

Tongue-tie, from embriology to treatment: a literature review

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Abstract

The aim of this review is to create a complete analysis about tongue-tie (or short lingual frenum or ankyloglossia) according to the most important works published in literature. The analysis allowed us to do a complete evaluation of this problem, from embriology to the therapeutic approach we could use today, focusing our attention on laser-assisted therapy. This review is based on the research on the PubMed Database (www.ncbi.nlm.nih.gov) of studies about lingual frenum written in English between January 1980 and May 2014. The keywords inserted were “lingual frenum”, “frenectomy”, “laser therapy”. We have analyzed: case series, case reports, clinical studies, and also literature reviews in which embryology, physiology, diagnosis and treatment of ankyloglossia were described. We excluded laboratory studies, studies based on animal tests and studies about patients with particular syndromes in which we can also find tongue-tie. The selection criteria allowed us to select 42 articles. The treatment options for the releasing of the frenum are surgically represented by frenotomy (i.e. simple horizontal cut of this training) and frenectomy (i.e. removal). In both cases, the intervention on the short lingual frenum is simple, short-lasting, and without particular complications. Furthermore, this kind of treatment can be carried out with different devices: with the typical cold blade scalpel or by the use of laser, a new method that shows more advantages over the prior art. Laser-assisted therapy permits to intervene on newborns (from 0 to 20 days, when there are breastfeeding problems) without total anesthesia and suture. The Er:YAG, CO₂ laser (according to literature data) and Diode laser (according to our experience) are advantageous, safe and effective in tongue-tie treatment.

Keywords

Tongue-tie, short lingual frenum, ankyloglossia, frenotomy, frenectomy, laser therapy.

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Introduction

The lingual frenum is a fibro-mucosal fold that connects the ventral surface of the tongue and the mucosa of the oral pavement. An erroneous cellular death process can cause an excessive shortness of this structure; in these cases the tongue adheres to the oral pavement because the cells of the frenum, that joined the two embryonic structures, don't succumb to the planned death that normally occurs. When this malformation reveals itself, we can talk about short lingual frenum or tongue-tie or ankyloglossia [1].

The epithelium that lines the bottom surface of the tongue is thinner and more delicate than the one that covers the back. Along the median line there is the lingual frenum, a thin fold of mucous membrane that connects the body of the tongue to the mucosa covering the floor of the oral cavity. Laterally to the frenum, the sublingual veins are evident, and above these, or laterally to them, there are the folds of mucous membrane flowing until the floor of the buccal cavity. On both sides of the lingual frenum, the emergence of the excretory ducts of the salivary glands is visible. The frenum presents an alveolar and a lingual placing. The insertion may be at the tip of the tongue, and this condition is called ankyloglossia, or little away (less than 2 cm) or very far (more than 2 cm) from the tip. The alveolar insertion can be marginal, that is to say at the neck of the tooth, or apical, i.e. at apex of the tooth root, or sub-apical, i.e. below the apex of the tooth. The presence of a short lingual frenum may be responsible for the low mobility of the tongue.

The anomalies of the lingual frenum can be classified according to different levels of gravity, for example distinguishing four grades on the basis of the type of lingual insertion (**Tab. 1**) [2].

The shortness of the lingual frenum can affect the physiological posture of the tongue and its

neuromuscular behavior. Different relations can be found between lingual posture and posture of the cervical spine, and skeletal relations between maxilla and mandible.

Another classification affirms that a clinically acceptable, normal range of free tongue is greater than 16 mm. The ankyloglossia can be classified into 4 classes based on Kotlow's assessment (**Tab. 2**) [1].

Class III and IV tongue-tie categories should be given special consideration because they severely restrict the tongue movement.

The tongue is a key organ for the growth and development of bone structures that are influenced by the forces activated during these stages. The functional matrix hypothesis [3-6] states that the origin, growth and maintenance of all skeletal tissues and organs are always necessarily secondary phenomena and offset by other previous events that occur in not skeletal tissues, organs or functional areas (functional matrix) that specifically bound. Hence, the joint bone structure is not equipped with its own growth schema, but increases secondarily to the tissues that surround them (functional matrices), for which the genetic control is outside of the bone component. The function is

Table 1. Different levels of gravity of the anomalies of the lingual frenum, on the basis of the type of lingual insertion.

Level of gravity	Type of lingual insertion
Level F3	The frenum has marginal alveolar insertion and lingual connection to the median raphe of the tongue away from the tip of the tongue itself
Level F2	The frenum goes from sublingual caruncle at half the distance between the plane of the lips and the plane of the tongue, that is, not far from the lingual tip
Level F1	The frenum goes from sublingual caruncle to the lower portion of the tongue, with an insertion at the lingual tip
Level F0	The frenum is absent

Table 2. Four classes classification of ankyloglossia based on Kotlow's assessment [1].

Type of ankyloglossia	Movement of the tongue
Clinically acceptable	> 16 mm
Class I (Mild)	12 to 16 mm
Class II (Moderate)	8 to 11 mm
Class III (Severe)	3 to 7 mm
Class IV (Complete)	< 3 mm

the main controlling factor for functional matrix theory, which provides a valid basis to the idea that the functions contribute in determining the morphology in the normal growth and that the alteration results in an alteration of the morphology of the functions. The tongue, as a functional matrix, plays a plastic role on the hard palate and the development of the jaws; its size, during fetal development and later in ontogenetic development, is always disproportionately large compared to the structure that contains it. As the tongue is devoid of neuromuscular spindles, its spatial regulation is conditioned by external receptors to it (on the teeth, the mucous membranes of the mouth and language itself) and therefore has a topological dimension, that is, its plastic structure allows it to fit into the free space. For instance, the tongue is able to adapt to a confined space, compensating the reduction of its cross-sectional diameter with an increase of the longitudinal one, but also to fill edentulous spaces, working in torsion along its major axis, adapting to asymmetric development of the palate as unilateral agenesis or asymmetric obstruction of the upper airways. The factors related to the definition of the shape and lingual functionality are:

- the posture of the cervical spine, especially in the atlanto-occipital hinge (rear control);
- the lip seal and breathing (front control);
- the temporomandibular joints;
- the relations with the intermaxillary bone.

For this reason, in the control of the head growth and development, the importance of functional factors may occur in cases of aglossia or temporomandibular joint ankyloses, as well as the importance of the dysfunctional factors is now proven for example by numerous clinical studies on the effects of mouth breathing on growth, morphology and posture [7]. Even a lingual dysfunction determined by the tongue itself, for example an anatomical impediment like the short frenum, is capable of creating disharmony in the stomatognathic system by altering the relationship between the bone bases and stability of both the front and rear control, causing abnormal stresses on the hyoid bone and, secondly, cervical and postural problems.

By now it is established that light forces are really important in morphogenetic development and these forces appear when the tongue is at rest position. The lingual position is due to the characteristics of the interior and external musculature and it is certainly conditioned by the morphological alterations of dental arches. In physiological conditions, the tongue fills all the oral cavity and the

tip is the most important area for a correct position. In most cases, after eruption of deciduous teeth the tongue is in contact with its apex with the palatal papilla, just behind the upper teeth, while the edges are supported on higher structures in the oral cavity. In this condition there is no contact between the teeth; the atlanto-occipital joint has a good posture, competence is normal and there is nasal breathing. So when the tongue is in the correct position, the rear control, represented by cervical kyphosis, and the front control, consisting of the lip seal, are not deficient. When the frenum is short, it is impossible or really difficult to establish normal anatomical rapports, so the anatomical deficiency becomes also a functional problem; this issue generates other anatomical problems related to the short frenum itself [8].

Aim

The aim of this review is to create a complete analysis about ankyloglossia according to the most important works published in literature. The analysis allowed us to do a complete evaluation of this problem, from embryology to the therapeutic approach we could use today (traditional surgery, laser-assisted therapy), focusing our attention on laser-assisted therapy.

Materials and methods

This review is based on the research on the PubMed Database (www.ncbi.nlm.nih.gov) of studies about lingual frenum written in English between January 1980 and May 2014. The keywords inserted were “lingual frenum”, “frenectomy”, “laser therapy”, focusing our attention on new therapeutic approaches. We analyzed case series, case reports, clinical studies, literature reviews in which surgical or laser-assisted procedures about frenectomy were described. We excluded laboratory studies, studies using animals and studies about patients with particular syndromes in which we can also find tongue-tie. The selection criteria allowed us to select 42 articles.

Embryology and physiology

Embryology

Before starting the literature analysis, we made a summary about embryology and physiology of lingual frenum and deglutition. Then we focused our attention on pathology (diagnosis and treatment).

In a four weeks human embryo there are five processes that occur in the future oral cavity. In that moment the biggest process is the frontal one. The mandible originates from the Mekel cartilage, that coalesces and forms a single bone. The complete substitution of the cartilage with bone occurs after birth. The tongue formation occurs in the ventral side of the oropharynxes. The first four brachial arches contribute to varying degrees to its development. At the fourth week, from the first brachial arch three mesenchymal proliferations appear: two lateral (lateral tubercles) and a medial proliferation (impaired tubercle) that constitute the anterior 66% of the tongue. The second arch gives a negligible contribution. Then the ventro-medial portions of the third and fourth arches proliferate and originate an impaired and medial formation, called “copula” or “ipobranchial eminence”, that forms the fixed portion of the tongue (the posterior 33% of the tongue). At about the 10th-11th week, the fusion of the different components causes the permanence of a depression, in other words the orifice of the thyroglossus duct that, in adults, will evolve in the foramen cecum and in the terminal sulcus. The complex tongue derivation is the reason of the complex innervation of this structure that involves the 5th, the 7th, the 9th, the 10th and the 12th pairs of cranial nerves. The formations that derive from the brachial arches originate only the tongue superficial mucosa. The internal portion, that is to say, the muscular portion, derives from the occipital somites (mesoderm) that invade the tongue with the hypoglossal nerve; this nerve supplies the motoric innervation of the lingual muscles. It is important to know that the oral cavity, the pharynx and the larynx can be considered as a unique district not only for the single innervation, but also for the same embryological derivation. The numerous muscular and nervous connections achieve functional synergies among the different systems of the oral cavity, the pharynx, the larynx, the soft palate, the face, the antero-lateral portions of the neck and of the postural muscles. The balance of this complex neuro-muscular system is fundamental for the face and body posture organization and development [9].

Physiological swallowing

The swallowing mechanism takes place through a series of coordinated muscular contractions that have the purpose of bringing the food bolus, the liquid and the saliva from the mouth to the stomach. The mature swallowing is the result of the

combined action of twenty masticatory and lingual muscles and it never involves mimic muscles; if facial muscles contractions are visible, a functional imbalance is probably present.

The swallowing of food bolus occurs about 150 times in 24 hours, but more important (for the purposes of postural muscles) is the unconscious swallowing of saliva that occurs every 30 seconds while awake and every minute during sleep, that is to say, about 1,600-2,000 times in 24 hours.

The tip of the tongue is able to perform a driving force on its point of support, which remains fixed, with a pressure of about 100 g/cm²; as performed by all its muscles on dental elements, this force is about 2 kg and is exerted at each swallowing act. Nevertheless one should not conclude that a disease of the swallowing function can determine dento-alveolar malocclusion on its own, because the acting forces, however strong, are not sufficient to allow orthodontic movement. The problem often occurs when a pathologic swallowing is associated with a non-physiological resting tongue posture, and the tongue behaves in this case as a fixed orthodontic appliance that acts 24 hours/day to cause malocclusion [8].

Swallowing in newborn is different from that of typical adult: it is defined “swallowing with lingual push” and occurs according to the sucking-swallowing-breathing scheme; the diet is liquid.

The swallowing reflex occurs when in the mouth there is sufficient quantity of milk, after 4-5 acts of suction. In the sucking, the front of the mouth performs movements of milking and squeezing of the nipple, while the posterior part is delegated to suction [10]. When the baby starts feeding with solid food, there are modifications in the swallowing model that allows him to get used to the new eating habits and the new needs: the pharynx stretches and enlarges, the soft palate becomes more mobile, the epiglottis lowers. The first teeth appear in the arches, and they reduce the free space for the tongue forcing it to shift back and high according to this scheme: the tip of the tongue moves from interalveolar space to a retroincisal position higher than before, thereby the anterior thrust of the tongue ceases; it has the appearance of occlusal contacts, supported by the increase in masticatory muscles tone, by the displacement of the tongue and by the decrease of the tone of orofacial (orbicularis oris, buccinator, mentalis) muscles.

When the first permanent molars erupt (at 6-7 years of age), chewing, swallowing, occlusal

balance, gait and posture develop completely. However, in this phase some variability in different people or also in the same person is acceptable.

Nervous control of swallowing

The portion of the nervous system that controls swallowing is largely related to the Central Nervous System (CNS). Swallowing lies in the center of the trunk brain, stimulated by the reticular formation, and governs this complex function for which many sensory and motor plexuses intervene. The afferent impulses originate from stimulation of the oral cavity and pharynx and they travel along the fibers of the glossopharyngeal, trigeminal and superior laryngeal nerves. The trigeminal afferents are actively involved in the provision of information to know the exact relationship of the skull on the trunk.

During the preparation of oral swallowing, physiologically dental contacts occur, and periodontal receptors send through the trigeminal system jaw-related information on maxilla and mandible, hyoid bone and cervical bone. For each act of swallowing, the CNS is well informed about the cranio-cervical-mandibular relationship, and this emphasizes strength and importance of the relationships between swallowing function and posture [10].

Atypical deglutition

Atypical deglutition phases are the subsequent:

- the tip of the tongue is pushed against the teeth or interposed (as happens in the infantile deglutition);
- the tongue is flattened unilaterally or bilaterally;
- the posterior portion of the tongue is pressed against the hard and soft palate;
- the contraction of masseters is absent;
- there is no elevation of the oral pavement;
- mental and orbicular muscles are activated.

The pushing of the tongue against the palatal surfaces of anterior-superior teeth can cause their protrusion.

The pushing of the tongue between the superior and inferior teeth can cause a retrusion of the inferior teeth.

The interposition of the tongue between dental arches can operate as a force of movement and impediment: this is the most frequent type of atypical deglutition [11, 12].

The atypical deglutition can be divided in simple (the most frequent) and complex. In the

simple atypical deglutition, the dental arches are in occlusion and we can see a localized anterior or lateral open-bite; in the complex atypical deglutition, the dental arches are not in occlusion and there is a total anterior and lateral open-bite.

Swallowing with short frenum

The tongue is fundamental for a correct swallowing; structural anomalies have certainly important consequences on its function. When the tongue is in rest position, it causes the creation of forces as if it was a muscle in contraction. In the case of short frenum, the genioglossus muscle modifies the correct position of the geniohyoid muscle with the consequent elevation and forward displacement of the hyoid bone. In a dynamic situation, tongue-tie causes different consequences, in particular:

- short frenum operates as an anterior anatomical restraint for the styloglossus and digastric muscle that during the contraction cannot move the hyoid bone in the right way;
- the tongue cannot impact against the hard palate, but it remains attached to the oral floor;
- the infrahyoid muscles cannot perform their action (stabilization of the hyoid bone) and this fact causes an incorrect flexion of the cervical rachis and of the head. The connections of the hyoid bone with the shoulder girdle bring to variations of the position of shoulders and cervical vertebrae [13].

The hyoid bone can be considered as a divider of multidirectional vector forces and it becomes a fixed point where tridimensional forces that act simultaneously can anchor.

During deglutition, short frenum causes an anterior block transferred through the suprahyoid muscles to the head and through the infrahyoid muscles to the neck and the shoulders, so the postural analysis shows anteriorization of the head and posterior protrusion of the shoulder [11, 12].

Short frenum and occlusion

Short frenum causes a lingual dysfunction especially on the sagittal plane. In this case one can develop different types of malocclusion related to the length of frenum and the neuromuscular action (different in each person). Occlusion and its characteristics are due to the centrifugal and centripetal forces. In case of tongue-tie, the tongue has a low position and – if there are also an anterior dental interposition and an hypertonic lip seal – we

will see an open bite because the tongue, interposing between the teeth, will prevent the contact; however, if the lip seal is hypotonic the lingual thrust will overbear it determining a 2nd class malocclusion that can be a 1st or 2nd division, sometimes associated to a mandibular hypo-development. In other situations, the low lingual position can cause a 3rd class malocclusion due to the excessive development of mandibular bone and an hypo-development of maxillary bone that wasn't driven in its expansion by the tongue thrust [14].

Cranio-degluto-postural syndrome

A symmetrical and uniform distribution of the body weight and a stable position of each articulation ensure an equilibrium position of the body around the line of gravity. There are many sensory systems that allow the programming and maintenance of the correct posture of the various body segments: among these there are the vestibular apparatus, visual system, auditory system and somatosensory system, which collect information from receptors in the skin, the muscle spindles, and the Golgi tendon organs. All these afferents first reach the CNS and then the reticular formation, from which the response to the stimulus are sent to the muscles that regulate the posture. The stomatognathic system, which fits in an active way in the complex postural system, is particularly rich in proprioceptors; muscle spindles are numerous in the muscles of the jaw, which is why their proprioceptive activities is so important for the control of the mandibular position and movements. The embryology recalls the close linking between the hypoglossal nerve, which governs the traction of the tongue muscles, and the atlanto-occipital bulbar nucleuses. The hypoglossal nerve, in fact, originates from the same structure from which the occipital bone develops and this link is the same that the hypoglossal nerve has with the first four cervical posterior roots. That is to say, in practice, that the cervical plexus shows an intimate bond with the tongue movement and this can modify the postural equilibrium. The head-cervical spine system can be treated as a lever of 1st kind, where the head is the resistance, the cervical musculature is the power and the column is the fulcrum, because the center of gravity does not coincide with the center of the cephalic skull base but is physiologically moved back, and, if the head is further forward towards the gravity line, the lever arm of the resistance increases. This is what happens in patients who have a short lingual frenulum and, as

already pointed out above, often results in the anterior displacement of the head and back shoulder blade. On a neuromuscular basis, this posture results from an activation of the anterior kinetic chain muscles, which starts from the front portion of the tongue, compared to the back kinetic chain muscles, with an advancement of the head to the body and an atlanto-occipital flexure with straightening of the cervical vertebrae. This imbalance causes an excessive anterior displacement of the center of gravity of the person, which, for the purpose of recovering the centrality, activates the posterior muscles of lumbar chains, giving rise to a lumbar hyperlordosis and resulting in low back pain. The increase in anterior postural tone also extends to the flexors of the foot resulting in some cases in an accentuation of the height of the arch and the attitude of a hollow foot. Considering all this, some authors speak of a glosso-postural syndrome, describing a complex symptom in which the morphostructure and the lingual movements affect its posture and vice versa. Others believe that it is more appropriate to speak of a cranial-degluto-postural syndrome, thus placing more emphasis on the swallowing function as a whole and on the interaction that exists among this fundamental physiological function, body posture and skull in a very special way. It is very important to consider that studies in progress in patients with pathological swallowing due to a short frenum are often associated to the calcification and elongation of the styloid process in a syndrome called "Eagle syndrome". This disease can cause a variety of symptoms such as dysphagia, earache, headache, toothache, pain in the facial muscles (commonly and wrongly associated with aging). Some authors speculate that today this is a pathognomonic symptom of pathological swallowing sometimes related to the presence of a short frenum and often this is also related to dysfunctions of temporomandibular joints [15].

Discussion

Ankyloglossia: definition and epidemiology

Ankyloglossia (also known as tongue-tie or short lingual frenum) is a congenital oral anomaly which may decrease mobility of the tongue tip and is caused by an unusually short, thick lingual frenum (which is a membrane connecting the underside of the tongue to the floor of the mouth).

Etymologically, the term "ankyloglossia" originates from the Greek words "agkilos" (curved)

and “*glossa*” (tongue). The first use of the term “ankyloglossia” in the medical literature dates back to the 1960s, when Wallace defined tongue-tie as “a condition in which the tip of the tongue cannot be protruded beyond the lower incisor teeth because of a short frenulum linguae, often containing scar tissue” [2]. The same term is used for very different clinical situations: when the tongue is fused to the floor of the mouth, but also if the lingual frenulum is only short and thick with slight impairment of tongue mobility. Ankyloglossia varies in degree of severity from mild cases characterized by mucous membrane bands, to complete ankyloglossia whereby the tongue is tethered to the floor of the mouth (Tab. 2) [16].

The present review of literature shows that the short frenum is a common condition; in fact, it appears in 3-4% or 4-5% of children (depending on the studies) and, in Europe, there is a higher manifestation of this disease in English newborns (about 10% affected). Of all these children, about 25% has a difficult breastfeeding. Besides, this problem seems to occur mostly in male subjects, with different ratios (from 1.5:1 to 3:1), depending on the studies analyzed. The prevalence is also higher in studies investigating newborns than in studies investigating children, adolescents, or adults (from 0.1% to 2.1%) [17]. It is possible that some milder forms of ankyloglossia may resolve with growth, explaining this age-related difference. The topic of ankyloglossia is controversial, with practitioners of many specialties having widely different views regarding its significance and management. In many individuals, ankyloglossia is asymptomatic; the condition may resolve spontaneously or affected individuals may learn to compensate adequately for their decreased lingual mobility. Some individuals, however, benefit from surgical intervention (frenotomy, frenectomy or frenuloplasty) for their tongue-tie. It is suggested that patients and/or their parents should be educated about the possible long-term effects of tongue-tie so that they may make an informed choice regarding possible therapy [18]. There is some evidence that ankyloglossia can be a genetically transmissible pathology, although it is not known which genetic components regulate the phenotype and penetrance in the affected patients. More basic research is needed to clarify the exact etiopathogenesis of ankyloglossia. Ankyloglossia was also found associated in cases with some rare syndromes such as X-linked cleft palate syndrome, Kindler syndrome, van der Woude syndrome, and Opitz syndrome. Nevertheless, most ankyloglossias

are observed in persons without any other congenital anomalies or diseases [17, 18].

Diagnosis

For a correct diagnosis [19] the function deserves more consideration than the appearance (Tab. 3). For this reason, aside from the direct observation of the frenum, it is also fundamental to observe the newborn during breastfeeding and to inquire the parents about the weight gain. In children or adults

Table 3. Hazelbaker’s Assessment Tool for appearance and function of the tongue (modified from: Amir et al., 2006 [20]).

Appearance	Function
Appearance of tongue when lifted	Lateralization
2: Round or square 1: Slight cleft in tip apparent 0: Heart or V-shaped	2: Complete 1: Body of tongue but no tongue tip 0: None
Elasticity of frenulum	Lift of tongue
2: Very elastic 1: Moderately elastic 0: Little or no elasticity	2: Tip to mid-mouth 1: Only edges to mid-mouth 0: Tip stays at lower alveolar ridge or rises to mid-mouth only with jaw closure
Length of lingual frenulum when tongue lifted	Extension of tongue
2: > 1 cm 1: 1 cm 0: < 1 cm	2: Tip over lower lip 1: Tip over lower gum only 0: Neither of the above, or anterior or mid-tongue humps
Attachment of lingual frenulum to tongue	Spread of anterior tongue
2: Posterior to tip 1: At tip 0: Notched tip	2: Complete 1: Moderate or partial 0: Little or none
Attachment of lingual frenulum to inferior alveolar ridge	Cupping
2: Attached to floor of mouth or well below ridge 1: Attached just below ridge 0: Attached at ridge	2: Entire edge, firm cup 1: Side edges only, moderate cup 0: Poor or no cup
	Peristalsis
	2: Complete, anterior or posterior 1: Partial, originating posterior to tip 0: None or reverse
	Snapback
	2: None 1: Periodic 0: Frequent or with each suck

14 = perfect score; 11 = acceptable if Appearance item score is 10. Frenectomy is necessary if total score is < 11 and Appearance item score is < 8.

we have to evaluate the possibility of the tongue to touch with its tip the retro-incisal papilla on the palate, the heart shape during the lingual protrusion, reduction of sublingual space, difficulty during the lingual movements, space between central inferior incisors due to the tensile force exerted by the lingual frenum during speech and deglutition. Furthermore, the affected children cannot lick their lips or an ice cream or cannot play a musical instrument. Localization of the frenum insertion on the gingiva seemed to be very important for gingival effects because the insertion of the lingual frenulum in the area of the papilla had the highest association with gingival recession.

Age and treatment

A functional assessment of the lingual frenum is essential to decide the need for speech therapy or surgical intervention. A speech therapy may be indicated for children who have not an excessive brevity of frenum (i.e. it allows a sufficient mobility of the tongue); in these cases the patients may present to us at about 4-5 years old because they highlight difficulties in articulatory features, sometimes associated with a pathological swallowing and postural changes, but in history there are no important problems during breastfeeding [21]. The speech therapy is based on a system of specific exercises for frenulum lengthening, that are essentially the same as for surgical patients; the treatment should be continued for at least three months with bi- or tri-weekly sessions and a personal daily training. If progress ceases to be satisfactory, the patients will be addressed towards the surgical therapy which, if required, should be performed as soon as possible to prevent the onset of compensatory habits and possible incorrect consequences on the entire auditory-degluto-postural system. Treatment options, if someone needs to release the frenum, are surgically represented by frenotomy (i.e. a simple horizontal cut of this training) and frenectomy (i.e. removal). In both cases, the intervention on the short lingual frenum is simple, of short duration, and does not present particular complications. Furthermore, frenotomy can be carried out with different devices: with the typical cold blade scalpel [22] or by the use of laser, a new method that shows more advantages over the prior art. The advantages which make it advisable to the classic frenotomy are reported in **Tab. 4**.

An intervention of frenotomy can be performed in outpatients in properly equipped dental surgery

Table 4. Advantages of laser frenotomy.

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| <ul style="list-style-type: none"> • Minimal invasiveness, with a microtraumatic technique and reduced bleeding and scarring • The possibility of an immediate post-operative speech therapy • In most cases the use of topical anesthesia, that it is often sufficient, instead of anesthesia by infiltration • The reduction of the operative time |
|--|

offices. Our literature analysis, on the section of short lingual frenum, shows some data and some general therapeutic indications, based on the age of the patient, as they are related to the problems and functional needs [16]. In newborns, short lingual frenum is diagnosed when it causes feeding difficulties rather than on the appearance of the frenum. In all studies the authors agree that the frenotomy in newborns is a low risk procedure, which can be performed without anesthetic and which is much more effective than intensive specialist support by a professional adviser for breastfeeding. The rapid improvement, often immediate, after surgery in patients with less than 3 months (on average from 0 to 20 days of life) was noted in 95% of cases already within 24 hours: infants are fed in a better way and the difficulties of breast attack and injury to nipple for mothers disappear [18]. In addition, the tongue movement during sucking (the infant will train from this moment at every meal and several times a day in a natural and correct way) is the best technique for stretching the frenum and prevents retraction scar resulting in relapse [23, 24]. The National Institute for Health and Clinical Excellence (NICE) published a full report [25] on the section of tongue-tie and breastfeeding to promote this intervention in the NHS (National Health Service) in England, Wales, Scotland and Northern Ireland. Even in older children a thorough functional analysis of the lingual frenum should be carried out before deciding which therapy is the best to carry on. It can happen that a child with a F2 level frenum (a milder form of malformation in which the mobility of the tongue is only partially reduced, **Tab. 1**) will not have problems related to the disease: the frenum stretches with growth and resizes itself to the tongue, or the child functionally adapts to reduced lingual movements [26]. A specialist evaluation for surgery must therefore take into account also spontaneous regressive phenomena that may occur before 6-7 years. The speech therapist can highlight the disease before this age, especially if the child shows dyslalia for specific phonemes; if he considers a

spontaneous regression likely, he can support the patient with a speech therapy including specific stretching exercises of the frenum, otherwise he may refer the patient to the intervention of frenotomy [27]. In several case studies, cases of marked improvement have been noted after surgery [28], but many children have shown a gradual improvement and need to continue the speech therapy; this fact is attributed to the need to correct articulation errors induced by the well-established design compensators. The observation by a specialist on speech therapy may also be required in cases of faulty habits, prolonged pathological or swallowing facial dysmorphic features or otolaryngologist problems that address to a tubal re-education therapy; in these cases he may intercept patients with short frenum for which it is certainly useful to intervene [29].

In adults, the diagnosis of tongue-tie is reached or suspected when there are dental malocclusion, which imply a wrong lingual posture, and pathological swallowing, or, in elderly mobile denture wearer, for pain or instability of the prosthesis itself that the short frenum can create. Sometimes patients report modification in quality of sleeping, or postural problems (neck pain, etc.).

The intervention of frenotomy consists in the disinsertion of the frenum in one of its sides to remove the tension forces exerted by the frenum itself when it is too short. Thus, the lingual frenotomy consists in the section of the ventral surface of the tongue. It can be performed with different methods. The frenectomy, instead, consists in the elimination of the whole frenum. When we make use of the scalpel, we can do a “V” shaped incision, in which we use two hemostats positioned so as to join the extremities and form a “V” upside down on which the blade of the scalpel is made to slide, so that the hemostats are detached together with the frenum [30].

Consequences of untreated tongue-tie

Appearance of the tongue could be abnormal in some individuals. Improper chewing and swallowing of food could increase the gastric distress and bloating, and snoring and bed wetting at sleep are common among tongue-tied children. Dental caries could occur due to food debris not being removed by the tongue action of sweeping the teeth and spreading of saliva. Malocclusion like open bite due to thrust created by being tongue-tied, spreading of lower incisors with periodontitis, and tooth mobility due to long-term tongue thrust

are associated problems. It also affects self-esteem because it has been clinically noted that occasionally older children or adults will be self-conscious or embarrassed about their tongue-tie because they may have been teased by their classmates for their anomaly. In infants, feeding problem may be experienced due to latching on to the nipple, which may compress the nipple against the gum resulting in nipple pain in mothers, and due to this the mothers may often choose to transition their babies to bottle [31-35].

Tongue-tie therapy: the use of laser

The possibility of a mean to absorb the light is related to the material that constitutes the mean itself. A part of material that absorbs the light is also called pigment. The biological tissues interact with the laser (light amplification by stimulated emission of radiation) following the four principal optical properties: absorption, reflection, diffusion and transmission. The laser emits a monochromatic ray of coherent and collimated light. There are different types of laser, with different active means (solid, liquid and gaseous), with different wavelength and so with different fields of application. The interaction between the laser and the tissue is related to the wavelength of the radiation and to the properties of the tissue. The principal effect of the laser for medical uses is represented by the transformation of the absorbed electromagnetic energy in thermic energy. This effect is also called “photothermal effect”. The biological effects of the thermal action are due to the optical properties of tissues, the thermal conductance of tissues and the accumulation of the heat of tissues (**Tab. 5**). If we want to increase or decrease the thermal accumulation in tissues, we can increase or decrease the power of laser, change the

Table 5. Biological effects of the thermal action.

°C	Effect
40°	Vasodilatation (hypertermia)
45°	Endothelial damage
50°	Block of enzymatic activity
60°	Proteins denaturation: the collagen is more resistant (it has covalent links), the blood viscosity increases, the circulation slows, the vascular gauge decreases. Activation of the platelet favoring thrombosis: coagulation effect
80°	Collagen retraction: hemostatic effect
100°	Vaporization of the interstitial and intracellular fluids, volatilization of the organic constituents

total time of the radiation and modify the distance from the tissues. The thermal accumulation in the tissues is also due to the way of emission, the length of every pulse and the time of thermal relaxation. In fact, laser emission can be: continue, pulsed, superpulsed, iperpulsed. The heating of the tissues is related to the period of the impulse. When the impulse is activated we will have a thermal effect on the tissue target, when the impulse is not applied there will be a cooling effect. Laser intensity is related to the dimension of the laser itself; in fact, it can be focalized, defocalized or not focalized. This dimension is related to the effect that the laser has on the tissues. Depending on the absorbed energy for time unit and volume unit we can have different effects on the target tissue: cutting, vaporization and coagulation [36, 37].

Thermal effects on the soft tissues

Since 75-95% of oral tissues are composed by water, the wavelengths absorbed by water are also absorbed by soft tissues. When the absorbed energy exceeds the ebullition point of cytoplasm, it causes the evaporation of intercellular water and therefore the destruction of the cellular membrane (**Tab. 5**). Some tissues cannot absorb the laser, so we can use some chromophores, introduced into a molecule, that make possible the absorption of the laser itself.

According to the Lambert-Beer rule, the intensity of the laser and the concentration of chromophores in the tissues determinate the penetration depth for an established wavelength. For the same energy given to an established surface or volume of a tissue, the type of effect on the tissue will be related above all to the time in which this energy will be administered. Long periods of application will cause photochemical effects, short periods will mostly produce mechanical effects. The analysis of the absorption spectrum shows the penetration potential of the different wavelength. It is possible to individuate an “optical window” and so a range of wavelengths capable to go deep into. The penetration depth, according to the Lambert-Beer rule, is related to the concentration of chromophores and so to the substances capable to absorb the used radiation (power density) [37]. The application time does not influence the depth of penetration when there are the same tissues conditions. Another factor that can influence the penetration depth is the scattering and so the possibilities of the parts of the tissues to dissipate the radiation, with or without maintaining the

original energy (elastic or non-elastic scattering). A diffuse radiation (Diodes 810 nm, Nd:YAG) that has a strong absorption penetrates more deeply due to the phenomenon called “forward scattering” and can penetrate even deeper due to the types of emission and intensity used. Time does not influence the penetration depth, but influences the thermal diffusion. Every tissue constituent has an own thermal conduction and thermal capacity: these parameters must correspond to the TRT (Thermal Relaxation Time) indicated as the necessary time for a given component to disperse the 50% of heat given. The quantity of water is really important to determinate this parameter. The first consequence is that pulses shorter than the relaxing time of water ensure that the heat caused by themselves remains only in the target tissue and does not permeate the neighboring tissues. Obviously, the repetition of the frequency of the pulses must be such as to prevent the accumulation of the heat. The shape of the pulse itself is really important because a rapid reaching of the energetic peak and a rapid return permit not to have tails that reduce the efficiency of the pulse and contribute to the heating of the tissue [38].

Advantages of the use of laser

In adults, but mostly in children, the use of laser brings great benefits in dental therapies. In fact, unpleasant and annoying noise and vibration of the drill (for example in conservative surgery) or the fear of the scalpel (in minor surgery) and, in most cases, local anesthesia and risk associated with it can be avoided with the use of this dispositive. The hemostatic, coagulant and cicatrizing effects are really important; in fact, laser surgery is less invasive, avoids bleeding and suture and eliminates complications and post operatory problems. The laser has also an important anti-bacterial effect that reduces the risk of infections and recidivisms, avoiding the swelling and the inflammation that usually occurs after surgery [39, 40].

Indication

The optimal coagulative capacity of laser such as KTP, Diodes 810/960 nm, Nd:YAG and carbon dioxide (CO₂) permit to intervene on soft tissues in a safe way, without necessity of suture or with less or no use of drugs, also in patients with coagulation problems. There are also decontaminations that nullify the risk of iatrogenic infections [41, 42].

Type of laser for treatment of ankyloglossia

Laser technique is an innovative, safe and effective therapy for frenectomy in both children and adolescents. The choice of the best type of laser is obviously due to the type of tissue that we want to treat (in this case, mucosa) and it is also due to the aim for which we have to use this instrument (cutting). The analysis of literature shows that Er:YAG laser (2,940 nm) can be useful for pediatric dentistry: 1.5 W at 20 pps is a commonly used average power to easily, safely and quickly cut the frenum [42]. The results indicate that only the Er:YAG laser can be used for lingual frenectomy without local anesthesia. In conclusion, these results indicate that the Er:YAG laser is more advantageous than the Diode laser in minor soft-tissue surgery because it can be performed without local anesthesia and with only topical anesthesia [43]. For the same aim we can use other types of laser such as the CO₂ laser, which is also an optimal instrument for frenectomy. The results demonstrated that this technique is safe, effective and simple to be used in young children and can be performed in an outpatient unit [44, 45].

However, despite literature data, in our practice the use of a Diode laser in tongue-tie therapy is safe and effective and this treatment causes an immediate improvement in speech and deglutition (**Fig. 1**).

Conclusions

Our literature analysis showed that tongue-tie is a very important problem. If not well treated, in fact, it can create problems not only related to feeding and speech, but also involving growth and posture. Since it is present in a relevant number of newborns, and given that sometimes it is important to intervene in preschool children, laser-assisted therapy is the best choice to solve this problem. It permits to intervene on newborns (from 0 to 20 days, when there are breastfeeding problems) without total anesthesia and suture. The Er:YAG, CO₂ laser (according to literature data) and Diode laser (according to our experience) are advantageous, safe and effective in tongue-tie treatment.

Declaration of interest

The Authors declare that there is no conflict of interest.

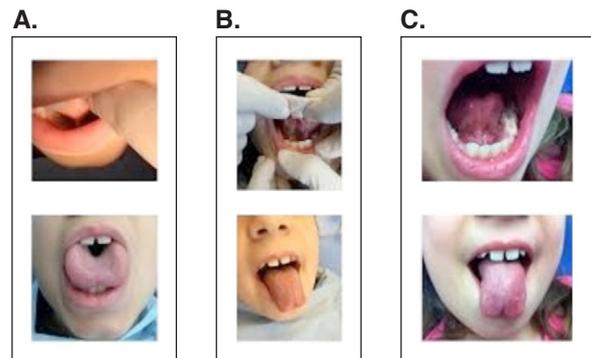


Figure 1. Diode laser in tongue-tie therapy: a patient before treatment (A), immediately after treatment (B) and two months later (C).

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