech therapists, may diagnose this condition during childhood and adolescence.

Methods

Patient inclusion

One hundred and thirty-two participant families were enrolled in the study, 65 (49%) female infants and 67 (51%) male, with an infant mean age of 43 days and a mean current weight of 3.4 kg. The infants were all born in hospital; 64% were vaginally delivered and 36% via caesarian section. Preoperative anatomical classifications are shown in Table 1. Ninety-nine infants (75.0%) received both lip and tongue surgery, followed by 24 infants (18.2%) who received only tongue surgery, 7 infants (5.3%) who received tongue, lip and buccal frenum surgery and only 2 infants (1.5%) received only lip surgery. Among the 132 surgical procedures, a 1470 nm wavelength laser was used in 82 (62.1%) surgical procedures, and 980 nm wavelengths laser in 50 (37.9%) surgical procedures. Maternal complaints from the initial questionnaire and their prevalence are detailed in Table 3.

Participants within the study were breastfeeding mother-infant dyads, with untreated ankyloglossia and/or tethered maxillary labial and buccal frena, who completed

Complaint	Percentage
Difficulty in achieving a good latch	88
Reflux (clicking, swallowing air whist nursing)	74
Painful latching of infant onto the breast	68
Milk leaking out sides of mouth whilst feeding	67
Falls asleep at the breast whilst attempting to nurse	63
Slides off the breast whilst feeding	49
Poor or incomplete drainage from breast	46
Gumming or chewing of the nipples whist feeding	46
Creased, cracked or blanching of nipples	46
Short sleep episodes (feeding every 1-2 hours)	38
Waking congested in morning	38
Unable to keep pacifier in mouth	36
Poor weight gain	29
Apnoea- snoring, heavy noisy breathing	24
Undersupply of breast milk	21
Waking congested after nap	21
Oversupply of breast milk	20
Only sleeping when in upright position or in car seat	18
Blocked ducts	14
Mastitis	9
Nipple thrush	8
Infected nipples	5
Depression	5
Abraded nipples	4

TABLE 1 Initial maternal complaints.

Coryllos Tongue-Tie Classification	Definition	No (%)
CLASS 1	Attachment of the frenulum to the tip of the tongue	6 (4.5%)
CLASS 2	Attachment is 2-4mm behind the tip of tongue/on or behind alveolar ridge	32 (24.2%)
CLASS 3	Attachment to mid tongue/middle of the floor of the mouth	37 (28.0%)
CLASS 4	Attachment against the base of the tongue, thick and inelastic	57 (43.2%)
Kotlow Lip-Tie Classification	**Definition**	**No (%)**
CLASS 1	No significant attachment	0 (0%)
CLASS 2	Attachment mostly into the gingival tissue	1 (0.8%)
CLASS 3	Attachment in front of the incisive papilla	51 (38.6%)
CLASS 4	Attachment into the papilla or extending into the hard palate	80 (60.6%)

TABLE 2 Lip and tongue-tie classification types and frequency preoperatively.

Breastfeeding outcome measures	Preoperative	One week postop.	One month postop.
VAS Pain Score (mean, SD; min-max) *	4.6 (2.8; 0-10)	2.1 (2.1; 0-8)	1.1 (1.6; 0-8)
I-GERQ-R Total Score (mean, SD; min-max) *	16.3 (6.1; 5-30)	13.9 (5.5; 3-29)	9.8 (5.4; 1-25)
BSES-SF Total Score (mean, SD; min-max) *	48.7 (11.3; 20-70)	54.9 (10.6; 23-70)	57.9 (9.8; 22-70)

** Differences between times - Kruskal-Wallis test=p<0.05)*

TABLE 3 Overall preoperative and all postoperative average outcome measure scores (n=132).

preoperative, 1 week and 1 month post-operative surveys consisting of the Revised Infant Gastroesophageal Reflux Questionnaire (I-GERQ-R), visual analogue scale (VAS) for severity of nipple pain, and Breastfeeding Self-Efficacy Scale-Short Form (BSES-SF) within an Australian private general dental practice setting.

Study participants were recruited from all dyads who were referred for evaluation for frenotomy if:

1) they were currently breastfeeding;
2) the infant was less than 12 weeks of age and greater than 37 weeks gestational age;
3) infants who were deemed to fulfil the criteria of functional restriction of movement of the tongue, upper lip, cheeks;
4) the infant underwent surgical correction for restricted (tethered), maxillary labial frenum (upper lip-tie) and/or maxillary buccal frena and/or ankyloglossia (tongue-tie) within an Australian private general dental practice setting by the study's principal author.

Oral assessment

All infants were initially evaluated by community lactation consultants before surgical referral as a prerequisite for consultation by the principal investigator. Latch assessment by the lactation consultants was considered in the decision-making process in whether frenotomy was offered. A targeted head and neck evaluation was performed to determine if restrictions were present, examining for maxillary bony alveolar notching, blanched frenula with elevation, anatomical restriction of elicited lateral lingual movement (impaired transverse tongue reflex), abnormal floor of mouth elevation with elevation of the tongue, and location of attachment of the frenula. A sucking evaluation was then performed, noting abnormal gum/lip grip pressure, cupping of the tongue against the finger, seal on the finger, and the nature of the tongue movements whilst sucking. The Bristol Tongue Assessment Tool (BTAT) / The Tongue-tie and Breastfed Babies (TABBY) assessment tool [Ingram et al., 2019] was also used. Standardised classification systems were used to describe frenula anatomy: The Kotlow upper lip-tie classification [Kotlow, 1999] and Coryllos tongue-tie classification systems [Elizabeth et al., 2004], as described in Table 1. A symptom/complaint checklist was also completed by each mother; the symptoms and frequency of symptom presentation are described in Table 2.

Surgical and study consent

Informed consent for surgery and study involvement was obtained prior to surgical intervention. The study was carried out according to the Australian National Statement on Ethical Conduct in Human Research (2007, updated 2018), and followed the guidelines as stated by the Australian Government's National Health and Medical Research Council (NHMRC).

Information gathered for the study included initial demographic details and preoperative, 1 week and 1 month post-operative surveys consisting of the Revised Infant Gastroesophageal Reflux Questionnaire (I-GERQ-R) to measure Gastroesophageal Reflux Disease (GERD), visual analogue scale (VAS) for severity of nipple pain, and Breastfeeding Self-Efficacy Scale-Short Form (BSES-SF) (Fig. 1, 2, 3).

Surgical intervention

Parents completed informed consent and the patient was moved to a laser safe dental surgery. Surgery was completed using 2 different near-infrared diode lasers.

One laser used was the 980nm wavelength diode laser (Lasotronix Smart Pro, Piaseczno Poland) with variable pulsed wave and power settings. The settings used were 4.0 W gated with 100 µs t/on and 100 µs t/off with a 300 µm diameter fibre.

The other laser used was a 1470 nm wavelength diode laser (Pioon S1, Wuhan Pioon Tech Co Ltd., Wuhan, China). The settings used were 3.5 W gated with 50 ms t/on and 50 ms t/off with a 300 µm diameter fibre. Among the 132 surgical procedures, the 1470 nm laser was used in 82 (62,1%) surgical procedures, and the 980 nm laser in 50 (37,9%) surgical procedures. Surgery was performed under operative microscope (Zeiss ProErgo, Germany). No local or topical anaesthesia was used.

The surgical release was completed for the tongue by elevation of the tongue with a sterile grooved tongue director as the initiated laser tip was applied to the frenulum starting at the anterior point of the frenulum, if it was attached to the alveolar ridge (anterior tie). Maxillary labial release was achieved by elevating the upper lip with gauze and removing the frenum from the alveolar ridge up to the mucogingival junction. Buccal frenal release was achieved by elevating the cheek with a retractor and then removing the frenum from the alveolar ridge up to the mucogingival junction. This was

Patient's Name ..... Birth Date ..... Today's .....
Parents' Names ..... Email .....
Address ..... Phone .....

Male/Female .....Home Birth ..... Hospital Birth .....Vaginal Birth C-Section birth_

Medical Problems.....Heart disease .....Bleeding Disorders.....Other ..... Birth Weight ..... Present weight.....

1. Are you presently breast feeding ____Yes_____No_____ if no, how long since you stopped breast feeding?	**Medical History:** Has your child experienced any of the following problems or treatment?
_____	1. Infants are usually given Vitamin K at birth to prevent bleeding in th first 8 weeks of life. Did you sign any waiver to refuse the administration of vitamin K? ____Yes_____No_____
2. Are you presently using a nipple shield?____Yes_____No_____	2. Was your infant premature ?____Yes_____No_____
3. Are you choosing not breastfeed?____Yes_____No_____	3. Does your infant have any heart disease? ____Yes_____No_____
4. Are you pumping breast milk? ____Yes_____No_____	4. Has your infant had any surgery? ____Yes_____No_____
5. Areyou supplementing using a bottle?____Yes_____No_____	5. Is your child taking any medications?____Yes_____No_____
6. Are you using an SNS device?____Yes_____No_____	Reflux Med's Thrush med's other Name of medications
7. Do you or any immediate family member have any bleeding disorders?____Yes_____No_____	6. Does your child have any other medical conditions?

Mother's Symptoms

_ Creased, cracked or blanching of nipples
_ Painful latching of infant onto the breast
_ Gumming or chewing of the nipples
_ Infant unable to achieve a successful tight latch
_ Poor or incomplete breast drainage
_ Infected nipples or breasts
_ Abraded nipples
_ Bocked ducts
_ Mastitis
_ Nipple thrush
_ Feelings of depression
_ Oversupply of breast milk
_ Undersupply of breast milk

Infant's Symptoms

_ Difficulty in achieving a good latch
_ Falls asleep while attempting to nurse
_ Sides off the breast when attempting to latch
_ Reflux (Clicking, swallowing air during nursing)
_ Poor weight gain
_ Short sleep episodes (feeding every 1-2 hours)
_ Apnoea - snoring, heavy noisy breathing
_ Unable to keep pacifier/dummy in the infant's mouth
_ Waking up congested in the morning
_ Waking up congested from nap time
_ Gagging when attempting to introduce solid foods
_ Only sleeping when in uprightt position or in car seat
_ Milk leaking outside of mouth whilst feeding

Paediatrician _____ Phone number_____
Address _____
GP Doctor_____ Phone number _____
Has your Doctor or Paediatrician evaluated your infant's lip and tongue ties? _____Yes_____No_____
Lactation Consultant _____ Phone number _____
Address _____
Who referred you to our office? _____
Did you use the internet to find our office?_____ Yes_____No_____
Have you visited our website?_____ Yes_____No_____
Additional comments
_____
_____
Signed_____

FIG. 1 Patient history form.

completed bilaterally in the cases where buccal frenotomy was deemed necessary. The infant was then taken back to the mother and immediately offered the breast. Post procedural stretching exercises were undertaken 3 times per day for several weeks by gentle massage and stretching to avoid reattachment of the tissues. Acetaminophen was suggested as an analgesic medication if required.

Stretching exercises

Post-operative wound care (wound stretching) is a topic of contention. with O'Callahan et al. [2013] not finding it safe and effective in preventing frenulum reattachment. In another study the opposite was found [Demyati et al., 2014]. It seems reasonable to assume that keeping the wound from sticking back together other than by the secondary intention intended, will reduce/negate reattachment of the wound.

In the principal author's experience, one can be assured of reattachment if stretches are not completed post-surgery. Further studies are required to determine what association there may be between stretching exercises preventing regrowth/reattachment of the frenulum and reoccurrence of symptoms for the breastfeeding dyad.

Post-procedure stretching exercises within this study were advised to be completed 3 times per day by gently massaging

Breastfeeding Self-Efficacy Scale – Short Form

For each of the following statements, please choose the answer that best describes how confident you are with breastfeeding your new baby. Please mark your answer by circling the number that is closest to how you feel. There is no right or wrong answer

1 = not at all confident 2 = not very confident 3 = sometimes confident 4 = confident 5 = very confident

1	I can always determine that my baby is getting enough milk	1	2	3	4	5
2	I can always successfully cope with breastfeeding like I have with other challenging tasks	1	2	3	4	5
3	I can always breastfeed my baby without using formula as a supplement	1	2	3	4	5
4	I can always ensure that my baby is properly latched on for the whole feeding	1	2	3	4	5
5	I can always manage the breastfeeding situation to my satisfaction	1	2	3	4	5
6	I can always manage to breastfeed even if my baby is crying	1	2	3	4	5
7	I can always keep wanting to breastfeed	1	2	3	4	5
8	I can always comfortably breastfeed with my family members present	1	2	3	4	5
9	I can always be satisfied with my breastfeeding experience	1	2	3	4	5
10	I can always deal with the fact that breastfeeding can be time consuming	1	2	3	4	5
11	I can always finish feeding my baby on one breast before switching to the other breast	1	2	3	4	5
12	I can always continue to breastfeed my baby for every feeding	1	2	3	4	5
13	I can always manage to keep up with my baby's breastfeeding demands	1	2	3	4	5
14	I can always tell when my baby is finished breastfeeding	1	2	3	4	5

FIG. 2 Breastfeeding Self-Efficacy Scale - Short Form by dr. Cindy-Lee Dennis [Dennis, 2006].

Infant Gastroesophageal Reflux Questionnaire (I -GERQ-R)

1. During the pasl week, how often did the baby usually spil-up (anything coming out of the mouth) during a 24-hour period?
❏ Less than once .....❏ 1 to 3 times ..... ❏ 4 to 6 times .....❏ More than 6 times

2. During the past week, how much did the baby usually spit-up (anything coming out of the mouth) during a typical episode?
❏ Did nol spit up ❏ Less than I tablespoonful ❏ I tablespoonful lo 4 tablespoons
❏ More than 4 tablespoons lo half the feeding ❏ More than half the feeding

3. During the past week, how often did spitting up (anything coming out of the mouth) seem to be uncomfortable for the baby, for example, crying, fussing, irritability, etc.?
❏ Never ❏ Rarely ❏ Sometimes ❏ Often ❏ Always

4. During the past week, how often did the baby refuse a feeding even when hungry?
❏ Never ❏ Rarely ❏ Sometimes ❏ Often ❏ Always

5. During the past week, how often did the baby stop eating soon after starting even when hungry?
❏ Never ❏ Rarely ❏ Sometimes ❏ Often ❏ Always

6. During the past week, did the baby cry a lot during or within 1 hour after feedings?
❏ Never ❏ Rarely ❏ Sometimes ❏ Often ❏ Always

7. During the past week, did the baby cry or fuss more than usual?
❏ Never ❏ Rarely ❏ Sometimes ❏ Often ❏ Always

8. During the past week, on average how long did the baby cry or fuss during a 24-hour period?
❏ Less than 10 minutes❏ 10 minutes to 1 hour ❏ More than 1 hour but less than 3 hours ❏ 3 or more hours

9. During the past week, how often did the baby bave hiccups?
❏ Never ❏ Rarely ❏ Sometimes ❏ Often ❏ Always

10 During the past week, how often did the baby have episodes of arching back?
❏ Never ❏ Rarely ❏ Sometimes ❏ Often ❏ Always

11. During the past week, has the baby stopped breathing while awake or struggled to breathe?
❏ No ❏ Yes

12. During the past week, has the baby turned blue or purple?
❏ No ❏ Yes

If breastfeeding your baby, please place a mark on the line for how breastfeeding feels for you:

Please return completed form to

FIG. 3 The Infant Gastro-esophageal Reflux Questionnaire Revised (I-GERQ-R) by Dr. Susan Orenstein (MD - University of Pittsburgh) [Orenstein, 2006].

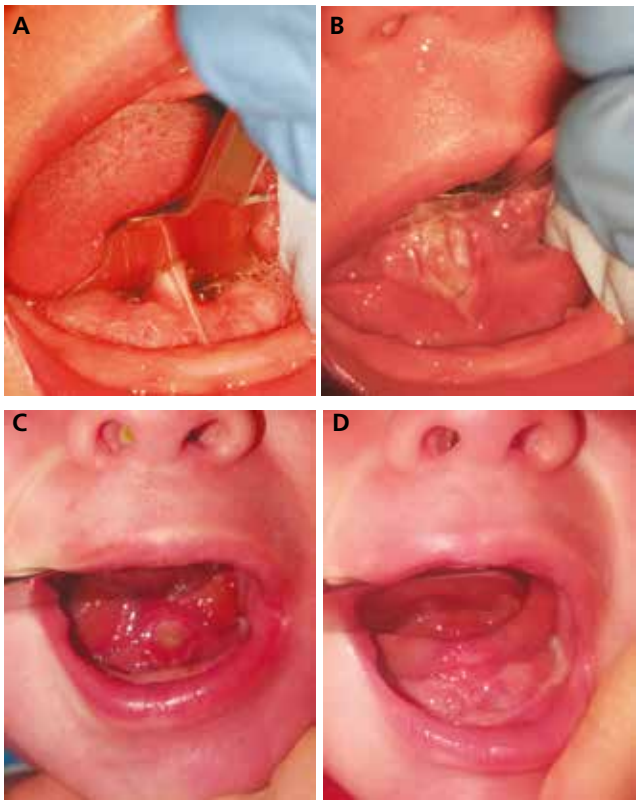

FIG. 4
A Pre-surgery intra-operative image showing thick frenum, blanching, restricted movement, and insertion close to the tip of the tongue and mandibular alveolar ridge.
B Post surgery intra-operative image showing typical diamond shaped wound, with no bleeding achieved with 1470nm diode laser at 3.5W 50ms on and 50ms off. Note the absence of any signs of charring.
C 5 Days post-operative image showing advanced second intention healing of the wound, with fibrin layer covering the surgically treated area.
D 12 days post-op image shows the healing with complete re-epithelialisation of the wound.

the wounds and by gentle elevation of the lip/tongue/cheeks (depending on the surgery completed) for 3 weeks.

Patients follow-up and re-assessment

All infants were seen one-week post-surgery for review. If symptoms persisted or returned, or if mothers had concerns, other reviews were held. The one-month review was done by survey with the use of the SurveyMonkey electronic transfer portal. The Breastfeeding Self-Efficacy Scale-Short Form (BSES-SF) (University of Toronto, Toronto, Ontario, Canada) is a validated, 14-item survey that measures breastfeeding efficacy and confidence. The responses are on a scale of 0–5 and are added to a total score of between 0–70. Higher scores indicate higher breastfeeding confidence and less breastfeeding impairment. The 12-item I-GERQ-R survey was used to evaluate the severity of symptoms associated with infant gastroesophageal reflux disease (GERD). Scoring involves the summation of the 12 questions with the score range from 0–40, where lower scores reflect lower symptom severity.

Exclusion criteria

Study participants were considered lost to follow up if breastfeeding outcome survey evaluations were not completed within the 1-month study follow-up period. Other dyads excluded from the study had had previous treatment for TOTS by another provider.

Statistical analyses

Quantitative variables were tested for normal distribution by a Kolmogorov-Smirnov test: Parametric variables were tested by means of two-tailed analysis of variance (ANOVA), whereas Mann-Whitney test was used for non-parametric variables. Binomial or discontinuous variables were assessed by means of the chi-square test and Fisher's exact test. Linear regression model were calculated to understand the effect of time on VAS, I-GERQ-R and BSES-SF. Statistics was performed with IBM SPSS Statistics Ver. 25 for Apple (IBM Corp., Armonk, NY).

Results

Statistically significant improvement was reported between preoperative, 1 week and 1 month I-GERQ-R total scores (Kruskal-Wallis test - P <.001), BSES-SF total scores (Kruskal-Wallis test - P <.001) and VAS pain scores (Kruskal-Wallis test - P <.001) (Table 3). This highly significant within subject improvement was seen in outcomes for VAS, breastfeeding efficacy and in the I-GERQ-R outcomes at one week and one month post operatively.

A linear correlation was detected between time and VAS (beta=-0.54; R^2=0.29; p<0.05), I-GERQ-R total scores (beta=-0.45; R^2=0.2; p<0.05) and BSES-SF (beta=0.34; R^2=0.11; p<0.05).

The highly significant within subject improvements were seen in outcomes for VAS, breastfeeding efficacy and in the I-GERQ-R outcomes in classes of lip and tongue-tie, laser wavelength used and in all 4 classes of surgery performed (lip, tongue, lip and tongue, and lip/tongue and buccal) with the only statistically different outcome seen for VAS pain score at 1 month post-operatively between tongue class (Kruskal-Wallis test - P <.05) (Table 4).

A linear correlation was detected between time and VAS (beta=-0.54; R^2=0.29; p<0.05), I-GERQ-R total scores (beta=-0.45; R^2=0.2; p<0.05) and BSES-SF (beta=0.34; R^2=0.11; p<0.05).

Discussion

Scissors are still the tool most frequently used for frenotomy. Results of lingual frenotomy conventionally released with scissors however can be varied, as an incomplete release is common. As the area bleeds, intra-operative adjustments can be difficult due to bleeding obscuring the surgical field. We aim to achieve a diamond-shaped wound under the tongue, but this is operator sensitive and therefore not predictable.

Great care of salivary glands orifices and ducts was taken during this stage, and then tissue behind the sublingual caruncle in the midline was removed overlying the genioglossus muscle to the extent of ≤ 1 mm in depth. The complete release of the mucosa was achieved by carefully releasing the frenum laterally on both sides of the midline wound, taking great care to not disturb the overlying fascia of the genioglossus muscle, or the lingual vessels present in this area.

		Lip class				Tongue class				Laser wavelength		Surgery performed			
		I	II	III	IV	I	II	III	IV	980 nm	1470 nm	Lip surgery	Tongue surgery	Lip and tongue surgery	Lip, tongue and buccal surgery
I-GERQ-R (mean, SD; min-max)	Pre-operative	-	19,0 (-; 19-19)	16,4 (6,1; 5-30)	17,1 (6,2; 5-29)	15,7 (7,6; 5-24)	15,9 (5,6; 5-25)	18,2 (6,4; 5-29)	16,5 (6,0; 5-30)	17,3 (6,0; 5-30)	16,5 (6,1; 5-26)	23,5 (7,8; 18-29)	15,6 (5,5; 5-26)	16,9 (6,1; 5-30)	17,4 (7,8; 5-26)
	1-week	-	5,0 (-; 5-5)	13,9 (5,2; 5-26)	14,1 (5,7; 3-29)	14,2 (7,5; 4-25)	14,3 (5,3; 5-23)	13,4 (5,6; 3-29)	14,0 (5,4; 5-26)	14,0 (5,5; 4-26)	13,9 (5,5; 3-29)	17,5 (3,5; 15-20)	13,3 (4,7; 5-21)	13,9 (5,8; 3-29)	14,6 (4,4; 8-20)
	1-month	-	5,0 (-; 5-5)	9,8 (4,4; 1-24)	9,8 (6,0; 1-25)	8,5 (5,5; 3-16)	9,1 (4,2; 1-20)	10,0 (5,4; 1-20)	10,1 (6,0; 2-25)	10,7 (5,7; 2-25)	9,2 (5,2; 1-23)	24,5 (0,7; 24-25)	10,1 (3,6; 1-16)	9,5 (5,5; 1-24)	8,3 (3,6; 3-13)
BSES-SF (mean, SD, min-max)	Pre-operative		47,0 (-; 47-47)	48,5 (11,5; 20-69)	48,5 (11,5; 20-69)	46,0 (16,0; 24-63)	50,3 (12,3; 20-70)	49,1 (10,2; 30-65)	47,8 (11,0; 26-69)	47,3 (11,3; 27-66)	49,5 (11,3; 20-70)	58,0 (8,5; 52-64)	47,1 (10,9; 33-70)	49,1 (11,3; 20-69)	45,4 (13,1; 30-60)
	1-week		67,0 (-; 67-67)	53,3 (11,0; 27-69)	55,7 (10,2; 23-70)	53,3 (14,5; 36-69)	55,0 (11,7; 23-69)	54,1 (10,5; 33-70)	44,4 (9,8; 33-69)	52,9 (10,4; 27-69)	56,0 (10,6; 23-70)	66,0 (4,2; 63-69)	51,6 (10,5; 33-69)	55,5 (10,6; 23-70)	54,1 (10,3; 40-66)
	1-month		68,0 (-; 68-68)	57,2 (10,1; 22-70)	58,2 (9,6; 27-70)	59,0 (12,1; 43-70)	58,0 (10,1; 33-70)	55,8 (11,0; 22-69)	59,1 (8,4; 33-70)	56,1 (9,6; 27-70)	59,0 (9,7; 22-70)	67,0 (4,2; 64-70)	55,4 (11,3; 22-70)	58,5 (9,5; 27-70)	55,9 (6,4; 47-66)
VAS pain scores (mean, SD, min-max)	Pre-operative		3,0 (-; 3-3)	4,7 (2,8; 0-8)	4,5 (2,8; 0-10)	4,5 (3,6; 1-10)	4,8 (3,1; 0-9)	3,9 (2,4; 0-8)	4,9 (2,8; 0-10)	5,0 (2,7; 0-9)	4,3 (2,9; 0-10	3,5 (2,1; 2-5)	4,9 (2,6; 0-8)	4,4 (2,9; 0-10)	5,6 (2,7; 3-9)
	1-week		0,0 (-; 0-0	14,1 (5,7; 3-29)	2,1 (2,1; 0-8)	1,2 (1,6; 0-4)	1,8 (1,9; 0-6)	2,6 (2,3; 0-7)	2,0 (2,0; 0-8)	2,0 (2,0; 0-8)	2,2 (2,1; 0-7)	0,5 (0,7; 0-1)	2,2 (2,3; 0-7)	2,2 (2,0; 0-8)	1,0 (1,2; 0-3)
	1-month 1		0,0 (-; 0-0	1,4 (1,8; 0-8)	0,9 (1,3; 0-5)	0,0 (0; 0-0)	1,1 (1,3; 0-5)	1,7 (2,1; 0-8)	0,9 (1,3; 0-5)	1,1 (1,3; 0-5)	1,1 (1,7; 0-8)	0,0 (0; 0-0)	1,4 (1,9; 0-7)	1,0 (1,5; 0-8)	1,4 (1,1; 0-3)

[1]Statistically significant difference between tongue anatomic classification - Kruskal-Wallis test=p<0.05

TABLE 4 Subgroup analysis for lip class, tongue class, laser wavelength and surgery performed.

During the surgery there is no need to create a diamond shaped wound by cutting laterally in the surgical area, because this is the natural shape the tissue takes when a sufficiently deep horizontal cut through the frenum is made. Strict attention to detail whilst performing the surgery is paramount to avoid vessels when cutting horizontally. The frenum is triangular, and when a triangular prism is cut through, the top and bottom flip out, forming a diamond shaped wound [Baxter, 2018].

If the frenum is only clipped and only the anterior tongue-tie has been released, a small vertical line-shaped wound will be noted as the posterior component of the tongue-tie still exists. This incomplete release leaves a thick band of tissue that still holds the tongue in a downward position and limits mobility for nursing, speech, and/or feeding. This thick band does not go away over time, and these restrictions of the tongue may cause functional issues throughout life [Baxter, 2018].

Frenotomy is considered a safe procedure in almost all cases. The most common risks include infection and minor bleeding at the site. Other issues are pain and discomfort, poor feeding, weight loss, pallor/anaemia, excess scarring, and injury to the salivary ducts and glands that are located in the floor of the mouth, near the frenum.

A recent consensus statement in Australia [Australian Dental Association, 2020] has been published highlighting potential problems with surgery and ankyloglossia. It is important to note that this surgery involves infants, our most vulnerable patients and that all surgery has associated risks. A systematic review of frenotomy found an overall rate of 1% for minor complications, with minor bleeding the most frequent [Constantine et al., 2011]. Complications have generally been published as case reports, including a report of two cases of hypovolaemic shock [Tracy et al., 2017]. The use of diode lasers, for their specific high absorption in haemoglobin and oxyhaemoglobin, is very safe for this procedure in infants, where the fibrous component is less pronounced than in children and youths, and near infrared lasers can perform a precise incision and effective coagulation. The high control of bleeding also allows safer

and better view of the surgical area, allowing more precise release. Most research studies that have been done on tongue-tie release report no complications occurring in their cohorts (Buryk et al., 2011), thus lending weight to the idea that frenotomy is, in most cases, without significant morbidity [Walsh and McKenna Benoit, 2019]. Within this study, no complications were reported following any procedure.

The purpose of increasing breastfeeding duration and exclusivity rates is to optimise infant and mother health. Breastfeeding achieves health benefits for the breastfeeding dyad. The numerous issues that can affect breastfeeding have been detailed and were examined within this study (questionnaire). Many studies have demonstrated that breastfeeding success is affected by congenital ankyloglossia [Puapornpong et al., 2017]. When conservative treatment such as lactation support and bodywork have proven ineffective, then it is shown in this study that surgical intervention can benefit both mother and child.

The large number of posterior tongue-ties (class 3 and 4) within the referred (and successfully treated) infants in this study, indicates that the still widely disregarded sub mucosal (posterior) tongue-tie (71%) demonstrates a population of infants who may very well wean because of the restriction that is there. The tongue must be palpated to feel the restriction. A coated dorsum of the tongue (not thrush but milk residue), poor lift and/or lateral movement of the tongue, may indicate the need for intervention. Without the knowledge to diagnose this restriction, this cohort of infants struggling to feed is likely to be weaned prematurely. It remains a major paradigm shift within the lactation and medical community for acceptance of what we have shown is a significant issue.

Maxillary labial restriction due to a restrictive lip-tie can affect the quality of the latch. Where indicated by poor shallow latch an upper labial frenotomy was also performed and the results from this study suggest that this was also beneficial. Infants requiring tongue-tie and lip-tie releases can open their mouth wider immediately after release. This increased opening allows a deeper latch where the infant can now engage not just the nipple but the areola as well, thereby stimulating the breast and milk production. In this study 99% of the infants also had a low insertion of the maxillary labial frenum, a figure comparable to the studies of Flinck et al., [1994]. In newborns, the attachment location of the labial frenulum is typically at the gingival margin or on to the palate, comprising more than 93% of all normal labial frena.

Within this study these infants are a select group that has firstly been referred to a general dental practice and are also determined to require surgery. The insertion point of the frenum is not the determining factor as to whether surgery is undertaken; this is determined after considering if there is failure of the lip to flange whilst nursing, lip dimpling, bony remodelling of the alveloar ridge or blanching of the frenum and mucosa over the alveloar ridge and sometimes incisive papilla upon elevation of the lip.

Nipple pain reduction was improved at the one week and one-month controls. A common complaint at presentation, nipple pain is an often-cited reason for early weaning [Gianni et al., 2019].

The BSES-SF designed by Dennis in 2006 is highly reproducible, easy to use, and can identify mothers at high risk for breastfeeding cessation. It is also used as a tool to evaluate the efficacy of interventions. Dennis identified numerous factors that predicted higher maternal self-efficacy scores [Dennis, 2006].

The BSES-SF has been used more often than any other breastfeeding self-efficacy instruments; more than 40 articles have been published using this instrument. In the 5 most recent publications, the Cronbach alpha scores [Cronbach, 1951] ranged from .86 to .93. The BSES-SF has been used worldwide and translated to other languages, including Chinese, Croatian, Japanese and isiZulu. The BSES-SF has also been used to investigate the relationships between breastfeeding determinants, such as self-efficacy and insufficient milk perceptions [Tuthill et al., 2016]. There is a significant increase in maternal self-efficacy at 1-week and 1-month post-procedure. Nanishi and colleagues indicated that a BSES-SF score below 50 was predictive of breastfeeding cessation [Nanishi et al., 2015]. The initial mean score in this study of 48.7 increased to a score of 57.9 at 1-month post procedure. Self-confidence plays a major part in breastfeeding success [Ahluwalia et al., 2005] and the improvement in this study suggests a perception that the problems associated with disrupted lactation were surmountable and can predict improved longevity of breastfeeding.

Crying is common in infants and signs and symptoms attributed to gastrointestinal reflux are common. This is distressing to families, and often results in the use of medication [Smith et al., 2013]. The use of Proton-pump inhibitors (PPIs) in infants and children has increased in recent years. In the 5-year period between 1999 and 2004 there was a greater than 7-fold increase in the prescription of PPIs for infants [Barron et al., 2007]. In a systemic review by Gieruszczak-Bialek et al. [2015], they found that there was no effect of PPIs on crying and irritability in infants.

Using a validated, patient-based instrument we were able to demonstrate a reduction in GERD symptoms scores after frenotomy, suggesting that lingual restriction may be associated with infant reflux symptoms, and that correction of latch abnormalities attributed to ankyloglossia significantly improves reflux scores at 1-week and 1-month post-procedure.

The 12-item I-GERQ-R survey was used to evaluate the severity of symptoms associated with infant gastroesophageal reflux disease (GERD). It is a reliable and validated measure of infant GERD symptoms. The I-GERQ-R can be used in the diagnosis of infant GERD to differentiate cases from those infants without sufficient symptoms for the diagnosis, to monitor treatment outcomes in clinical practice, and to serve as an evaluative tool in clinical trials [Orenstein, 2010]. Scoring involves the summation of the 12 questions with the score range from 0–40, where lower scores reflect lower symptom severity. Smith et al., in their structured review of 42 papers relating to I-GERQ-R found that a threshold for clinically important difference (CID) for the I-GERQ-R of around 6 could signify a clinically important difference for this instrument. The lower limit of the 95% confidence interval suggested a threshold of 3 to 4 could represent a minimally important difference [Smith et al., 2020]. This study has measured reflux symptomatology before and after frenotomy. Infant reflux is multifactorial in nature. Siegel [2016] has suggested that the mechanism that explains the improvement of the reflux scores is a resolution of aerophagia. The reflux improvement seen in this cohort soon after the procedure suggests that the decrease in aerophagia is due to an improved latch. A spontaneous resolution of

other factors contributing to reflux during the period of the study is unlikely.

Conclusion

Infants in this study were only seen after having sought lactation advice and were only offered surgical intervention when restrictive tethered tissues (TOTS) were found. Laser surgical release of frenal restriction used in this study provided significant average improvement in all categories of restriction treated. These improvements were seen in breastfeeding outcomes for infants and their mothers. Improvements were evaluated at the 1-week and 1-month post-operative assessments in all categories treated (lip, tongue, lip/tongue and lip/cheek/tongue). All classes of tongue-ties treated showed significant improvement.

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