Short lingual frenum in infants, children and adolescents. Part 2: Lingual frenum release. Functional surgical approach

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Abstract

Aim The aim of this study was to review the craniofacial growth impairment and different malfunctions associated with short lingual frenum and to assess the validity of lingual frenum surgery based on minimally invasive laser release with a myofunctional approach.

Materials and methods Thirty patients, children and adolescents whose ages ranged from 8 years to 18 years, diagnosed with a short lingual frenum and concomitant orthodontic problems and/or presence of associated muscular or postural problems, were treated in this study. Pre-operative tongue assessment was performed following morphological and functional criteria, consisting of measurement of the free tongue, and of visual assessment of tongue protrusion out of the mouth and elevation to the incisive palatal papilla. Postural evaluation was assessed in frontal and lateral view. Laser surgery was completed with local anaesthesia, using Erbium YAG laser (2940 nm, LightWalker, AT-Fotona, Ljubljana, Slovenia) equipped with sapphire conical tip (600 micron), with energy ranging from 120 to 160 mJ, at 15 Hz frequency, and varying the adjustable pulse duration from 300 µs to 600 µs.

Results Significant improvement was noted in 29 of 30 patients comparing preoperative scores to both three-week and two-month post-op scores. Postural improvement was found in 18 of 30 patients, indicating the multifactorial involvement of different causes for correct body posture.

Conclusion This study confirmed the validity of Erbium:YAG laser surgery as an effective technique in children and adolescents to release a short lingual frenum. The functional approach of the procedure performed with the Erbium:YAG laser, and the concomitant myofunctional therapy demonstrated to be simple and safe in children, and adolescents. Because of the multifactorial causes involved in correct body posture, an adequate osteopathic therapy is important to successfully complete the full body rehabilitation.

KEYWORDS Ankyloglossia; Tongue-tie; Lingual frenum; Laser lingual frenotomy; Airway impairment; OSAS; Speech impediment; Postural evaluation.

Introduction

The lingual frenum is a fibro-mucosal fold that connects the body of the tongue to the floor of the mouth and the mandibular bone.

Depending on its place of insertion on the ventral surface of the tongue, the frenum can be defined as normal, or short with different severity levels [Kotlow, 1999]. A short lingual frenum can limit the mobility of the tongue, impairing the lingual function [Hand et al., 2020]. Among different classifications of short lingual frenum severity, some authors consider the impaired function of the tongue [Hazelbaker, 1993; Queiroz Marchesan, 2004], and clinical and functional criteria [Olivi et al., 2012]. Beside its place of insertion, a frenum can be thick and very tight in its structure, also contributing "to tethering of the tongue in the floor of the mouth", resulting in the so called ankyloglossia or tongue-tie (from the Greek "ankylos" which means tied, and "glossa" which means tongue) [Various authors, 1975].

Its prevalence in the population varies from 0.1% to 10.7% [García Pola et al., 2002; Ballard et al., 2002; Sedano, 1975; Ugar-Cankal et al., 2005]. The wide range of prevalence seen in these studies, appears to be related to the different purposes of the investigations and to the different classifications used during the assessment of ankyloglossia [Suter and Bornstein, 2009]. Indeed, aepidemiological studies focused on general oral mucosa lesions reported lower prevalence of ankyloglossia (0.1% to 4.4%) [Sedano, 1975; Flinck et al., 1994; García-Pola et al., 2002; Mumcu et al., 2005; Ugar-Cankal et al., 2005] than studies aimed only to assess the prevalence of ankyloglossia (4.2% to 10.7%) [Ballard et al., 2002; Messner et al., 2000; Hogan et al., 2005; Ricke et al., 2005]. The prevalence of ankyloglossia in the general population is also higher in studies investigating newborns (1.72% to 10.7%) [Ballard et al., 2002; Jorgenson et al., 1982; Flinck et al., 1994; Messner et al., 2000; Hogan et al., 2005; Ricke et al., 2005;], than in studies investigating children, adolescents, or adults (0.1% to 2.08%) [García Pola et al., 20021; Sedano, 1975; Salem et al., 1987; García-Pola et al., 2002-2; Cinar and Onat, 2005; Mumcu et al., 2005; Ugar-Cankal et al., 2005]. This difference can be explained in different ways; as possible self-resolution of mild forms of ankyloglossia with growth, or as a possible underestimation of the anomaly at a later age, explaining this age-related difference [Suter and Bornstein, 2009].

The exact aetiopathogenesis of ankyloglossia is unknown. It is more frequently diagnosed as an isolated event, however its association with genetically-related malformative syndromes (Simpson-Golabi-Behemel Syndrome, Optiz Syndrome, Beckwitz-Wiedemann Syndrome, Oro-facial-digital Syndrome; cleft palate) [Moore et al., 1987; Björnsson et al., 1989; Gorski et al., 1992; Gorski et al., 1994; Forbes et al., 1995; Forbes et al. 1996; Klockars, 2007] may suggest its transmission as an autosomal X-linked dominant trait [Suter and Bornstein, 2009], affecting males more than females in a 3:1 ratio.

The aim of this study was to review the craniofacial growth impairment and different malfunctions associated to short lingual frenum and to assess the validity of a lingual frenum surgery based on minimally invasive laser release and myofunctional approach.

Lingual Function

The tongue is a fundamental organ for deglutition and a short lingual frenum is a mechanical impediment to its proper function. The tongue in physiological rest position is positioned high in the palate. Swallowing is a natural function which involves complex neuromuscular activity that occurs with a progressive push of the tongue apex onto the retroincisal-palatal spot followed by the medium and posterior area of the tongue pressing on the hard palate first and soft palate after, thus ending on the wall of the pharynx.

The tongue develops at the fourth week of embryonic life from the median tongue bud of the first pharyngeal arch. Already during the intrauterine life (14–16 weeks gestation) [Sajapala et al., 2017] lingual function includes both suction and swallowing of the amniotic liquid, and through its continuous activity during life the tongue induces stimulation of the intermaxillary synchondrosis [Guilleminault and Akhtar, 2015], which is active until adolescent age, leading to normal orofacial growth. Normal nasal breathing is associated with physiological tongue position [Guilleminault et al., 2016].

Impaired lingual functions

At birth, the effects of tongue-tie, often associated with lip and buccal-tie in newborn infants are well known and range from altered latch and sucking mechanics [Ghaheri et al., 2017], infant poor weight gain, air induced reflux and associated symptoms, to orofacial growth retardation [Hand et al., 2020].

Bearing in mind the close relationship and interdependence between form and function (the "functional matrix" theory of Melvin Moss) [Moss, 1985], we can understand why the low position of the tongue and the consequent restricted lingual functions can be correlated with abnormal bone growth stimulation and consequent impaired cranio-facial growth [Defabianis, 2000; García Pola et al., 2002; Olivi et al., 2012]. The observed anatomical orofacial changes lead directly to orthodontic alterations, to absence of nasal breathing with secondary development of mouth breathing, that is also co-responsible for abnormal development of the orofacial bone structures supporting the upper airway, that increase the risk of upper airway collapse during sleep [Lee et al., 2015] and that also worsens the orthodontic alterations.

Clinical significance

The clinical significance of ankyloglossia in children, adolescents or adults varies. Many affected people do not know or report about their anatomic anomaly or complain about any functional impairment, although some anatomical and functional problems can be associated with ankyloglossia in different stages of life [Suter and Bornstein, 2009]. In these cases, when the diagnosis is late, it is performed by a paediatrician, or by an ENT (Ear, Nose & Throat) physician; by a paediatric dentist, or an orthodontist; by a speech therapist, or a myofunctional therapist; by a physical therapist or any other health therapist involved in this field with the many problems associated with a short lingual frenum. Although different pathologies are closely related one to another, even if not necessarily associated by a linear relationship, these alterations will be reviewed separately. However, the complex nature of the alterations involved has to be deeply understood by the medical/dental operator in order to perform a comprehensive multidisciplinary approach.

Speech impediment

Speech impediment for the correct pronunciation of dento-lingual-labial phonemes, due to the impaired lingual mobility, is one of the most diagnosed alterations associated to short lingual frenum, lingual hypotonicity or lingual size (macroglossia). Speech problems in children with ankyloglossia are considered articulation disorders caused by restricted mobility of the tip of the tongue [Plummer, 1956]. A study on 1402 patients reported that more frequent speech disorders were: omission and substitution of /r/, and consonant clusters with /r/, and of /s/ and /z/. Frontal and lateral lisps also occurred. The relationship between altered frenum and speech disorders was considered statistically significant [Queiroz Marchesan, 2004]. Another study reported how substitution and omission improved relatively early after tongue-tie revision, while distortion required more time for improvement, needing post-operative tongue exercises and speech training to correct defective speaking habits [Ito et al., 2015]. A recent three-dimensional ultrasound (3DUS) investigation on the association of anomalous resting tongue posture, speech disorders and otorhinolaryngological characteristics in preschool children (aged 3–7 years), found that children with improper tongue posture were more frequently associated with speech disorders and anterior open bite malocclusion [Kravanja et al., 2018].

Orthodontic alterations

Kravanja et al. [2018] assessed, in a functional three-dimensional ultrasound (3DUS) study, the higher odds ratios for the presence of anterior open bite in preschool children with improper tongue posture. There is a secondary association of short lingual frenum with anterior and posterior crossbite, disproportionate growth of the mandible, and abnormal growth of the maxilla [Defabianis, 2000; García Pola et al., 2002; Olivi et al., 2012; Huang et al., 2015; Vaz and Bai, 2015]. An anomalous low lingual posture promotes an excessive growth of the mandible, while the growth of the upper arch is not stimulated by the tongue thrust in its anterior aspect (premaxilla) and transversal planes, during each swallowing process that occurs approximately 1500/2000 times every 24 hrs [Olivi et al., 2012; Gonzales et al., 2019]. An anomalous or non physiological lingual function, with or without association of hypotonicity of the lingual muscles (mono- or bilateral), may lead to the placement of the tongue in between the two arches during deglutition and speech, causing a posterior open bite. Lingual anterior thrust, interposition, and protrusion may be associated with anterior open bite [Botero-Mariaca et al., 2018]. Depending on the anomalous position of the tip of the tongue, and on the periodontal condition of the anterior teeth (incisors), possible opening of a diastema between the lower or upper incisors may result from an abnormal lingual thrust [Olivi et al., 2012; Vaz and Bai, 2015].

Airway impairment

The impaired orofacial growth also involves abnormal development of the nasal and facial bone structures supporting the upper airway, with a reduction of the ideal size of the upper airway. The associated oral breathing induces a vicious circle of alterations that, depending on their severity, lead first to an occasional increased respiratory effort during sleep caused by upper airway resistance, then to snoring, initially with flow limitation, up to progressive worsening toward obstructive sleep apnoea (OSAS). A study on a group of children (aged $\geq$3 years), diagnosed with OSAS, found short lingual frenulum, undiagnosed or left untreated, and mouth breathing in 41 of 63 children [Guilleminault et al., 2016]. The study highlighted that children with sleep disordered breathing (SDB) should be evaluated for a short lingual frenulum, and conversely, children with an abnormally short frenulum should be investigated for the presence of SDB. Authors concluded that lingual frenum revision should be performed as early as possible, but it may be not sufficient to restore normal nasal breathing function during sleep, particularly if the frenulum-related problems have existed for many years. Nasal breathing re-education may be needed in these cases [Huang et al., 2015]. A retrospective study evaluated the prevalence of orthodontic abnormalities and oral dysfunctions in a population of 100 children (mean age 8.8 ± 3.5 years) with persistent sleep-disordered breathing after adenotonsillectomy (mean 4.6 ± 3.1 years after). Short lingual frenulum was associated in 40% of cases with oronasal anatomical and functional abnormalities and persistent sleep-disordered breathing after adenotonsillectomy [Cohen-Levy et al., 2020].

Postural evaluation

Altered postures are often present in individuals with ankyloglossia due to anatomical connections of the tongue that is attached to the bone and fascial structures of the head and torsum. A functional synergism between the lingual muscles and muscles of the anteromedian chain has been reported [Scoppa, 2005]. Also neurophysiological connections between the exteroceptors of the palatine spot (emergence of the nasopalatine nerve at the naso-palatine spot, maxillary nerve ramus which is a branch of the trigeminal nerve), trigeminal nuclei of the encephalic trunk, reticular substance, locus coeruleus, cerebral and cerebellar cortex are known [Halata and Baumann, 1999; Martin et al., 2004]. A short lingual frenum limits the tongue movement during different functions and, as a result of the hypertonicity of the extrinsic and suprahyoid lingual muscles (attached to the mandibular bone and cranium) and the consequent stretch of the subhyoid muscles (connected to sternum, clavicle, scapula, larynx, pericardium and mediastinum through the cervical mid-fascia) this is associated with more advanced position of the hyoid bone and of full-body posture. When observed in a posterior-anterior plane, the body leans anteriorly with head, shoulders, and body's centre of balance shifted forward (in lateral view). In an attempt to compensate and maintain the body's centre of balance well centred, and depending on the muscle support, a cervical hyperlordosis (increased cervical lordosis) with high dorsal kyphosis (dorsal kyphosis), or a lumbar hyperlordosis (increased dorsal lordosis) with predisposition to abdominal ptosis may occur. The scapular plane can be in line with the gluteal plane (normal scapulum) but with the head propelled forward and straightening of the cervical area; in these subjects, during the dysfunctional deglutition, the head typically performs a "chicken-like" movement [Scoppa, 2005].

Tongue assessment

Morphological and functional criteria are available to assist the operator to assess anatomical restriction of the tongue, confirming or not an indication for surgery. A morphological classification, based on the distance from the tip of the tongue to the attachment of the frenum, has been suggested by Kotlow [1999]. Kotlow recommends the revision of a short lingual frenum in case of Class IV and Class III ankyloglossia; Class II and Class I ankyloglossia are the most difficult to evaluate and functional criteria of normal range of motion of the tongue can be utilised for surgical indication. Martinelli et al. [2014] proposed a comprehensive protocol, that also evaluates the difference between maximal interincisal mouth opening, and mouth opening with tongue tip to maxillary incisive papillae at roof of mouth, considering anomalous a difference between the two measurements larger or equal to 50.1% (score 1) (Fig. 1, 2). Hence, upon completion of the diagnosis, a clinical-functional evaluation for possible surgical indication has been

FIG. 1 Short lingual frenum: mouth opening (15 mm) with tongue tip to maxillary incisive papillae at roof of mouth.

FIG. 2 Maximal interincisal mouth opening (40 mm); a difference between the two measurements larger or equal to 50.1%, is considered anomalous.

FIG. 3 Intraoperative check of the lingual frenum release is assessed repeating the movement of placing the tip of the tongue on the palatal incisive papilla (Fig. 1).

FIG. 4 Eight year-old child with severe tongue tie. Cleft at the tip of the tongue (heart-shape aspect) is typical of severe ankyloglossia with free part of the tongue shorter than 7 mm according to Kotlow [1999].

suggested by Olivi [Olivi et al., 2011]. When impaired lingual function, such as speech impediment and/or atypical swallowing, and functional appearance, such as the impossibility to sweep the upper and/or lower lips, or the inability of the tongue to reach the palatal retroincisal spot when the mouth is wide open, the shape of the tongue is distorted and/or invaginates at the tip during protrusion outside the mouth, are present, the surgical release of lingual frenum should be considered. It should be considered that a short frenum is not always inelastic or fibrotic and, despite the reduced length, it may allow a normal lingual mobility thus not necessitating a surgical intervention; also the elasticity of the floor of the mouth can mitigate the effects of ankyloglossia and help lingual mobility.

Surgical technique

Different surgical protocols are indicated for cases of ankyloglossia with functional impediment. Frenotomy (or lingual frenulum release) is the most commonly used technique for newborns, since it is a conservative, simple and quick procedure [Hong et al., 2010]. Frenectomy is a more invasive procedure, more difficult to perform in newborns, and is considered a more predictable technique when the procedure is performed in adolescents and young adults with shorter and thicker frenula [Kupietzky and Botzer, 2005]. However, both these techniques, performed with conventional tools (scissors and/or scalpel), require surgical skills, as well as the capacity to work with small patients: often paediatric dentists or oral surgeons do not have both these capabilities. In addition, when a lingual frenum is released or clipped with conventional tools, an incomplete release can result, due to the bleeding in the area obscuring the surgical field, making intra-operative adjustments difficult [Hand et al., 2020]. Conventional surgery is performed using local anaesthesia and sutures.

Laser technique is a valid alternative to traditional surgery. It is simple and rapid to perform, and requires a minimal amount of anaesthesia. Different wavelengths can be utilised for lingual frenotomy/frenectomy following the concept to choose and match the laser wavelength with the prevalent chromophore in the target tissue (affinity/selectivity rule). Depending on the wavelength used, lasers produce a good haemostatic and decontaminating control of the surgical wound, enhancing access, visualisation and precision of the intervention due to the minimal bleeding; for this, also sutures can be avoided (Fig. 3). Laser frenotomy/frenectomy is often followed by an asymptomatic postoperative period, so that it is generally well accepted and tolerated by patients [Boj et al., 2005; Haytac and Ozcelik, 2006; Genovese and Olivi, 2008; Kara, 2008; Olivi et al., 2012]. Laser frenotomy can be performed with topical anaesthesia, however, the authors recommend to avoid any unpleasant discomfort to the patient during surgery, to allow also a complete release of the frenum. Indeed, post-surgical recurrence after laser frenectomy described by some authors [Junqueira et al., 2014], can be related to cases treated without anaesthesia [Olivi et al., 2010], and/or to the absence of completeness of the treatment, that involves also concomitant myofunctional therapy.

Materials and methods

Thirty children and adolescents (from 8 years to 18 years old), diagnosed with short lingual frenum and concomitant orthodontic problems and or presence of associated muscular or postural problems, were treated in this study. Pre-operative tongue assessment was performed following the morphological and functional criteria presented by Kotlow [1999], Martinelli [2004], and Olivi [2011]. At this time the parents and patients, informed about the problem, the treatment and the post-operative care, signed the consent. Postural observation and evaluation was also assessed before and 60 days after surgery. The operative field, the lingual anatomy, the veins, and ducts of the salivary glands were first investigated during the tongue assessment visit, also taking close-up pictures of the area. A minimal amount (0.6 ml, 1/3 of vial) of anaesthetic (4% Articaine) with epinephrine (1:200,000) was sufficient to carry out the procedure with minimum stress for both patient and operator. The anaesthetic was gently injected directly in the frenum using a 30 G needle.

The tongue was held upwards with a gauze or, better, with a special tongue retractor (W. Lorenz instruments; Miltex GmbH Germany). The frenum release was performed by using an Erbium:YAG laser (2940nm, LightWalker AT-Fotona; Ljubljana Slovenia), equiped with sapphire conical tip (600µ) of different lengths (9–14mm). The incision of the frenum was performed with energy ranging from 120 to 160mJ, depending on the target composition; the frequency used was 15 pulses per second (15Hz) to allow a precise surgical control. The adjustable pulse duration used was set to 600 microseconds (long pulse), in order to achieve a better thermal control of the bleeding. In presence of a very fibrotic frenum, a shorter pulse of 300 microseconds was used to achieve more ablative effect on the collagen fibres. Minimal water spray was used during the intervention (10ml/min), setting properly the laser handpiece air/water spray to (2/3). All the surgery were performed under operative microscope control (Leica M655) at a magnification power of 6.4-10X.

Results

One patient (9 years) refused anaesthesia and intervention and was not included in the group. All patients were collaborative during the procedure and reported no pain during surgery. The average operative time was 5 minutes. One girl (17y.o-1/30) had profuse bleeding in the first 2 hours, controlled suturing first, and using anticoagulant drug. The post-operative period, described at the 7-day control, was comfortable for the majority of the patients (28/30). Mild to severe pain was reported only during the functional stretching of the tongue in the initial post-operative days. At the 21-day follow-up, most of the patients (29/30) showed improved lingual movement and function. At the 2-month follow-up, the patients (29/30) presented improved lingual function. Significant postural improvements were reported on 18 of 30 patients, indicating the multifactorial involvement of different causes for correct body posture and the necessity to intervene with different treatments to improve the problem.

Discussion

If health professionals fail to diagnose a short lingual frenum early (preferably at birth), 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 with associated orthodontic alterations [Defabianis, 2000; García Pola et al., 2002; Olivi et al., 2012; Huang et al., 2015; Vaz and Bai, 2015], speech impediment [Queiroz Marchesan, 2004], and sleep-disordered breathing (SDB, OSAS) [Guilleminault et al., 2016] during childhood and adolescence [Hand et al., 2020]. 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, not only solves the breastfeeding difficulty and related problems, but may also prevent this vicious cascade of functional impairments [Hand et al., 2020]. Due to the frequent association of a short lingual frenum in OSAS patients, any specialist involved in the care of children has to coordinate the patient full body assessment with the entire medical team, including the paediatrician, ENT specialist, paediatric dentist, orthodontist, and oral surgeon. In addition, a dental team should be co-ordinated with myofunctional and speech therapists when treating orthodontic malocclusions and lingual restriction, and with the paediatrician and ENT specialist, in order to prevent or intercept the summation of multiple negative effects also concomitant or arising from the persistence of a short lingual frenum (SDB-OSAS). At a medical level, early treatment of OSAS can prevent neurocognitive, behavioural, cardiovascular and metabolic consequences [Evangelisti and Villa, 2019]. Interdisciplinary connections have to be encouraged to always investigate sleep habits and the possible presence of snoring, respiratory efforts or pauses during routine examination of children. Collaboration with physiotherapist/chiropractor/osteopath is fundamental to assess the correct body postural growth of the patient, completing the therapeutic approach.

When a short lingual frenum is diagnosed by a paediatric dentist, an orthodontist, or a general dentist, the surgical solution is often referred to a surgeon for a conventional procedure. Conversely, laser technology allows early intervention, with a simple and effective surgery performed by the same paediatric dentist, thus offering the patient a complete treatment, from diagnosis to minimally invasive therapy. Laser frenum release is very effective: it is safe, rapid to perform for the clinician and minimally invasive for the patient. Furthermore, laser therapy is always better accepted than conventional therapy [Boj et al., 2005; Haytac and Ozcelik, 2006; Genovese and Olivi, 2008; Kara, 2008; Olivi et al., 2012]. The prevalence of relapse is minimal and depends on different conditions: the correct laser wavelength and the technique used, as well as the concomitant myofunctional therapy. The correct choice of the laser type (wavelength) depends on the anatomical structure of the frenum itself (the target tissue). In newborns and children, short frenula are more frequently thin, than in adolescents and adults, where it is relatively common to find short frenula that can be also fibrous and thick. For this reason diode lasers (from 445nm to 1470nm) [Hand et al., 2020] and CO_2 lasers (from 9300nm to 10600nm) [Bullock, 1995; Fiorotti et al., 2004; Puthussery et al., 2011] can be considered as first choice in the newborn, due to better control of bleeding and the absence of water spray, which can be hazardous in newborns, allowing very safe and effective surgery. In this clinical study, an Erbium YAG laser was preferred according to Kotlow [2004], Margolis [2008], Aras et al. [2010], and Olivi et al. [2012]. Indeed, in children, adolescents and adults, in case of fibrous and thicker frenulum, the use of Erbium lasers (2780–2940nm), with water spray, is the best option among the other wavelengths, because of the minimal thermal interaction of these lasers [Genovese and Olivi, 2008; Genovese and Olivi, 2010]. Indeed, the Erbium:YAG laser selectively and effectively targets the hydroxyl radical of fibrous tissue; when utilised with water spray, there is no thermal damage, minimising the rise in temperature in the tissue and consequently the formation of scar tissue and post-operative pain. A study conducted by Aras et al. [2010] compared the tolerance of lingual frenectomy with and without local anaesthesia and the post-surgical discomfort experienced by patients operated with both diode and Erbium YAG lasers, and concluded that only the Erbium YAG laser can be used for lingual frenectomy without local anaesthesia, and that no difference between the two groups was found, regarding the degree of the post-surgical discomfort, except in the first 3 hours, when Erbium YAG laser was more comfortable than Diode.

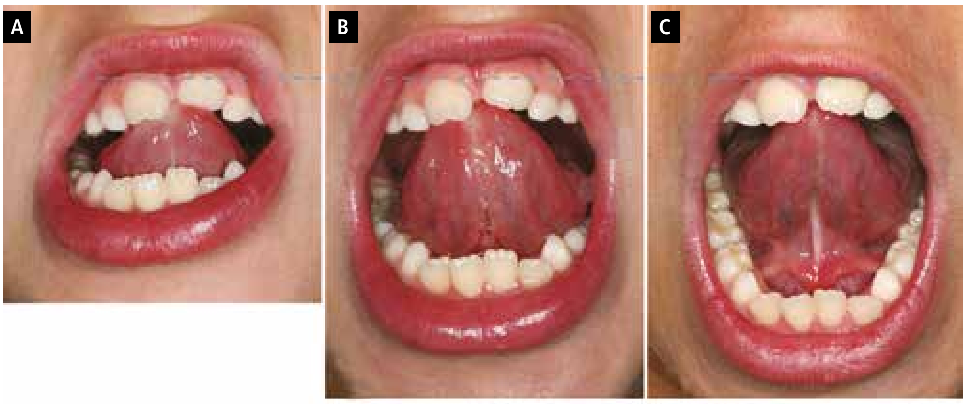
The laser technique suggested by the authors is a functional release. Beside the surgical outline of the technique, the anatomical limits of the surgery consider the functional release achieved with the incisions (Fig. 4). The first incision of the frenum is vertical, along the frenum axis; it starts immediately back to the salivary glands, arriving up to the insertion of the frenum, close to the tip of the tongue: it allows an immediately visible release. After that, a first check of the mobility of the tongue must be assessed, repeating the simple movement of placing the tip of the tongue on the palatal incisive papilla (Fig. 3). A horizontal incision carefully follows the first, performed inside the surgical wound that automatically opens during the first incision (Fig. 5). 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; Hand et al., 2020]. During the horizontal incision, magnification (Dental Operative Microscope), and very clean surgical field, when using the laser with water spray, is a paramount to identify the anatomical structures of the floor of the mouth, the vertical collagen and elastic fibres of the frenum, the salivary ducts and glands, the vessels, as well as the genioglossus muscle fibres and fascia. The vascular vessels (lingual veins), are normally located laterally to the midline, while lingual nerve, normally stays beyond the vein: consequently the extension of the horizontal incision does not extend to these lateral points. Distinguishing these anatomical structures permits a much easier, confident and safe approach to the surgical area, to be selective with the fibrous structures and so minimally invasive, avoiding unwanted bleeding from the hidden vessels. Using Erbium YAG laser with this approach, profuse bleeding will be avoided; the minimal increase of heat, the absence of carbonisation usually present using other laser wavelengths, will allow a healing process with less connective tissue, and subsequent scar that is minimal. A final and more superficial incision, starts from the insertion of the frenum on the tongue-tip side, up to the tip, to gently release the cleft (heart shape) when present on tongue tip (Fig. 4, 5); this aspect is typical of severe ankyloglossia when the free tongue is very short [Kotlow, 1999]. The limited bleeding eliminates the need for sutures, a technical step that is often difficult in children, also decreasing the operative time. Second intention healing allows the tissue to heal with an increase in tissue formation, if myofunctional therapy and stretching are correctly applied. Indeed, to reduce scar tissue formation at the surgical area, the tongue must be mobilised immediately after the laser session, by instructing the patient to perform simple mobilisation and stretching exercises several times a day (Fig. 6). Proper myofunctional therapy session will start a few days after surgery, possibly including osteopathic care to complete the functional rehabilitation of the lingual fascia, and prevent any related relapse [Campan, 1996; Ferrante, 2004; Saccomanno et al., 2012]. Frenotomy is considered a safe procedure if the correct protocol is applied. The most common risks include, incomplete release and relapse, minor bleeding, pain and post-operative discomfort, excess scarring, and injury to the salivary ducts and glands.

FIG. 5 Lingual frenum release of severe tongue tie, performed with Erbium YAG laser: the first incision of the frenum is vertical, along the frenum axis (No. 1); it starts immediately back to the salivary glands, and reaches the apical insertion of the frenum, allowing an immediately visible release. A horizontal incision (No. 2) carefully follows the first, performed inside the surgical wound. A final, more superficial incision (No. 3), releases the insertion of the frenum up to the tip of the tongue, typically when heart-shape (cleft) aspect is present. Note the minimal tissue removal, absence of bleeding and of any laser thermal signs.

This study confirmed the laser surgical release as comfortable in the majority of patients, and good control of bleeding without suturing, with the exception of one case that had profuse bleeding; this problem probably occurred for an excessive extension of the horizontal incision up to vascular structures. The concomitant functional lingual stretching and myofunctional therapy confirmed the completeness of the treatment, with improved lingual movement and function in most of the patients (29/30) (Fig. 7, 8).

Conclusion

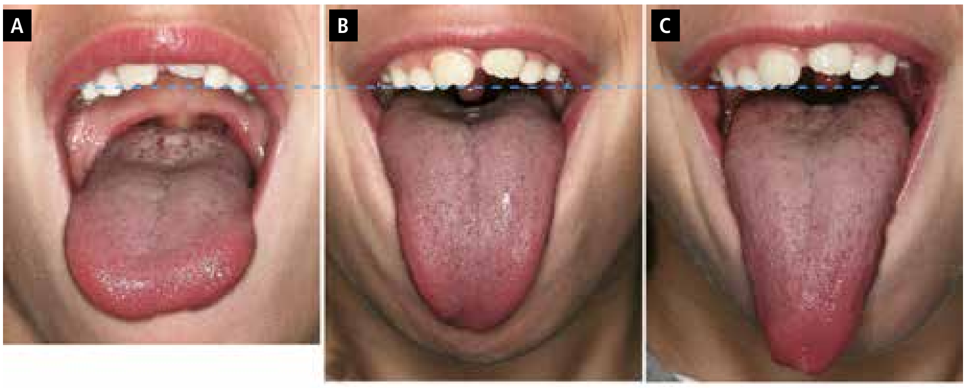
When early diagnosis of short lingual frenum at birth is missed, it is important to intercept and correct morpho-functional growth alterations in children as early as possible, preventing the onset of a vicious cascade of functional impairments. A multidisciplinary approach is necessary to complete the therapy and improve the results, decreasing the



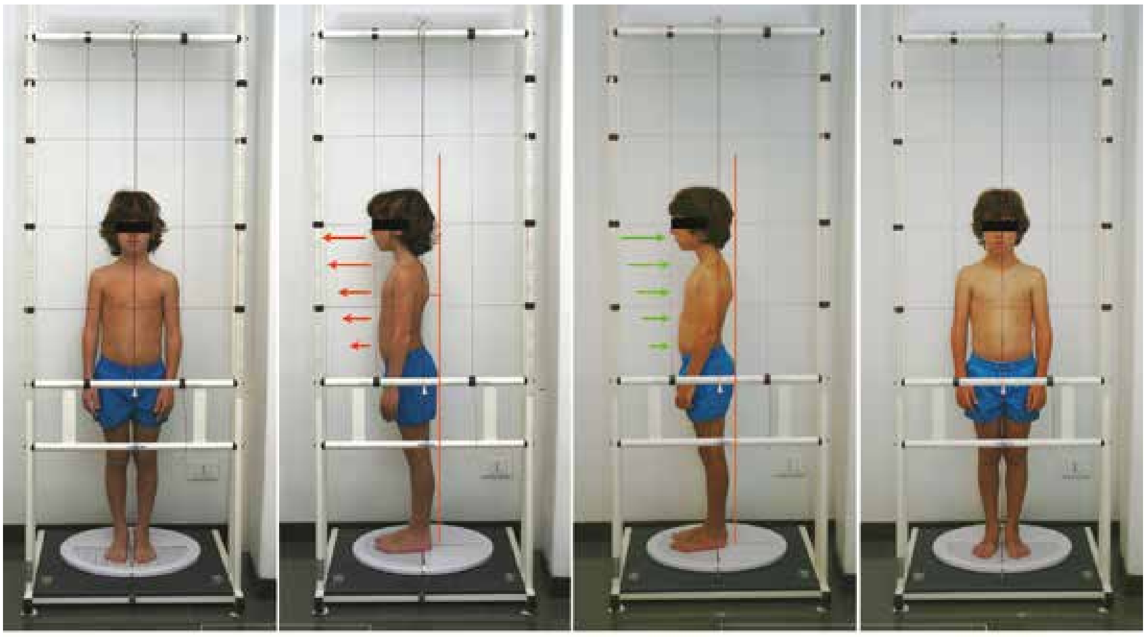
Pre-operative | Immediate post-operative | 60 days post-operative

FIG. 6 Pre-operative view shows the limitation of the lingual function while placing the tip of the tongue at the incisor palatal papilla (a); the intraoperative view shows the immediate improvement after the release (b), confirmed 60 days post-op (c). Note the good second intention healing and the minimal amount of scar on the ventral surface of the tongue.

FIG. 7 Pre-operative view shows the functional limitation during protrusion of the tongue (a); the lingual function clearly improved after surgery (b) and much more after myofunctional therapy (c). Note the change of the shape of the tongue, at the tip and on the lateral margins, due to the improved tone of the intrinsic muscles of the tongue.



Pre-operative 21 days post-operative 60 days post-operative



Before After 60 days

FIG. 8 Eight year-old patient with short lingual frenum, observed in a posterio-anterior plane (in lateral view), shows the body leaning anteriorly with head, shoulders, and body's centre of balance shifted forward. The scapular plane is anterior to the gluteal plane (anterior scapulum), with the head propelled forward. The patient was not compliant with myofunctional therapy; 60 days after lingual frenum release, the patient spontaneously recovered to normal scapulum, in line with the gluteal plane.

recurrence of many of the associated pathologies. Laser surgery is a valid and effective technique in paediatric and adolescent dental patients to release a short lingual frenum. The lingual frenum release procedure with the Erbium:YAG laser has been demonstrated to be simple and safe in children, and adolescents. Correct information and motivation of both parents and patient, as well as an adequate myofunctional therapy are important elements for the overall success of the therapy. A period of education in basic laser physics and training on the technique to be used is highly advisable before applying this technology on paediatric patients.

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