Comparative study on the effectiveness of myofunctional therapy of the tongue after frenectomy in ankyloglossia

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A Thesis Submitted in Partial Fulfillment of the Requirements
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การศึกษาเปรียบเทียบประสิทธิผลของการบริหารลิ้น ร่วมกับการผ่าตัดเนื้อเยื่อยึดใต้ลิ้นในผู้ป่วยที่มีภาวะลิ้นติด

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ณัฐกานต์ โพธิ์วิจิตร : การศึกษาเปรียบเทียบประสิทธิผลของการบริหารลิ้น ร่วมกับการผ่าตัดเนื้อเยื่อยึดใต้ลิ้นในผู้ป่วยที่มีภาวะลิ้นติด. (Comparative study on the effectiveness of myofunctional therapy of the tongue after frenectomy in ankyloglossia) อ.ที่ปรึกษาหลัก : อ. ทพญ.ดร.บุศนา คะบุศย์

วัตถุประสงค์ของการศึกษานี้คือเปรียบเทียบประสิทธิผลของการบริหารลิ้นต่อการเคลื่อนไหวและการทำงานของลิ้นและอวัยวะที่เกี่ยวข้อง ภายหลังการผ่าตัดเนื้อเยื่อยึดใต้ลิ้นในผู้ป่วยที่มีภาวะลิ้นติด ศึกษาในอาสาสมัคร ๑๕ คน อายุระหว่าง ๑๗ ถึง ๓๖ ปี โดยอาสาสมัคร ๕ คนเป็นกลุ่มควบคุมและอาสาสมัคร ๑๐ คนเป็นผู้ป่วยที่มีภาวะลิ้นติด ซึ่งถูกแบ่งเข้ากลุ่ม ๒ กลุ่มอย่างสุ่มเพื่อรับการรักษา ได้แก่กลุ่มที่ได้รับผ่าตัดเนื้อเยื่อยึดใต้ลิ้นเพียงอย่างเดียว ๕ คน และกลุ่มที่ได้รับผ่าตัดเนื้อเยื่อยึดใต้ลิ้นร่วมกับการบริหารลิ้น ๕ คน โดยจะเริ่มการบริหารลิ้นวันถัดไปหลังจากได้รับการผ่าตัด บริหารวันละ ๓ ครั้ง ตลอด ๓ เดือน การเก็บรวบรวมข้อมูลประกอบด้วย อายุ เพศ ส่วนสูง ดัชนีมวลกาย และพารามิเตอร์ในการวัดลิ้น ได้แก่ Kotlow's free tongue movement, maximal interincisal mouth opening (MIO) , Interincisal mouth opening with tongue tip to maxillary incisive papillae (MOTTIP), tongue range of motion ratio (TRMR), tongue range of motion deficit (TRMD), tongue mobility, maximum tongue elevation pressure และ maximum bite force ผลการศึกษาพบว่า การผ่าตัดเนื้อเยื่อยึดใต้ลิ้นสามารถเพิ่มการเคลื่อนไหวของลิ้นและการทำงานของลิ้นที่เกี่ยวข้องได้ อาสาสมัครกลุ่มที่ได้รับผ่าตัดเนื้อเยื่อยึดใต้ลิ้นร่วมกับการบริหารลิ้น มีค่าพารามิเตอร์ TRMR, TRMD, tongue mobility และ maximum bite force ดีกว่ากลุ่มที่ได้รับการผ่าตัดเพียงอย่างเดียวอย่างมีนัยสำคัญทางสถิติ และแสดงค่า maximum tongue elevation pressure สูงกว่าก่อนได้รับการรักษาอย่างมีนัยสำคัญทางสถิติที่ ๑ สัปดาห์และสูงกว่ากลุ่มปกติที่ ๓ เดือนหลังได้รับการรักษา จึงสามารถสรุปได้ว่าการรักษาภาวะลิ้นติดโดยการผ่าตัดเนื้อเยื่อยึดใต้ลิ้นร่วมกับการบริหารลิ้นจะช่วยเร่งการหายและคงประสิทธิผลของการรักษาได้ดีกว่าการรักษาโดยการผ่าตัดเพียงอย่างเดียว

สาขาวิชา	ศัลยศาสตร์ช่องปากและแม็กซิลโลเฟเชียล	ลายมือชื่อนิสิต .....
ปีการศึกษา	2562	ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

6175812432 : MAJOR ORAL AND MAXILLOFACIAL SURGERY

KEYWORD: Lingual frenulum, Ankyloglossia, Frenectomy, tongue, myofunctional therapy

Nattakarn Povichit : Comparative study on the effectiveness of myofunctional therapy of the tongue after frenectomy in ankyloglossia. Advisor: BOOSANA KABOOSAYA, D.D.S, Ph.D.

Background: This study's objective of was investigate the effectiveness of myotherapy on tongue mobility and tongue function after surgical correction in ankyloglossia.

Method: This study was carried out in 15 subjects assigned to the control group (n=5). The other 10 individuals with ankyloglossia were randomly received frenectomy alone (F; n=5) and frenectomy performed with tongue myofunctional therapy (FM; n=5). Tongue myofunctional therapy was performed 1 day after surgery, and 3 times a day for 3 months. Age, gender, height, weight, IBM, Kotlow's free tongue movement, maximal interincisal mouth opening (MIO), interincisal mouth opening with tongue tip to maxillary incisive papillae (MOTTIP), tongue range of motion ratio (TRMR), tongue range of motion deficit (TRMD), tongue mobility, maximum tongue elevation pressure, and maximum bite force were evaluated.

Results: Frenectomy demonstrated improvement of tongue mobility and function. FM group showed significant improvement of tongue parameters faster than the F group in TRMR, TRMD, tongue mobility, and MBF. Moreover, MTEP of the FM group significantly increased at the 1st-week follow-up ($p<0.05$) and higher than the control group at the 3rd-month follow-up.

Conclusion: The results of this study indicated that lingual frenectomy performed with tongue myofunctional therapy could accelerate and maintaining the treatment results concerning free tongue movement, TRMR, TRMD, tongue mobility, maximum tongue elevation pressure, and maximum bite force.

Field of Study: Oral and Maxillofacial Surgery Student's Signature .....

Academic Year: 2019 Advisor's Signature .....

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Nattakarn Povichit

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CHAPTER I

INTRODUCTION

1.1 Background and Rationale

The tongue is a cardinal organ that affects speech, a position of the teeth, periodontal tissue, nutrition, and swallowing [1]. It consists of striated muscle, adipose tissue, specialized mucosa and a lingual frenulum. The lingual frenulum is a fibro-mucosal fold of mucous membrane that attaches the anterior of the ventral surface of the tongue to the floor of mouth. It is essential in the tongue movements and functions. Orofacial functions can be altered according to the degree of lingual frenulum alteration [2].

The oral cavity of a human develops in the fourth-week embryo. It develops from a smooth-walled tube. The tongue formation occurs at the ventral of the oropharynges, from bilateral tissue buds that grow from the inner surface of the oral tube or the first brachial arch. In that arch, three mesenchymal proliferations, including two laterals (lateral tubercles) and a medial proliferation (impair tubercle), constitute the anterior 2/3 of the tongue. Third, the ventromedial portions of the third and fourth arches proliferation called “copula” or “hypobrachial eminence” become the posterior 1/3 of the tongue. A tenth to eleventh week, the different components fuse posteriorly to anteriorly and separate from the floor of the mouth, causes the permanence depression called “foramen cecum” in adults. The separation of the tongue with the floor of mouth occurs by a combination of tissue growth and programmed morphologic cell death (apoptosis). The persistent lingual frenum is likely a remnant of incomplete apoptosis. This anomaly most commonly occurs alone but sometimes associated with cleft palate due to *TBOX* gene association [3, 4].

Tongue-tie is a nonmedical term for a relatively common physical condition that limits tongue use, which is called ankyloglossia [5]. Before birth, a strong cord of tissue guides the development of oral frenulum, positioned in the center of the mouth. After birth, this lingual frenulum continues to guide the position of erupting teeth. As the child grows, it recedes and becomes thin. Hence ankyloglossia is defined as a developmental anomaly of the tongue characterized by an abnormally short, thick lingual frenum resulting in tongue movement limitation. Otherwise, tongue-tie is present when the lingual frenulum is attached close to the tongue tip, resulting in reduced tongue movement [6].

There is variation in diagnostic criteria, the prevalence of ankyloglossia is 4 to 10% [7], and tongue-tie incidence varies from 0.2% to 5% depending on the population examined. It is more common in males than females with, a ratio of 2.5: 1 [8]. Ankyloglossia in infants has an incidence rate from 25% to 60%, and its presence can lead to difficulty in breastfeeding [7].

Ankyloglossia can rarely associate with any other congenital craniofacial disorders such as Van der Woude syndrome, Smith-Lemli-Opitz syndrome, Orofacial digital syndrome, Beckwith Weidman syndrome or Simpson-Golabi-Behmel syndrome and X-linked cleft palate with the autosomal dominant or recessive trait [9-12].

The shortness of the lingual frenum can affect the physiological posture of the tongue and function. The variations of the lingual frenum can be classified according to different levels of insertion or normal range of free tongue due to Kotlow's classification of tongue-ties [1] (Table 1) or appearance and tongue function 'Hazelbaker assessment tool for the lingual frenum function (HATLFF)' [13] (Table 2).

Table 1. Kotlow's classification of tongue-ties

Type of ankyloglossia	Movement of the tongue
Clinically acceptable, normal range of free tongue movement	>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

Table 2. The Hazelbaker assessment tool for the lingual frenulum function (HATLFF) evaluate five appearance items and seven function items.

Appearance	Function
Appearance of tongue when lifted	Lateralization
2: Round or square	2: Complete
1: Slight cleft in tip apparent	1: Body or tongue but no tongue tip
0: Heart or V-shaped	0: None
Elasticity of frenum	Lift of tongue
2: Very elastic	2: Tip to mid-mouth
1: Moderately elastic	1: Only edge to mid-mouth
0: Little or no elasticity	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	2: Tip over lower lip
1: 1 cm	1: Tip over lower gum only
0: <1 cm	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	2: Complete
1: At tip	1: Moderate of partial
0: Notched tip	0: Little or none
Attachment of lingual frenulum to inferior alveolar ridge	Cupping
2: Attachment to floor of mouth or well below ridge	2: Entire edge, firm cup
1: Attached just below ridge	1: Side edges only, moderate cup
0: Attached at ridge	0: Poor or no cup
	Peristalsis
	2: Complete, anterior or posterior
	1: Partial, originating posterior to tip
	0: None
	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 function score is <11 and appearance score is <8.

The short tongue frenum determined lingual dysfunction, leads to disharmony in the stomatognathic system by changing the relationship between the bone and stability of the front and rear control. It causes abnormal stresses on the hyoid bone and cervical and postural problems [14]. Complications reported historically for frenotomy and frenectomy are few and include infection, excessive bleeding, 'tongue swallowing' due to excessive tongue mobility [15-17]. The most common frenectomy failures are a high risk of reoccurrence due to hypertrophic scarring [18, 19]. Many surgery techniques evolved to solve this condition.

Orofacial myofunctional therapy (OMT) or myofunctional therapy (MFT) is a neuromuscular re-education program of the orofacial muscles developed to correct abnormal positions to new neuromuscular pattern and proper resting postures. Orofacial myofunctional therapy helps in the normalization of the developing or advanced craniofacial structures and functions due to behavioral modification using isotonic and isometric exercises. Various muscles such as masticatory muscle, facial muscle, the tongue were formed, balanced, and stabilized. Moreover, myofunctional therapy associated with the improvement of the resting position of the tongue [20].

Since myofunctional therapy associated with the improvement of neuromuscular pattern, myofunctional therapy may improve the results of ankyloglossia treatment. No study was carried out to investigate whether this combination is truly capable of achieving better outcomes regarding tongue mobility and masticatory function in ankyloglossia.

1.2 Conceptual framework

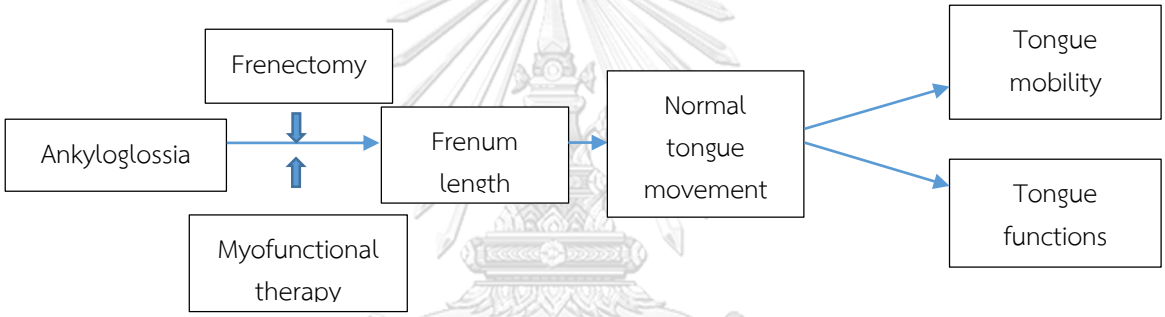


Figure 1. Conceptual framework

Keyword : Lingual frenulum, Myofunctional therapy, Tongue, Frenectomy

1.3 Research question

Is frenectomy performed with myofunctional therapy improve the tongue mobility and tongue function more than frenectomy alone?

1.4 Research hypothesis

Frenectomy performed with myofunctional therapy improve tongue mobility and tongue function more than frenectomy alone.

1.5 Research objectives

1. To investigate the effects of myotherapy on tongue mobility and tongue function in patient after surgical correction of ankyloglossia

2. To compare the improvement of tongue mobility and tongue function in frenectomy performed with myofunctional therapy with frenectomy alone.

1.6 Expected benefit

The results from this study may provide information for the dentists in choosing an appropriate treatment plan and generate myofunctional therapy protocol to reach better quality of care for ankyloglossia patients.

CHAPTER II

REVIEW OF RELATED LITERATURES

2.1 Tongue

The tongue is composed of eight muscles, four intrinsic muscles and four extrinsic muscles [21]. Intrinsic muscles originate and insert within the tongue and have no bony attachments. The superior longitudinal muscle runs on the dorsal surface of the tongue along the length, base to apex. Contraction of the superior longitudinal muscle shortens the tongue and also dorsiflexes the tip of the tongue. The Inferior longitudinal muscle runs along the length of the ventral surface of the tongue. The action of the Inferior longitudinal is tongue shortening and ventroflexion. The transverse muscle stretches horizontally from the medial septum to the lateral border. The action of the transverse is to narrow the tongue, thereby simultaneously elongating of the tongue body. The vertical muscle spans vertically from ventral to dorsal sides. The action of the vertical muscle is to flatten the tongue and increasing its width [22]. These muscles are named for their orientation in the body and merely control the tongue's shape [23].

The extrinsic muscles of the tongue are important in the movements of the tongue [24]. A fan-shaped genioglossus muscle origin is the genial tubercles. Its insertion is on both the hyoid muscle and along most of the ventral surface of the tongue. The genioglossus helps with a protrusion and partially depressing the tongue. The hyoglossus originates from the hyoid bone and inserts into the lateral borders of the tongue. This muscle assists in depression and retrusion of the tongue. The styloglossus originates from the styloid process of the temporal bone and inserts at two points, one near the apex of the tongue and the other near the base of the tongue. The action of this muscle is retrusion and elevation of the lateral margin of the tongue. Lastly, the palatoglossus muscle originates from the median palatine raphe and inserts into the lateral borders of the tongue. This muscle raises and seals the tongue to the soft palate during the swallowing [22].

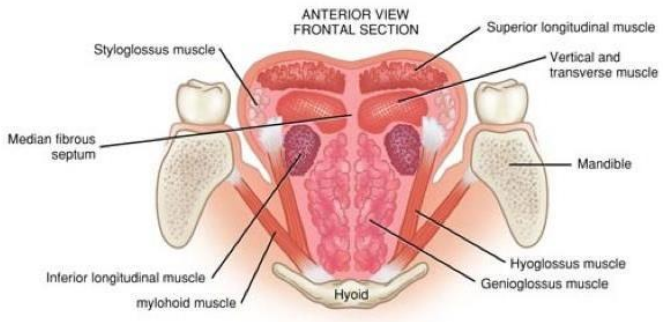


Figure 2. Intrinsic muscle of the tongue

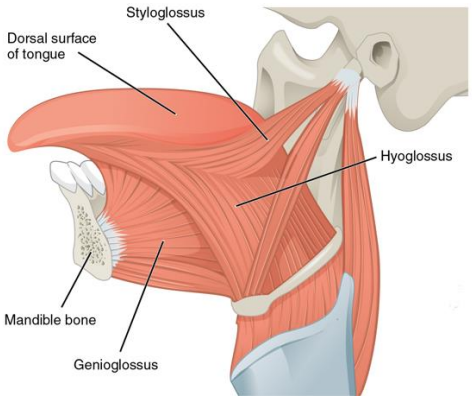


Figure 3. Extrinsic muscle of the tongue

2.2 Relation of tongue and occlusion

Ankyloglossia causes a lingual dysfunction, especially in the sagittal plane in types of malocclusion development related to the length of frenum and the neuromuscular function. Studies were reporting contrasting results about the relationship between ankyloglossia and occlusion anomalies. Ankyloglossia patients had low tongue posture. There was a posteroinferior movement of the tongue that created forward and downward pressure to the mandible, inducing a clockwise rotational mandible and increased lower anterior face height [25]. Moreover, the study of Meenakshi & Jagannathan described that restricted tongue movement resulted in inadequate lingual expansion force, interrupted balance between buccal and lingual musculature [26].

Tuerk and Lubit (1959) reported that Angle's class III malocclusion and open bite patients would be presented with ankyloglossia and infantile swallowing pattern. Moreover, Mukai et al. (1993) reported that 84% of ankyloglossia patients have Angle's class III malocclusion with irregular tooth alignment and high palatal vault [27]. R Ruffoli et al. (2005) found 61.5% of bite anomalies patient-related with ankyloglossia[28]. Because of low tongue posture and ankyloglossia, the protrusive chin may be considered a result of either maxillary hypo-development or mandibular hyper-development [25, 29].

Figure 4. Ankyloglossia patients has Angle's class III malocclusion with irregular tooth alignment a high palatal vault [27]

The theory could describe by the centrifugal and centripetal forces which developed occlusion and its characteristics. In case of tongue-tie, the tongue has a low position. It also interposes between the anterior teeth that prevent the contact, together with a hypertonic lip seal, resulting in an open bite. On the other hand, if the lip seal is hypotonic or associated with hypo-development of the mandible, the occlusion can be Class II malocclusion with a first or second division. In other situations, the low tongue position which there is not the expansive force from the tongue and the excessive development of mandible, Class III malocclusion may appear [30].

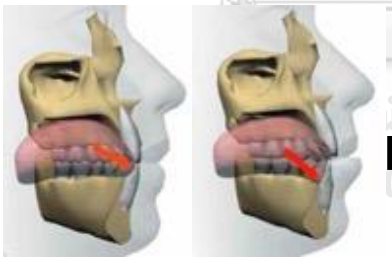


Figure 5. Low tongue position and Very low tongue position

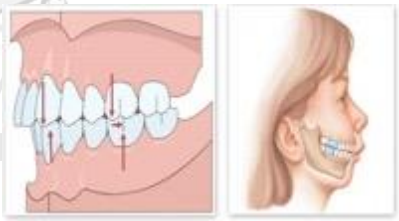


Figure 6. Class II Malocclusion

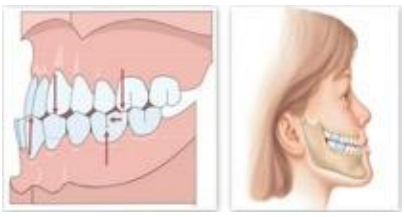


Figure 7. Class III Malocclusion

Moreover, the association between swallowing abnormalities with ankyloglossia, the babies swallowing is an infantile pattern and turns into a mature pattern in 2-4 years old [31]. Infantile swallowing pattern in adults might be due to the inability to elevate the tongue. Moreover, infantile swallowing patterns in adults affect the occlusion such as anterior open bite and deep bite, commonly related to ankyloglossia. Concerning speech impairment due to tongue-tie, restricted tongue mobility slightly affects speech articulation on particular phonemes [32]. In children with ankyloglossia, Messner and Lalakea (2002) found errors in articulating formal speech associated with limit tongue mobility[30]. R Ruffoli (2005) found a relationship between the presence of speech anomalies and a decreased mobility of the tongue, but only in moderate or severe levels of ankyloglossia which depends on the modality of frenulum insertion [28].

2.3 Relation of tongue and stomatognathic system

Fletcher SG (1968) described that the tongue is an organ that able to compensate in spaces, for example, to reduce its cross-sectional diameter, to increase a longitudinal one, to fill edentulous spaces, and to develop the palate asymmetrically 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

The short tongue frenum causes abnormal stresses on the hyoid bone and cervical and postural problems [14]. The tongue physiological fills all the oral cavity, and the tip of the tongue is the most crucial area for a correct position. After deciduous teeth eruption, the apex of the tongue contact with the palatal papilla, while the structures support the edges in the oral cavity. There is no contact between the teeth; the atlanto-occipital joint has a good posture, which leads to normal nasal breathing. When the tongue is in the appropriate position, the rear control, cervical kyphosis, and the front control or the lip seal, are not deficient. On the other hand, when the frenum is short, normal anatomical rapports cannot establish, so the anatomical deficiency becomes also a functional problem; this issue generates other anatomical problems related to the short frenum [33].

Daniela GDA. Prado [34] reported that the orofacial myofunctional therapy provides an improvement in aspects related to the maximum score of the Expanded protocol of orofacial myofunctional evaluation (OMES-E), masticatory type, lower lip tone and tongue mobility in the patient after orthognathic surgery. W. Bigenzahn et al. [35] reported that myofunctional therapy is highly significant in correcting myofunctional disorders, orofacial muscle imbalance and eliminating speech disorders in articulations of teeth and tongue.

The relationships and interrelationships in the stomatognathic system between primary function (respiration, mastication and swallowing), secondary functions, dysfunctions, parafunctions and the masticatory system as well as the possible therapeutic measure (NMS=Neuromuscular systems; TMJ=temporomandibular joint; ENT=ear-nose-throat; At=adenotomy; Te=tonsillectomy)as shown in Figure 8.

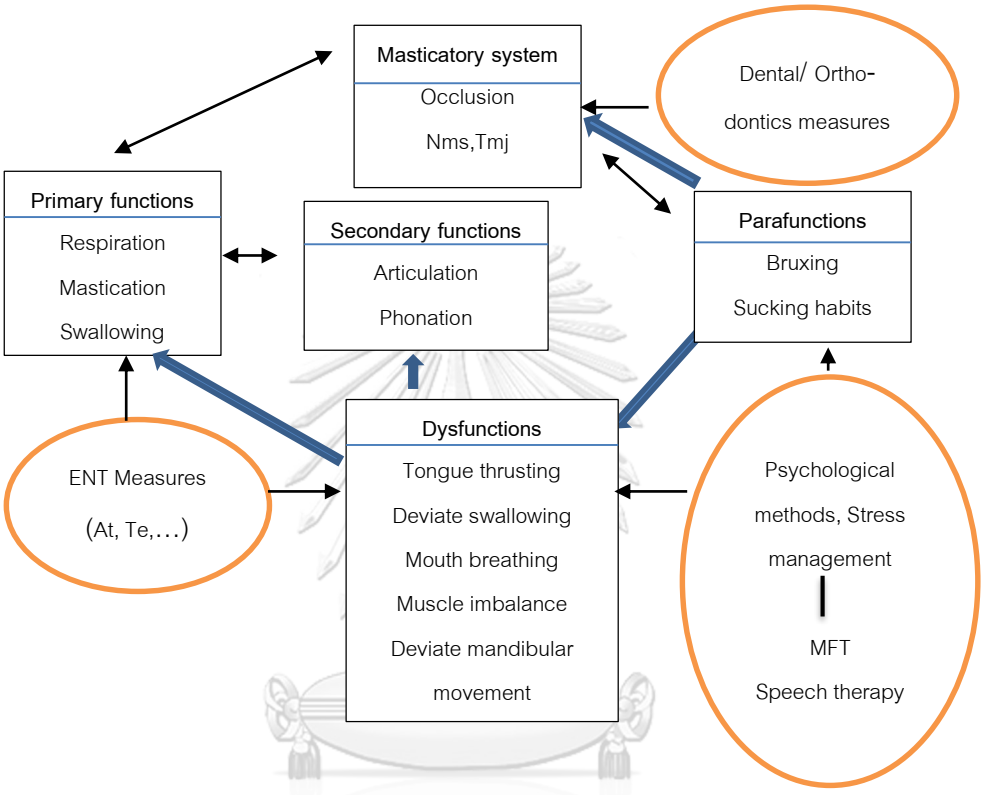


Figure 8. Relationships (↑) and interrelationships (↔) in the stomatognathic system between primary functions, secondary functions, dysfunctions, parafunctions and the masticatory system

2.4 Frenectomy

The procedure releases the tongue, solves a limited range of motion in the tongue, prevents improper function such as eating, swallowing and speaking. The treatment options used to correct ankyloglossia are frenuloplasty frenectomy and frenotomy with the use of one hemostat, two hemostats, a groove director or laser. Frenectomy defines the complete removal of the frenum, including its attachment to the underlying bone, while frenotomy is the incision and the relocation of the frenal attachment [36]. Frenectomy can be accomplished by the conventional scalpel technique, electrosurgery or by using lasers. Functional and aesthetic results depend on proper technique selection and considerations of the regular adverse event, such as, bleeding and patient compliance [37].

Complications reported historically for frenotomy and frenectomy are few and include infection, excessive bleeding, 'tongue swallowing' due to excessive tongue mobility [15-17] and most common frenectomy failures are a high risk of reoccurrence due to hypertrophic scarring [18, 19]. Many surgery techniques evolved to solve this condition. A technique Z-Frenuloplasty, a soft tissue surgery, is used to lengthen a frenum. It works best when used for hypertrophic thick frenula with low insertion and a shallow sulcus [19]. A study by Heller et al. 2005 [38] compared the treatment outcome for Z-frenuloplasty and the traditional horizontal to vertical frenuloplasty in the management of ankyloglossia. The results revealed the Z-frenuloplasty to be a more superior technique, showing improved frenum length and tongue protrusion. Furthermore, underwent the Z-frenuloplasty showed improvement in speech compared the horizontal-to-vertical frenuloplasty [39].

2.5 Orofacial myofunctional therapy (OMT)

In 1939, Alfred Rogers believed that suitable oral muscular function needed to be established through exercises, rather than acceptable occlusion. So, Rogers was credited with being the originator of OMT [40]. These exercises were used as a combination for orthodontic treatment termed 'Myofunctional Therapy' [41]. In 1960s, Walter Straub was summarized in a series of articles published in the American Journal of Orthodontics. He proposed that incorrect tongue function and some behaviors, for example infant bottle-feeding, improper leaning and sleeping habits were the primary causes of malocclusion.

Then, in the 1970s, Walter Straub et al. [42, 43] was the first to recommend a therapeutic routine for nighttime sleeping consisting of keeping the lips together and the tongue upon the palate to solve malfunctions of the tongue and abnormal swallowing habits and their relationship to orthodontics and speech. They thought a major cause of oral problems was bottle-feeding. Then, in the 1980s, Garliner, D. [44, 45] created a university program for speech pathologists centered on treating orofacial myofunctional disorders. Techniques for reeducation of the orofacial muscles were published in French in the 1990s [46]. Then, the series of randomized control trials [47-49] investigating the role of oropharyngeal exercises, speech therapy, myofascial reeducation and oronasal rehabilitation for adults and children with sleep-disordered were released. Furthermore, series of meta-analysis about myofunctional therapy to treat obstructive sleep apnea & snoring [50, 51] were published. Nowadays, continuing myofunctional therapy studies were in attentions within dental and medical communities.

Márcio Alexandre Homem et al. (2014) published the systematic review demonstrating the effectiveness of orofacial myofunctional therapy (OMT) as an adjuvant to orthodontic treatment in orofacial disorders [20]. New proprioceptive schemes of patients after orthognathic surgery must be acquired. Soft tissue structures may perform their functions properly. OMTs are based on the 10 principles of neuroplasticity. Neuroplasticity means the brain's ability to change, following physiologic or pathologic input, generating an adaptive response. These principles

include ‘use it or lose it’, which means the brain will decrease the useless muscles [52]. Secondly, ‘use it and improve it’ means improve a function through repetition, metacognition, and awareness [47]. Third, ‘plasticity is experience specific’ means target hypofunctional muscles, for example, protocols for sleep disorders will target the soft palate, tongue, and pharyngeal walls [47]. The next is “practice”; that creates, maintains, and expands new neural areas corresponding to the new behavior. Then, intensity, time, age and saliency are also important in OMT [53]. Moreover, transference or the co-occurrence of multiple functions when an overlapping one has been established. When the patient breathes well through the nose, other functions can now easily occur such as tongue repositioning or lip seal and ‘interference’ or neurologically interfere by the old behavior, to continue repeating the new behavior [54].

2.6 Orofacial myofunctional therapy (OMT) and Ankyloglossia

Most evidence-based information for the treatment of ankyloglossia that was published on this topic was also limited. The benefits of treatment combination are attributed to improving the tongue and oral functions. Ferrés-Amat, E., et al. 2015 [55] reported the management of ankyloglossia and breastfeeding difficulties in the newborn. The managements are breastfeeding sessions, myofunctional stimulation and the lingual frenotomy. The myofunctional stimulation in this research included the extraoral stimulation exercises aimed to stimulate the masseter muscle by putting pressure with the thumb and index fingers in a circular motion in the masseter muscle area and stimulating the rooting reflex in the perioral region by gently moving the lip forward. The intraoral exercises aimed to stimulate the sucking reflex by touching the tip of the tongue and the incisive papilla. The myofunctional stimulation was recommended to carry out a minimum of 3 times a day, repeating it 6 times on each occasion and recommended to do before the feeds. The baby has more appetite and is more likely to be cooperative. The result was very favorable. Two months post-operative check-up, the nipple pain reduced to 0 (from 10 VAS scale), and the newborn's weight continued to increase by 200 grams weekly and the time of the feeds reduced 75%.

Another, Ferrés-Amat, E., et al. published in 2016 [56], also reported the effect of frenectomy and lingualplasty compared with rehabilitation service in 4-14 years old patients. The writer proposed an orofacial rehabilitation protocol, began one week before surgery. The treatment results showed that rehabilitation exercises improved lingual mobility and improved degree of ankyloglossia, although there was some postoperative complication in 6% of the participants: tongue bites, hemorrhage and infections. Nevertheless, none of these were severe. Moreover, Zaghi et al.’s retrospective study demonstrated 420 patients treated with myofunctional therapy and lingual frenuloplasty for indications of mouth breathing, snoring, dental clenching, and/or myofascial tension [57]. The results were 91% of satisfaction rate and 87% rate of improvement in quality of life through amelioration of mouth breathing (78.4%), snoring (72.9%), clenching (91.0%), and/or myofascial tension (77.5%). Even though, minor

complications occurred in <5% of cases, including complaints of prolonged pain or bleeding, temporary numbness of the tongue-tip, salivary gland issues, minor wound infection or inflammation, and need for revision excise scar tissue. In addition, orofacial myofunctional treatment in children with anterior open bite and tongue dysfunction demonstrated a significantly improved in tongue elevation strength, tongue posture at rest, and tongue position during swallowing [58].

CHAPTER III

RESEARCH METHODOLOGY

This study was a randomized controlled clinical trial to compare the effectiveness of myofunctional therapy of the tongue after frenectomy in ankyloglossia conducted at the Department of Oral and Maxillofacial Surgery between March 2019 to May 2020.

3.1 Ethical approval

This research project was approved by the Human Research Ethics Committee of the Faculty of Dentistry, Chulalongkorn University, in compliance with the ICH/GCP no.084/2019. Informed consent was obtained from all subjects before the experiment.

3.2 Study design and subjects

The sample size calculation referred from the studies of Jang et al., 2011 [59], using G*Power 3.1.9.2 program, the effect size was 0.8055364, Power was 0.8. Then, the sample size calculation was 15.

Ankyloglossia was classified using the free tongue movement (Kotlow's measurement; the normal range of free tongue movement (greater than 16 mm.), Class I (12-16 mm.), Class II (8-11 mm.), Class III (3-7 mm.) and Class IV (less than 3 mm) [1]. The subjects who had been categorized to normal or Class I were put into control group (n=5). The subjects who had been categorized to Class II, III, IV were ankyloglossia, which was divided randomly into group F (frenectomy alone, n=5) and group FM (frenectomy performed with myofunctional therapy, n=5).

3.2.1 Inclusion criteria

- Age between 20-50 years old
- Visceral swallowing pattern
- Normal occlusion or Angle Class I malocclusion
- Healthy patient (ASA Class I, II), no severe systemic disease
- Occlusal stability
- The patients had teeth 11 and 41 or 21 and 31

3.2.2 Exclusion criteria

- Sucking habits not ceased for at least 6 months
- History of myofunctional therapy

- Previous facial surgery or craniofacial trauma
- Previous orthodontic treatment
- Angle Class II or III malocclusion
- Mental retardation or psychiatric problem
- Orofacial congenital deformities or orofacial syndromes
- Muscular or connective tissue disorders
- Macroglossia defines as hypertrophy or hyperplasia of the tongue muscles that protrudes beyond the teeth or alveolar ridge in resting tongue position
- Respiratory disease such as Obstructed nasal airway
- Noncooperative patient, patient unable to follow-up or loss to follow-up and patient who done Tongue myofunctional therapy less than 80%
- Difficulty in mouth opening such as temporomandibular joint disorders
- Xerostomia
- Operative time was longer than 1 hour

3.3 Surgical technique

The surgical treatment of ankyloglossia (group F and group FM) was performed by conventional frenectomy by one surgeon using the scalpel. The local infiltration was performed under local anesthesia 2% Mepivacaine with 1:100,000 epinephrine. The surgical technique used one hemostats approach. The straight hemostats were placed against the tissues facing the ventral surface of the tongue, over the superior aspects of the frenum with their tips meeting in the profound aspect near the base of the tongue. The incision was made following the hemostats with a #15 blade. Blunt dissection of the frenum until the tongue reaches the vermillion border of the lower lip. Then, fiber remnants were excised. The wound was careful haemostasis and sutured the wound with Vicryl suture 5-0. The postoperative period to follow was 7 days after frenectomy [37, 60].

3.4 Orofacial myofunctional therapy (OMT) [61]

The group FM participants underwent a program of myofunctional therapy of the tongue and were thoroughly instructed to perform exercises at home by another assistant. In this protocol, all the 3 tongue exercises began 1 day after surgery and done 3 times a day, in the morning, noon and evening. Moreover, patients received the checklist notebook that contains a tongue myofunctional therapy guideline and personal checklist record for each day. An evaluation was performed by one blinded independent observer at baseline (T0), at 1st week (T1), 2nd week (T2), 1st month (T3), 3rd month (T4) after frenectomy.

Palate scrapes: Bring the tip of the tongue touch the anterior palate, then pull it back as much as possible and hold for 5 seconds; do it 5 times.

Elephant swing: Open the mouth and reach the tongue forward, then move it to the left and right corner of the lip; do it 5 times.
Tongue click: Elevate the tip of the tongue to touch the anterior palate like sucking with the palate, then clatter down with 'click' sound; do it 15 times.

3.5 Tongue Assessments

3.5.1 Free tongue movement (mm) [1]

Free tongue movement was measured by Vernier caliper, from the base of lingual frenum to the tip of the tongue. The values were classified into 5 groups; the normal range of free tongue movement (greater than 16 mm.), Class I (12-16 mm.), Class II (8-11 mm.), Class III (3-7 mm.) and Class IV (less than 3 mm.) (Figure 9).

Figure 9. Free tongue movement measurement

3.5.2 Maximal interincisal mouth opening (MIO; mm) [62]

A ruler measured the Maximal interincisal mouth opening (MIO). The patients were instructed to open mouth to the maximum. They were recorded the scale from the incisal edge of tooth 11 to tooth 41, or the incisal edge of tooth 21 to tooth 31 in case of the patient had no tooth 11 and 41, or tooth 11 and 41 were crowding/unrepeatable (Figure 10).

3.5.3 Interincisal mouth opening with tongue tip to maxillary incisive papillae (MOTTIP; mm) [62]

A ruler measured MOTTIP. All patients were instructed to touch the tongue behind the upper front two teeth during open their mouth and recorded the scale from the incisal edge of tooth 11 to tooth 41, or the incisal edge of tooth 21 to tooth 31 in case of the patients have no tooth 11 and 41, or tooth 11 and 41 were crowding/unrepeatable (Figure 11).

3.5.3.1 Tongue range of motion ratio (TRMR; %) [62]

TRMR was defined as the MOTTIP divided by MIO.

3.5.3.2 Tongue range of motion deficit (TRMD; mm) [62]

TRMD was defined as different between MIO and MOTTIP.

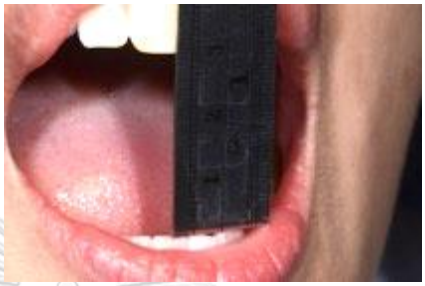


Figure 10. Maximal interincisal mouth opening (MIO)

Figure 11. Interincisal mouth opening with tongue tip to maxillary incisive papillae (MIOTTIP)

3.5.4 Tongue mobility [63]

Tongue mobility test was used to evaluate and descript tongue mobility measuring in 7 aspects; protrude and retract, touch the upper lip with the apex, touch the right and left labial commissures, touch the upper and lower molars, vibrate the tip of the tongue and sucking the tongue against the palate. Tongue mobility test was done before frenectomy and 3 months after frenectomy, for 3 times per each aspect, and an average result was described. The best result was 0, and the worse result was 14 (Table 3).

Table 3. Tongue mobility test

	Successful	**Partially successful**	**Unsuccessful**
Protrude and retract	0	1	2

Touch the upper lip with the apex	0	1	2
Touch the right commissura labiorum	0	1	2
Touch the left commissura labiorum	0	1	2
Touch upper and lower molars	0	1	2
Apex vibration	0	1	2
Sucking against the palate	0	1	2

3.5.5 The maximum tongue elevation pressure (kPa)

The maximum tongue elevation pressure was measured using a tongue pressure measurement device (JMS tongue pressure device*)(Figure 12)[64]. The balloon was positioned on the anterior part of the participant's palate, with the lips closed. The participants raised their tongue and compressed the balloon onto the palate with the maximal voluntary muscular effort for approximately 7 seconds (Figure 13). The values were recorded 3 times, with intervals of more than 30 seconds for rest, or mouth rinsing if requested. An average result was described.

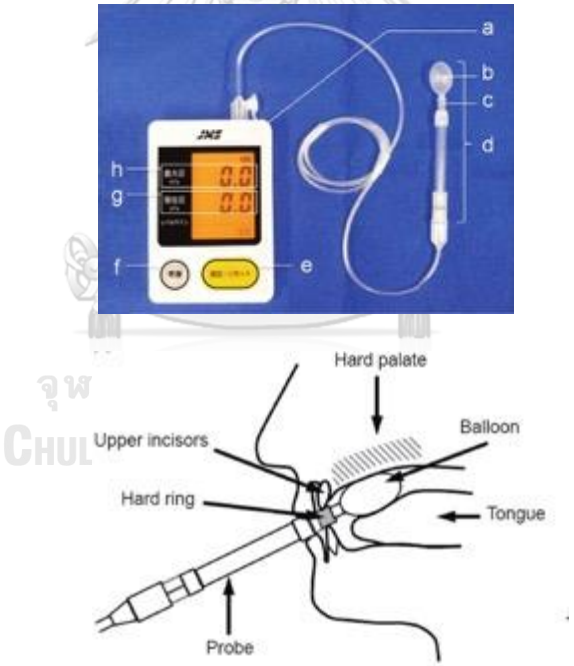


Figure 12. A balloon-based tongue pressure measurement device (JMS tongue pressure measurement device ®): (a) Digital tongue pressure measurement device; (b) Balloon (width: 18 mm, height: 25 mm); (c) Plastic pipe (width: 6 mm, height: 10 mm); (d) Disposable probe; (e) Measurement/reset; (f) Power; (g) Present pressure; (h) Maximum pressure

Figure 13. A balloon-based tongue pressure measurement

3.5.6 Mixing ability [65]

Mixing ability was evaluated using a color changeable chewing gum (Masticatory Performance Evaluating Gum Xylitol)(Figure 14). The participants were instructed to chew the chewing gum, using 60 chewing cycles, at a chewing rhythm once per second. Participants were instructed to chew the gum on the right, left or both sides, depending on their preference (habitual chewing). The chewed gum was flattened to a thickness of 1.5 mm by compression between two glass slab and photographed immediately in natural light at the Dental surgery clinic. The chewed gum photograph was examined the intermediate colors based on a Visual chart of color-changeable chewing gum (Figure 15) [66] by two independent observers.

Figure 14. Color-changeable chewing gum

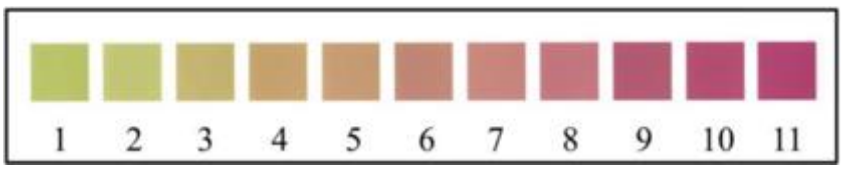


Figure 15. Visual chart of color-changeable chewing gum

3.5.7 Maximum bite force (kg.m/s^2)

The maximum bite force was assessed by occlusal force meter GM10 (Figure 16). This device determined the amount of force applied by an individual at the time of the bite. Participants performed 3 bites on each left, central incisor, and right first molar (Figure 17 and 18). An average result was described [67].

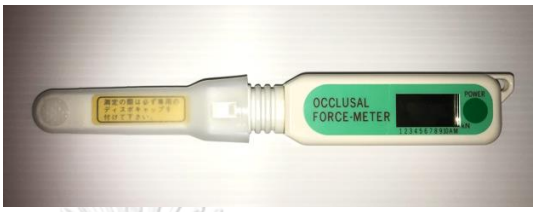


Figure 16. Occlusal force-meter GM10

Figure 17. Maximum bite force measurement

Figure 18. Maximum bite force measurement

3.5.8 Method errors [59]

The reliability of the lingual frenulum measurement was assessed on 20 randomly selected adults not included in this study. The same methods as in the present investigation; Free tongue movement, Maximal interincisal mouth opening (MIO) and Interincisal mouth opening with tongue tip to maxillary incisive papillae (MOTTIP)

were determined at intervals of 14 days by the same examiner. Testing for all measurements's method error was done with Dahlberg's formula13 (method error = $\frac{\sqrt{\sum d^2}}{2n}$ where d was the difference between 2 measurements of a pair, and n was the number of subjects).

The method error of the measurements calculated with Dahlberg's formula was found to be 3.99 mm for Kotlow's free tongue movement, 3.11 mm for MIO, respectively. The intra-class correlation coefficients (ICC) were calculated for MIO (.976; 95% CI = .873-.996), MTEP (.978; 95% CI = .876-.996)

3.6 Statistical Analysis

The descriptive statistics consisted of the frequencies and percentages. The assumption of normality was assessed using the Shapiro–Wilks test. Free tongue movement, TRMR, TRMD, tongue mobility, maximum tongue elevation pressure, mixing ability and maximum bite force were assessed using the Kruskal-Wallis test for the intergroup difference. Time-dependent intragroup data were analyzed using the Wilcoxon sign rank test. The categorical variables between groups were analyzed using the Chi-square test. Data were reported as mean ± SD. All analyses were set at *P* values of < 0.05 considered statistically significant and performed using IBM SPSS Statistics version 22 (IBM Japan, Tokyo, Japan).

CHAPTER IV

RESULTS

4.1 Demographic data

A total of 15 subjects (60% male, 40% female) were recruited with ages ranging from 17 to 36. The general information of participants was shown in Table 4. There were no differences in age, gender, weight, height, BMI, Number of teeth, Number of Posterior teeth and operative time among control, group F, and group FM.

*Table 4. Demographic data of the patients (*p-value < 0.05) Intergroup comparison*

	All	Control	Group F	Group FM	*p*-value
Age (mean±SD)	23.4±4.6	22.6±1.1	21.6±1.7	26.0±2.9	0.145
Gender (n,%)					
Male	9, 60%	1, 11.1%	4, 44.4%	4,44.4%	0.097
Female	6, 40%	4, 66.7%	1, 16.7 %	1,16.7%	
Weight and Height (mean±SD)					
Weight(kg.)	62.3±11.7	57.6±5.1	68.4±6.7	60.8±3.0	0.349
Height(cm.)	167.1±8.9	164.4±9.4	171.2±8.3	165.6±9.3	0.472
BMI	22.3±4.1	21.3±1.6	23.3±2.1	22.4±2	0.827
Number of Teeth	26.8±2.2	28.0±0.0	27.2±1.8	25.2±1.3	0.114
Number of Posterior teeth	15.0±2.2	16.0±0.0	15.2±1.8	13.8±1.4	0.291
Operative time(mins.)	24.0±17.9	-	36.2±3.6	35.8±2.7	0.915

4.2 Tongue parameters correlation

The correlations of evaluating factors were found. There was a significant correlation coefficient between gender and height (r_s = 0.806, p<0.05), gender with free tongue movement (r_s = 0.568, p<0.05) and tongue mobility (r_s = 0.535, p<0.05). Additionally, maximum tongue pressure was significantly correlated with age (r_s = 0.530, p<0.05) (Table 5).

The study indicated significant correlations among tongue parameters; free tongue movement with tongue mobility (r_s = 0.940, p<0.01),TRMR (r_s = 0.880, p<0.01), TRMD (r_s = -0.683, p<0.01), tongue mobility with TRMR (r_s= 0.927, p<0.01), and TRMD (r_s = 0.756, p<0.01). Moreover, the significant correlations were found among TRMR with TRMD (r_s = 0.761, p<0.01), mixing ability with MIO (r_s = 0.761, p<0.01), anterior maximum bite force with left maximum bite force (r_s = 0.514, p<0.05) and anterior maximum bite force with right maximum bite force (r_s = 0.618, p<0.05) (Table 6).

Table 5. Correlations among evaluation factors

		Height	Free tongue movement	Tongue mobility	Maximum tongue pressure
Gender	Correlation coefficient	0.806	0.568	0.535	-0.283
	p-value	0.000**	0.027*	0.040*	0.306
Age	Correlation coefficient	0.018	0.295	0.122	0.530
	p-value	0.951	0.286	0.665	0.042*

*Correlation is significant at the .05 level (2-tailed), **Correlation is significant at the .01 level (2-tailed)

Table 6. Correlations among evaluating factors

		Free tongue movement	Tongue mobility	TRMR	TRMD	Maximal interincisal mouth opening (MIO)	Mixing ability	Left maximum bite force	Anterior maximum bite force	Right maximum bite force
Free tongue movement	Correlation coefficient	1.000	0.940	0.880	-0.683	0.105	-0.100	-0.186	0.166	-0.038
	p-value	.	0.000**	0.000**	0.005**	0.711	0.724	0.507	0.553	0.894
Tongue mobility	Correlation coefficient	0.940	1.000	0.927	-0.756	0.056	-0.110	-0.289	0.05	-0.070
	p-value	0.000**	.	0.000**	0.001**	0.844	0.697	0.297	0.861	0.805
TRMR	Correlation coefficient	0.880	0.927	1.000	-0.761	0.118	-0.219	-0.182	-0.018	0.025
	p-value	0.000**	0.000**	.	0.001**	0.676	0.433	0.516	0.950	0.930
TRMD	Correlation coefficient	-0.683	-0.756	-0.761	1.000	-0.136	-0.215	0.154	-0.054	-0.207

	p-value	0.005**	0.001**	0.001**	.	0.630	0.441	0.585	0.850	0.459
Maximal interincisal mouth opening (MIO)	Correlation coefficient	0.105	0.056	0.277	0.173	1.000	-0.761	0.086	-0.083	0.076
	p-value	0.711	0.844	0.318	0.538	.	0.001**	0.760	0.769	0.789
Mixing ability	Correlation coefficient	-0.100	-0.110	-0.219	-0.215	-0.761	1.000	-0.051	0.118	0.047
	p-value	0.724	0.697	0.433	0.441	0.001**	.	0.858	0.677	0.868
Left maximum bite force	Correlation coefficient	-0.186	-0.289	-0.182	0.154	0.086	-0.051	1.000	0.514	0.618
	p-value	0.507	0.297	0.516	0.585	0.760	0.858	.	0.05*	0.014*
Anterior maximum bite force	Correlation coefficient	0.166	0.05	-0.018	-0.054	-0.083	0.118	0.514	1.000	0.500
	p-value	0.553	0.861	0.950	0.850	0.769	0.677	0.05*	.	0.058
Right maximum bite force	Correlation coefficient	-0.038	-0.070	0.025	-0.207	0.076	0.047	0.618	0.500	1.000
	p-value	0.894	0.805	0.930	0.459	0.789	0.868	0.014*	0.058	.

*Correlation is significant at the .05 level (2-tailed), **Correlation is significant at the .01 level (2-tailed)

4.3 Tongue parameters comparison

4.3.1 Free tongue movement

The pre-operative free tongue movement of ankyloglossia was significantly lower than the control ($p<0.01$). At 3rd -month after frenectomy, the value significantly increased ($p<0.05$) but not as reached as the control group and had no difference between group F and group FM (Table 7 and Table 8).

Table 7. Free tongue movement (Intragroup comparisons)

	Pre-operative visit	3 months Post-operative visit	Total Mean ± SD	Z	p-value
Group	Mean ± SD	Mean ± SD			
Control	30.8 ± 6.03	30.8 ± 6.03	30.8 ± 6.03	0.00	1.000
F	13.0 ± 4.85	29.1 ± 3.81	21.05 ± 4.33	-2.023	0.043*
FM	12.8 ± 7.03	25.2 ± 7.57	19.0 ± 7.3	-2.023	0.043*

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

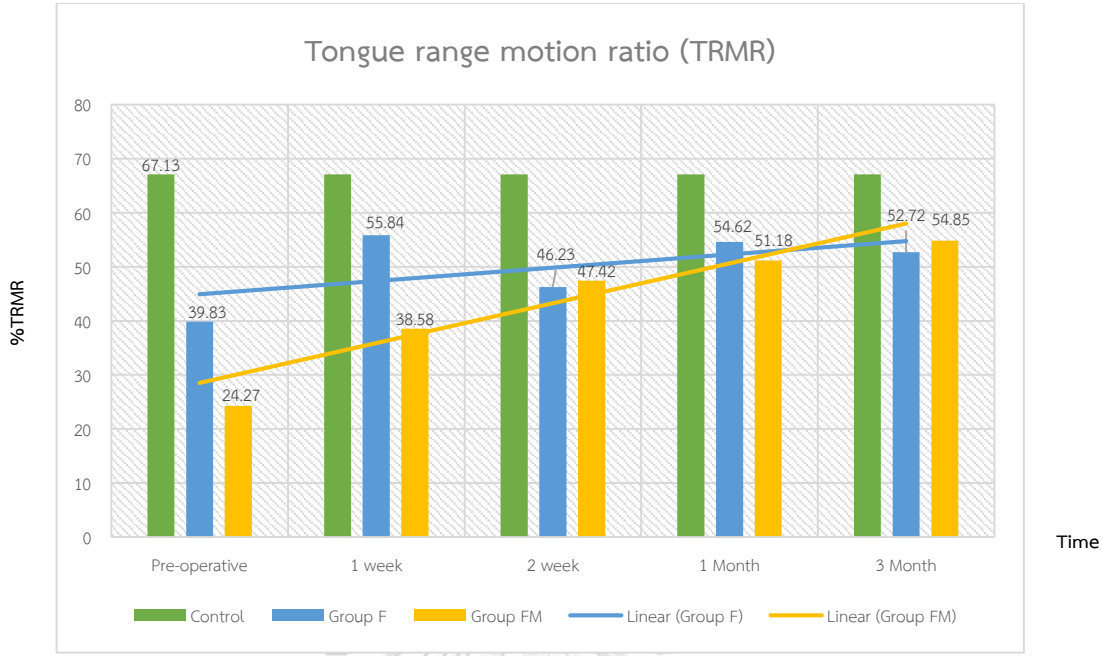
Table 8. Free tongue movement (Intergroup comparisons)

	Pre-operative visit	p-value	3 months Post-operative visit	p-value
Group	Mean ± SD		Mean ± SD	
Control	30.8 ± 6.03	0.009**	30.8 ± 6.03	0.834
F	13.0 ± 4.85	0.009** / 0.753	29.1 ± 3.81	0.347 / 0.753
FM	12.8 ± 7.03		25.2 ± 7.57	
Total Mean ± SD	18.87 ± 10.37		28.37 ± 6.07	
p-value	0.009*		0.716	

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

4.3.2 Tongue range motion ratio (TRMR)

TRMR of the control group significantly higher than ankyloglossia. After frenectomy, TRMR of group F significantly increased at 1st-week follow-up ($p<0.05$), then dropped at 2nd-week and significantly lifted back again at 1st-month follow-up ($p<0.05$). Meanwhile, TRMR of group FM continuously increased and significantly different with pre-operative value since 2nd-week follow-up ($p<0.05$) (Figure 19).



*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Figure 19. Tongue range motion ratio (TRMR)

Table 9. Tongue range motion ratio (TRMR) (Group F Intragroup comparisons)

	TRMR1wk - TRMR	TRMR2wk - TRMR	TRMR1M – TRMR	TRMR3M – TRMR
Z	-2.023	-1.483	-2.023	-1.753
p-value	0.043*	0.138	0.043*	0.080

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Table 10. Tongue range motion ratio (TRMR) (Group FM Intragroup comparisons)

	TRMR1wk - TRMR	TRMR2wk - TRMR	TRMR1M - TRMR	TRMR3M - TRMR
Z	-1.753	-2.023	-2.023	-2.023
p-value	0.080	0.043*	0.043*	0.043*

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Table 11. Tongue range motion ratio (TRMR) (Intergroup comparisons)

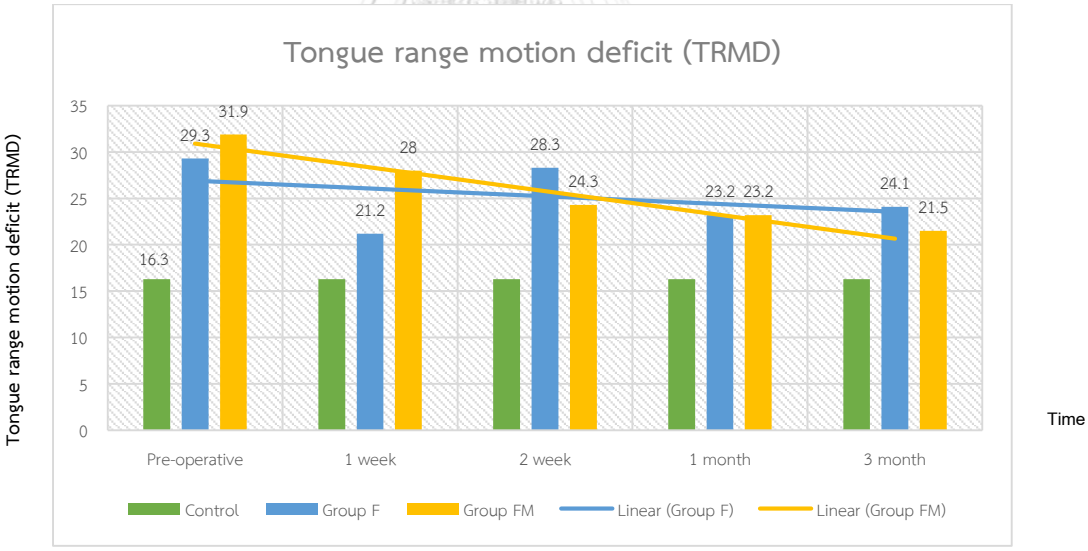
Group	Time	Mann-Whitney U	*p-value*
Control-GroupF	Pre-operation	1.0	0.16
	1week	8.0	0.347
	2week	4.5	0.094
	1month	7.0	0.251
	3 month	7.0	0.251

Control-GroupFM	Pre-operation	0.0	0.009**
	1week	1.0	0.016*
	2week	2.0	0.028*
	1month	6.0	0.175
	3 month	7.0	0.251
GroupF-GroupFM	Pre-operation	4.0	0.076
	1week	1.0	0.016*
	2week	12.0	0.917
	1month	9.0	0.465
	3 month	12.0	0.917

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

4.3.3 Tongue range motion deficit (TRMD)

TRMD of the control group significantly higher than ankyloglossia. After frenectomy, TRMD of group F dropped near the control at 1st-week follow-up then it increased in the 2nd-week follow-up. Meanwhile, TRMD of group FM continuously lower since the 1st-week follow-up until a 3rd -month follow-up (Figure 20).



*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Figure 20. Tongue range motion deficit (TRMD)

Table 12. Tongue range motion deficit (TRMD) (Group F Intragroup comparisons)

	TRMD1wk - TRMD	TRMD2wk - TRMD	TRMD1M - TRMD	TRMD3M - TRMD
Z	-2.023	-0.674	-2.023	-1.753
p-value	0.042*	0.500	0.042*	0.080

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Table 13. Tongue range motion deficit (TRMD) (Group FM Intragroup comparisons)

	TRMD1wk - TRMD	TRMD2wk - TRMD	TRMD1M - TRMD	TRMD3M - TRMD
Z	-0.944	-1.483	-1.483	-1.214
p-value	0.345	0.138	0.138	0.225

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

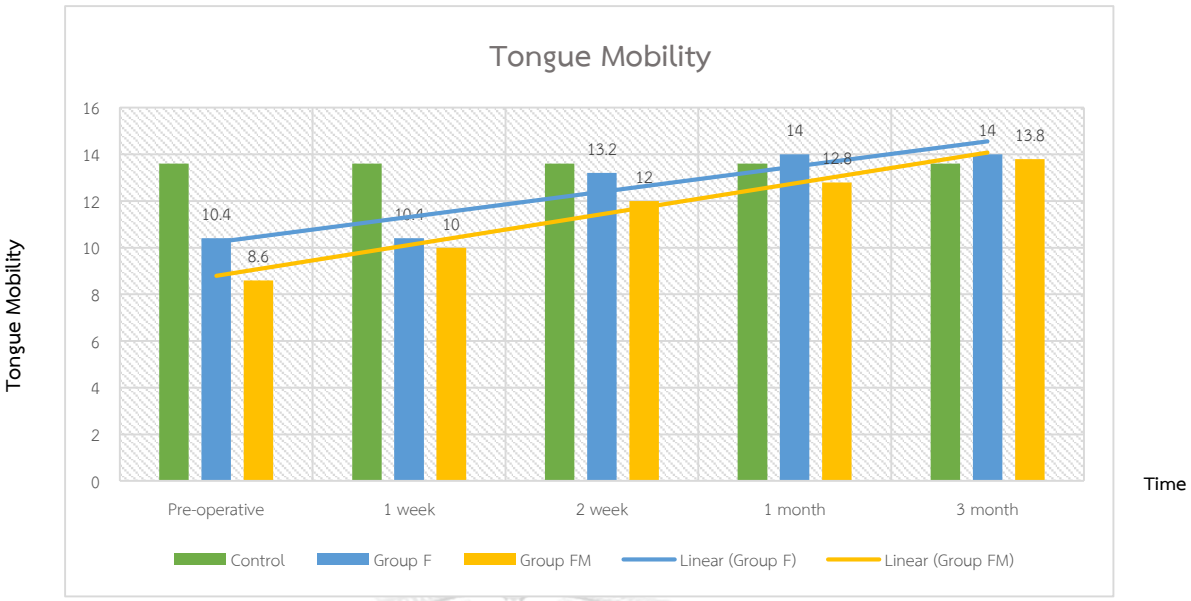
Table 14. Tongue range motion ratio (TRMD) (Intergroup comparisons)

Group	Time	Mann-Whitney U	*p-value*
Control-GroupF	Pre-operation	3.0	0.047*
	1week	6.0	0.169
	2week	3.5	0.059
	1month	5.5	0.142
	3 month	6.0	0.175
Control-GroupFM	Pre-operation	1.0	0.016*
	1week	4.0	0.076
	2week	6.0	0.175
	1month	6.0	0.172
	3 month	8.5	0.402
GroupF-GroupFM	Pre-operation	10.0	0.602
	1week	5.0	0.116
	2week	10.5	0.675
	1month	11.5	0.834
	3 month	9.5	0.530

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

4.3.4 Tongue mobility

After surgical correction, tongue mobility of ankyloglossia continuously increased. The parameter of group F significantly increased since the 1st-month follow-up ($p<0.05$). Meanwhile, the parameter of group FM continuously significantly increased since the 2nd-week follow-up ($p<0.05$) (Figure 21).



*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Figure 21. Tongue mobility

Table 15. Tongue mobility (Group F Intragroup comparisons)

	Tongue mobility 1wk - Tongue mobility	Tongue mobility 2wk - Tongue mobility	Tongue mobility 1M - Tongue mobility	Tongue mobility 3M - Tongue mobility
Z	0.000	-1.890	-2.060	-2.060
p-value	0.100	0.059	0.039*	0.039*

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Table 16. Tongue mobility (Group FM Intragroup comparisons)

	Tongue mobility 1wk - Tongue mobility	Tongue mobility 2wk - Tongue mobility	Tongue mobility 1M - Tongue mobility	Tongue mobility 3M - Tongue mobility
Z	-1.890	-2.041	-2.041	-2.032
p-value	0.059	0.041*	0.041*	0.042*

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Table 17. Tongue mobility (Intergroup comparisons)

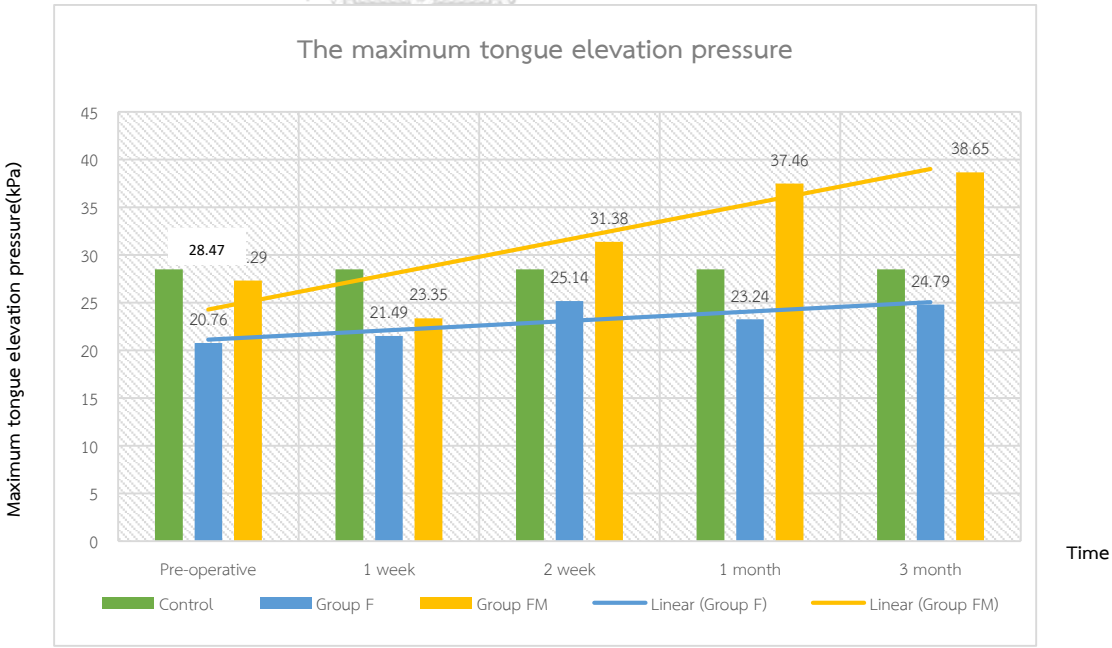
Group	Time	Mann-Whitney U	*p-value*
Control-GroupF	Pre-operation	1.5	0.014*
	1week	1.5	0.014*
	2week	10.0	0.513
	1month	10.0	0.317

	3 month	10.0	0.317
Control-GroupFM	Pre-operation	0.5	0.009**
	1week	3.0	0.033*
	2week	6.5	0.155
	1month	9.5	0.439
	3 month	12.0	0.881
GroupF-GroupFM	Pre-operation	7.0	0.233
	1week	11.0	0.742
	2week	8.0	0.307
	1month	7.5	0.136
	3 month	10.0	0.317

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

4.3.5 The maximum tongue elevation pressure

After surgical correction, group F's maximum tongue pressure slightly increased in 2nd-week follow-up but not significant and presented lower than the group FM at the 3rd-month follow-up. Conversely, group FM's maximum tongue elevation pressure significantly increased at the 1st-week follow-up ($p<0.05$) and higher than the control group at the 3rd-month follow-up (Figure 22).



*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Figure 22. The maximum tongue elevation pressure

Table 18. The maximum tongue elevation pressure (Group F Intragroup comparisons)

	Tongue pressure1wk - Tongue pressure	Tongue pressure2wk - Tongue pressure	Tongue pressure1M - Tongue pressure	Tongue pressure3M - Tongue pressure
Z	-0.944	-1.753	-1.483	-1.753
p-value	0.345	0.080	0.138	0.080

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Table 19. The maximum tongue elevation pressure (Group FM Intragroup comparisons)

	Tongue pressure1wk - Tongue pressure	Tongue pressure2wk - Tongue pressure	Tongue pressure1M - Tongue pressure	Tongue pressure3M - Tongue pressure
Z	-2.023	-1.483	-1.753	-1.753
p-value	0.043*	0.138	0.080	0.080

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

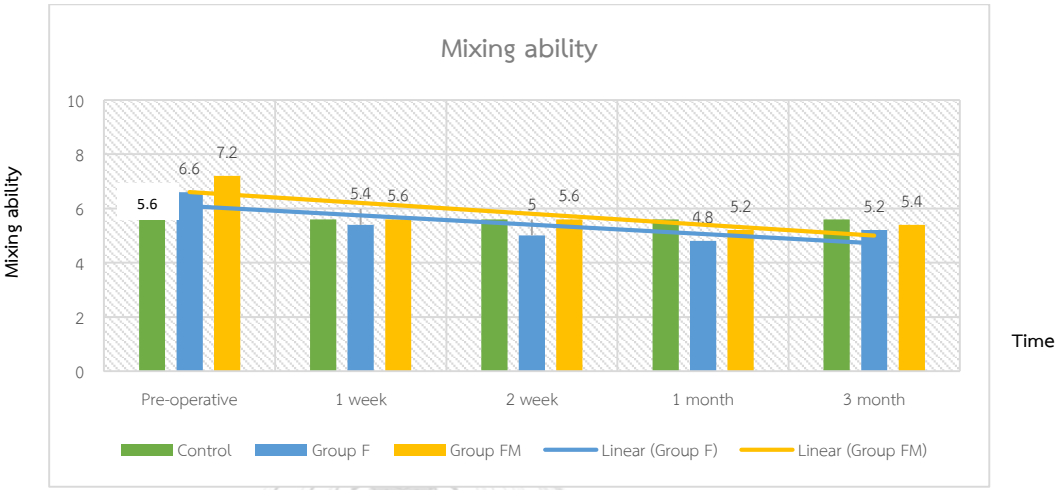
Table 20. The maximum tongue elevation pressure (Intergroup comparisons)

Group	Time	Mann-Whitney U	*p-value*
Control-GroupF	Pre-operation	7.0	0.251
	1week	9.0	0.465
	2week	11.5	0.834
	1month	9.0	0.465
	3 month	12.0	0.917
Control-GroupFM	Pre-operation	12.0	0.917
	1week	8.0	0.347
	2week	8.0	0.347
	1month	5.0	0.117
	3 month	4.0	0.075
GroupF-GroupFM	Pre-operation	8.0	0.347
	1week	12.0	0.917
	2week	8.0	0.347
	1month	5.0	0.117
	3 month	3.0	0.047*

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

4.3.6 Mixing ability

There was no difference in pre-operative mixing ability among groups. After surgical correction, both ankyloglossia groups' mixing ability slightly decreased until 1st-month follow-up and then increasing at the 3rd-month follow-up. The value of group FM was higher than group F all the period (Figure 23).



*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Figure 23. Mixing ability

Table 21 Mixing ability (Group F Intragroup comparisons)

	Mixing ability 1wk - Mixing ability	Mixing ability 2wk - Mixing ability	Mixing ability 1M - Mixing ability	Mixing ability 3M - Mixing ability
Z	-0.736	-1.461	-1.841	-1.511
p-value	0.461	0.144	0.066	0.131

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Table 22. Mixing ability (Group FM Intragroup comparisons)

	Mixing ability 1wk - Mixing ability	Mixing ability 2wk - Mixing ability	Mixing ability 1M - Mixing ability	Mixing ability 3M - Mixing ability
Z	-0.921	-1.300	-2.06	-1.841
p-value	0.357	0.194	0.039*	0.066

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Table 23. Mixing ability (Intergroup comparisons)

Group	Time	Mann-Whitney U	*p-value*
Control-GroupF	Pre-operation	7.5	0.287

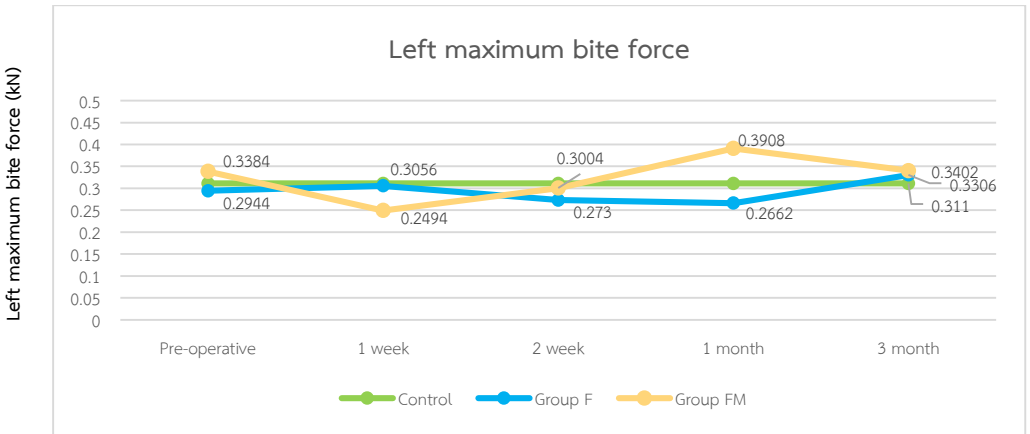
	1week	11.5	0.827
	2week	9.5	0.523
	1month	8.5	0.390
	3 month	9.5	0.512
Control-GroupFM	Pre-operation	6.5	0.206
	1week	12.0	0.916
	2week	11.0	0.737
	1month	10.0	0.590
	3 month	10.5	0.667
GroupF-GroupFM	Pre-operation	9.0	0.455
	1week	11.5	0.831
	2week	8.5	0.345
	1month	9.5	0.519
	3 month	11.0	0.736

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

4.3.7 Maximum bite force

Before treatment, there were no significant differences among the three groups. After surgical correction, group F and group FM had a higher maximum bite force on the left side than the control group. However, group FM reached over the control group faster at the 1st-month follow-up while group F reached the control group at the 3rd-month follow-up. For the anterior and right maximum bite force, group F slightly increased at 1st-week follow-up but no significance. While group FM significantly increased at 1st-week follow-up and appeared higher than the control group at a 1st-month follow-up (Figure 24- 26).

- Left



*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Figure 24. Left maximum bite force

Table 24. Left maximum bite force (Group F Intragroup comparisons)

	Left maximum bite force1wk - Left maximum bite force	Left maximum bite force2wk - Left maximum bite force	Left maximum bite force1M - Left maximum bite force	Left maximum bite force3M - Left maximum bite force
Z	-0.674	-0.674	-0.674	-0.405
p-value	0.5	0.5	0.5	0.686

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Table 25. Left maximum bite force (Group FM Intragroup comparisons)

	Left maximum bite force1wk - Left maximum bite force	Left maximum bite force2wk - Left maximum bite force	Left maximum bite force1M - Left maximum bite force	Left maximum bite force3M - Left maximum bite force
Z	-1.483	-0.405	-0.944	-0.135
p-value	0.138	0.686	0.345	0.893

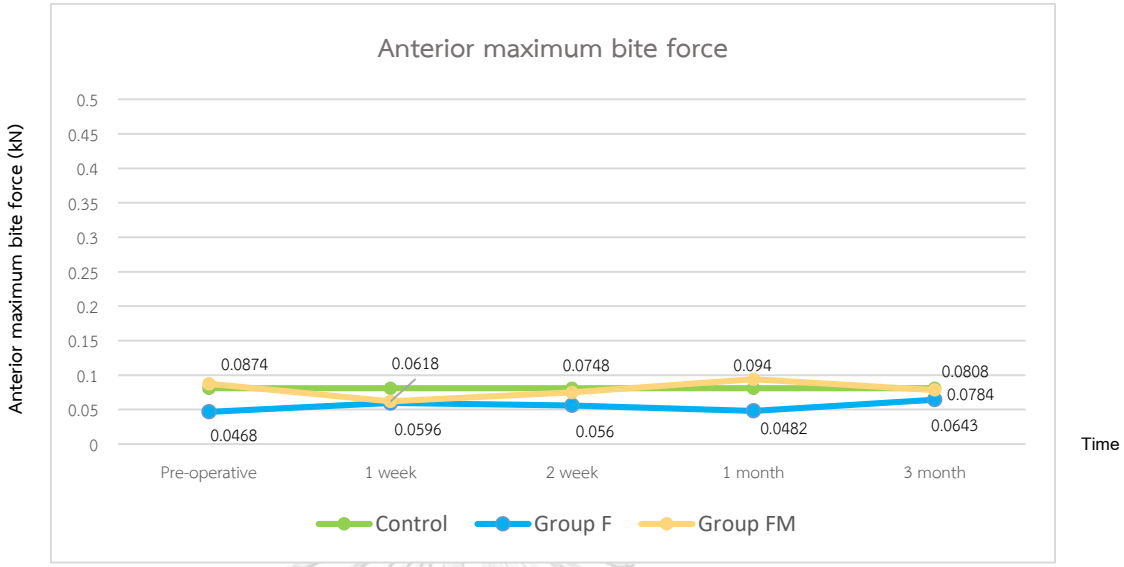
*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Table 26. Left maximum bite force (Intergroup comparisons)

Group	Time	Mann-Whitney U	*p-value*
Control-GroupF	Pre-operation	12.0	0.917
	1week	11.0	0.754
	2week	10.0	0.602
	1month	9.0	0.465
	3 month	12.0	0.917
Control-GroupFM	Pre-operation	12.0	0.917
	1week	8.0	0.347
	2week	12.0	0.917
	1month	7.0	0.251
	3 month	12.0	0.917
GroupF-GroupFM	Pre-operation	10.0	0.602
	1week	11.0	0.754
	2week	9.0	0.465
	1month	4.0	0.076
	3 month	8.0	0.346

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

- Anterior



*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Figure 25. Anterior maximum bite force

Table 27. Anterior maximum bite force (Group F Intragroup comparisons)

	Anterior maximum bite force1wk - Anterior maximum bite force	Anterior maximum bite force2wk - Anterior maximum bite force	Anterior maximum bite force1M - Anterior maximum bite force	Anterior maximum bite force3M - Anterior maximum bite force
Z	-1.753	-1.753	-0.405	-1.214
p-value	0.080	0.080	0.686	0.225

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Table 28. Anterior maximum bite force (Group FM Intragroup comparisons)

	Anterior maximum bite force1wk - Anterior maximum bite force	Anterior maximum bite force2wk - Anterior maximum bite force	Anterior maximum bite force1M - Anterior maximum bite force	Anterior maximum bite force3M - Anterior maximum bite force
Z	-2.023	-1.483	-0.674	-0.674
p-value	0.042*	0.138	0.500	0.500

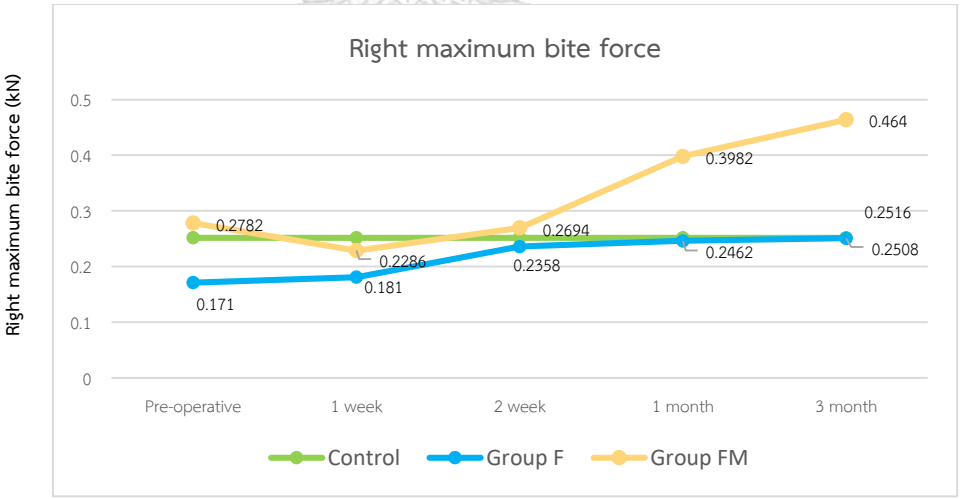
*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Table 29. Anterior maximum bite force (Intergroup comparisons)

Group	Time	Mann-Whitney U	*p-value*
Control-GroupF	Pre-operation	4.0	0.076
	1week	7.0	0.251
	2week	6.0	0.175
	1month	5.0	0.117
	3 month	8.5	0.402
Control-GroupFM	Pre-operation	11.0	0.754
	1week	8.0	0.346
	2week	9.5	0.530
	1month	8.0	0.347
	3 month	12.0	0.917
GroupF-GroupFM	Pre-operation	4.0	0.076
	1week	9.5	0.528
	2week	6.0	0.175
	1month	3.0	0.047
	3 month	11.0	0.754

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

- Right



*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Figure 26. Right maximum bite force

Table 30. Right maximum bite force (Group F Intragroup comparisons)

	Right maximum bite force1wk - Right maximum bite force	Right maximum bite force2wk - Right maximum bite force	Right maximum bite force1M - Right maximum bite force	Right maximum bite force3M - Right maximum bite force
Z	-0.405	-1.490	-1.095	-1.753
p-value	0.686	0.136	0.273	0.080

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Table 31. Right maximum bite force (Group FM Intragroup comparisons)

	Right maximum bite force1wk - Right maximum bite force	Right maximum bite force2wk - Right maximum bite force	Right maximum bite force1M - Right maximum bite force	Right maximum bite force3M - Right maximum bite force
Z	-1.214	-0.674	-2.023	-2.023
p-value	0.225	0.500	0.043*	0.043*

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

Table 32. Right maximum bite force (Intergroup comparisons)

Group	Time	Mann-Whitney U	*p-value*
Control-GroupF	Pre-operation	8.0	0.347
	1week	8.0	0.347
	2week	12.0	0.917
	1month	12.0	0.917
	3 month	11.0	0.754
Control-GroupFM	Pre-operation	11.0	0.754
	1week	11.0	0.754
	2week	12.0	0.917
	1month	5.0	0.117
	3 month	2.0	0.028*
GroupF-GroupFM	Pre-operation	5.0	0.117
	1week	10.0	0.602
	2week	12.0	0.917
	1month	4.0	0.076
	3 month	4.0	0.076

*Comparison is significant at the .05 level (2-tailed), ** Comparison is significant at the .01 level (2-tailed)

CHAPTER V

DISCUSSION

Besides esthetic and morphological problems, individuals with ankyloglossia may present alterations in stomatognathic functions, particularly in masticatory muscle activity. Morphological and functional analyses are important for diagnosis and evaluation of treatment outcomes. Thus, the clinical and instrumental aspects of masticatory function in individuals undergoing surgical correction of ankyloglossia, as well as the effect of tongue myofunctional therapy were verified. Subjects' limited age range controlled the growth, strength of muscle and orofacial functions. Moreover, only Angle class I occlusion were included because we would like to expurgate the confounding factors that had been reported the relationship of tongue position with malocclusion [25]. This article investigated the effectiveness of myofunctional therapy of the tongue after frenectomy in ankyloglossia. There were no differences in age, gender, weight, height, and BMI in this study. It indicated that all study groups were appropriately selected. Moreover, the intra-rater reliability test was high. Thus, it was clear that the systematic error of tongue evaluation was absent.

One of the common principles to describe abnormal lingual frenum attachments was the free-tongue measurement proposed by Kotlow et al. [1] that the lingual frenum length would be greater than 16 mm. Although the tongue was flexible, it was challenging to stabilize during measurement. Merchensan et al. [68] described a quantitative method to categorize the short lingual frenum in adults by sort of the relationship between maximal interincisal mouth opening (MIO) and mouth opening with tongue tip to incisive papilla (MOTTIP). The ratio of MOTTIP to MOI (tongue range of motion ratio; TRMR) was the only independent measurement of tongue mobility because it was an individual parameter, and straight associated with tongue function [68]. Our finding corresponded that TRMR was significantly correlated with free-tongue movement and tongue mobility.

Orofacial myofunctional therapy was defined as the treatment of dysfunction of orofacial muscle [69]. In 1918, myofunctional therapy was first described as an adjunct to orthodontic treatment to improve mandibular growth, facial appearance, and breathing [70]. The later article indicated that the open bite and overjet could be improved by myofunctional therapy without prior or concurrent orthodontic intervention [71]. Regarding the problems and sequelae associated with limited tongue movement, Frenectomy is efficient to improve tongue posture, tongue mobility, and oral functions [72]. Surgical correction of lingual frenum with myofunctional therapy was approved for safe and potentially effective treatment of mouth breathing, snoring, clenching, and myofascial tension [57] .

Age is not necessarily a predicting success of a myofunctional therapeutic program [71]. Tongue strength training by tongue-to-palate resistance exercise performed 5 times a week for 6

weeks has been reported to increases the thickness and strength of oropharyngeal muscles. Clark et al. [73] stated that tongue exercise, such as pushing the tongue forward, increased lingual strength, and was not related to training conditions (sequential or concurrent). Yano et al. [74] found the anterior tongue exercises affect the posterior tongue in healthy young adults. They observed 11 subjects who exercised by merely pushing the anterior tongue to the palate 30 times, 3 times a day, 3 days a week for 8 weeks. The results showed a significant increase in both anterior and posterior maximum tongue pressure.

Yoon et al. [62] mentioned a functional TRMR that was graded by tongue mobility as grade 1 = >80%, grade 2 = 50–80%, grade 3 = <50%, grade 4 = <25%, and a normal value was between 51 and 77%. Correspondingly, our study presented pre-operative TRMR of control group 67.13±15.69%, group F 39.83±12.18% (grade 3), and group FM 24.27±10.82% (grade 4). After treatment, the value significantly increased in both ankyloglossia: group F 49.85±12.01% (grade 2) and group FM 43.26±12.01% (grade 2). TRMD of normal subjects and ankyloglossia were18.4±7.3 and 31.5±7.2, consecutively. Meanwhile, our study showed the pre-operative value of control group 16.3±8.76, group F 29.3±5.62, and group FM 31.9±5.88. After treatment, the value increased in both ankyloglossia: group F 24.1±6.39 and group FM 21.5±8.99, although no significance. Thoroughly, TRMR of group FM was continuously increased and significantly different from pre-operative value since the 2nd-week follow-up ($p<0.05$). In contrast, TRMR of group F had some inconstant between 1st-week to 1st-month follow-up. These results suggested that tongue myofunctional therapy not only improved tongue mobility but improved more constantly.

Patients with ankyloglossia may experience difficulty protrusion, lateralization, and the tongue's tip or body's essential elevation. The tongue mobility protocol was a functional test in seven directions. It was necessary for a normal tongue function (protrude and retract, touch the upper lip with the apex, touch the right labial commissure, touch the left labial commissure, touch upper and lower molars, apex vibration, sucking against the palate) [75]. Though the improvement of the tongue movement immediately after the surgical correction was commented in the literature [76], our experiment found the significantly increased tongue mobility near the control in the FM group (2nd-week follow-up) faster than the F group (1st-month follow-up). Tongue myofunctional therapy could accelerate the healing time of ankyloglossia after surgery.

Although the maximum tongue elevation pressure of the control group in this study was lower than the standard value stated by Utanohara et al [77], our investigation revealed that orofacial myofunctional therapy increased maximum tongue pressure, consistent with previous studies [78, 79]. Arakawa et al. [80] have reported that the maximum tongue elevation pressure increased by approximately 4.4 kPa at 1 month and 9.65 kPa at 3 months after tongue training. As our results, the increase of maximum tongue elevation pressure was approximate 2.48±0.6 in group F and 10.17±0.22 in group FM at the 1st-month follow-up and 4.03±2.05 in group F and 11.36±2.12 in group FM at 3rd-month follow-up. Even though the maximum tongue elevation

pressure of both F and FM groups significantly increased after intervention, the FM group's result significantly increased faster and more constantly than the F group, and higher than the control group at 3 months post-tongue training. It may suggest that orofacial myofunctional therapy stabilized the tongue muscle's neuromuscular adaptation process [61].

The color-changeable chewing gum (Masticatory Performance Evaluating Gum XYLITOL, Lotte Co., Ltd., Tokyo, Japan) was used for evaluating masticatory performance by color scale [65]. The developed unique color scales to reduce the technical and temporal expenditure of the measurement. This evaluation method’s validity and reliability compared with the colorimeter measurements have been proven [81]. However, whether the color scales are differentiated enough to reproduce sufficient differences in masticatory efficiency. Moreover, it appeared useful to apply color scales in cases in which a significant difference is expected, and a large sample size allows the detection of significant differences statistically. On the other hand, the standardized colorimetric measurement approach should be used to present more detailed or small differences [82].

The maximum bite force has been observed to correlate with maximum tongue elevation pressure and decline with age [83]. Consistent with our observation, we detected a significant correlation between maximum bite force and age, but no maximum tongue elevation pressure. After controlling for age, anterior bite force was absolutely and relatively more reliable than molar bite forces [84]. Our study revealed that myofunctional therapy facilitated a positive impact on the anterior, right, and left maximum bite force after surgical correction of the lingual frenum. Primarily, the anterior and right maximum bite force of group FM significantly increased at 1st-week follow-up and appeared higher than the control group at a 1st-month follow-up.

In contrast, group F slightly increased at 1st-week follow-up but no significance. Consonance with the previous study. Ohira et al. [85] described that chewing the exercise gum daily over several weeks will increase maximal bite force as well as masticatory performance significantly and maintain elevated the values for several weeks. Sonnesen L et al. [86] reported the positive correlation of the maximum bite force and the number of teeth in both sexes. Although, our observation had no significant difference between the number of teeth in F and FM group, the raw data of FM was less than the F group. It might cause the deviated value of 3rd-month maximum bite force (the right side’s value was more than left side). Thus, further studies need to define the coincident number of teeth and myofunctional therapy affects maximum bite force.

To train the tongue muscle affects strengthen masticatory muscles unintentionally. These isotonic and isometric exercises establish a new neuromuscular pattern and to correct abnormal functional and resting postures, change orofacial muscular and functional patterns using for orofacial and oropharyngeal muscles targeting the functions of breathing, mastication, swallowing and speech [82]. Tongue myofunctional exercises influenced a positive effect on

overall tongue mobility and tongue function in our study. Myofunctional therapy can improve abnormal tongue posture not only during function but also in the resting condition, in which the position of the tongue body affects masticatory muscle activity. Moreover, the dynamic position of the tongue maintain normal occlusion [82].

Myofunctional therapy base on neuroplasticity. The brain's ability to follow the physiologic or pathologic input and generate an adaptive response. These principles included such as; “use it or lose it” indicating that if a neural substrate is not biologically active, its function can degrade, “use it and improve it” indicating that with increased biological activity, future functioning will be enhanced, “plasticity is experience specific” indicating that changes may occur only in the neural substrates involved in the particular behavior being trained, “repetition matters” indicating that neural substrates may be modified by extensive and prolonged practice [69]. The period of the tongue muscle exercise in previous researches varied: 4 weeks [78], 6 weeks [87], 8-12 weeks [74, 88], in which the period of the present study was 12 weeks. However, we found a significant difference in the group FM almost tongue parameters since the 2nd-week follow-up, and significantly higher than the control since the 4th-week follow-up.

This study reflects the first step in understanding tongue myofunctional therapy and a frenectomy procedure which influences tongue mobility and tongue function in ankyloglossia more than do frenectomy alone. The study's critical limitations of this study were the small sample size (n=15). Further studies, we need to expand the sample sizes to explore the effects of myofunctional therapy on tongue mobility and tongue functions. Likewise, the period follow-up could be extended to evaluate the recurrence of tongue-tie and treatment outcomes.

CHAPTER VI

CONCLUSION

Our study's results demonstrated that both lingual frenectomy alone and frenectomy performed with tongue myofunctional therapy had improved tongue mobility and function but not as reached as the control group. Tongue myofunctional therapy can accelerate and maintain the treatment results of tongue anatomy and function in ankyloglossia. If the surgical intervention of lingual frenum was reinforced with myofunctional therapy protocol described in this present study and good patient collaboration, tongue myofunctional therapy combined with frenectomy achieves better results in the correction of limit tongue mobility and tongue function than frenectomy alone.

APPENDICES

Appendix A Thai consent form

เอกสารยินยอมเข้าร่วมการวิจัย
(Consent Form)

การวิจัยเรื่อง การศึกษาเปรียบเทียบประสิทธิผลของการบริหารลิ้นร่วมกับการผ่าตัดเนื้อเยื่อยึดใต้ลิ้น ในผู้ป่วยที่มีภาวะลิ้นติด

ข้าพเจ้า (นาย/ นาง/ นางสาว/ เด็กชาย/ เด็กหญิง).....

อยู่บ้านเลขที่.....ถนน.....ตำบล/แขวง.....

อำเภอ/เขต.....จังหวัด.....รหัสไปรษณีย์.....

ก่อนที่จะลงนามในใบยินยอมให้ทำการวิจัยนี้

1. ข้าพเจ้าได้รับทราบรายละเอียดข้อมูลคำอธิบายสำหรับอาสาสมัครที่เข้าร่วมในการวิจัย รวมทั้งได้รับการอธิบายจากผู้วิจัยถึงวัตถุประสงค์ของการวิจัย วิธีการทำวิจัย อันตรายหรืออาการที่อาจเกิดขึ้นจากการทำวิจัย
   หรือจากยาที่ใช้รวมทั้งประโยชน์ที่จะเกิดขึ้นจากการวิจัยอย่างละเอียดและมีความเข้าใจดีแล้ว
2. ผู้วิจัยได้ตอบคำถามต่างๆ ที่ข้าพเจ้าสงสัยด้วยความเต็มใจไม่ปิดบังซ่อนเร้นจนข้าพเจ้าพอใจ
3. ผู้วิจัยรับรองว่าจะเก็บข้อมูลเฉพาะเกี่ยวกับตัวข้าพเจ้าเป็นความลับและจะเปิดเผยได้เฉพาะในรูปที่เป็นสรุป ผลการวิจัย การเปิดเผยข้อมูลเกี่ยวกับตัวข้าพเจ้าต่อหน่วยงานต่างๆ ที่เกี่ยวข้องกระทำได้เฉพาะกรณีจำเป็นด้วยเหตุผลทางวิชาการเท่านั้น และผู้วิจัยรับรองว่าหากเกิดอันตรายใดๆ จากการวิจัยดังกล่าว ข้าพเจ้าจะได้รับ
   การรักษาพยาบาลโดยไม่คิดมูลค่า
4. ข้าพเจ้ามีสิทธิที่จะบอกเลิกการเข้าร่วมในโครงการวิจัยนี้เมื่อใดก็ได้และการบอกเลิกการเข้าร่วมการวิจัยนี้จะไม่
   มีผลต่อการรักษาโรคที่ข้าพเจ้าจะพึงได้รับต่อไป

ข้าพเจ้าจึงสมัครใจเข้าร่วมโครงการวิจัยนี้ตามที่ระบุในเอกสารข้อมูลคำอธิบายสำหรับอาสาสมัครและได้ลง นามในใบยินยอมนี้ด้วยความเต็มใจ และได้รับสำเนาเอกสารใบยินยอมที่ข้าพเจ้าลงนามและลงวันที่ และเอกสารยกเลิกการเข้าร่วมวิจัย อย่างละ 1 ฉบับ เป็นที่เรียบร้อยแล้ว ในกรณีที่อาสาสมัครยังไม่บรรลุนิติภาวะจะต้องได้รับการยินยอมจากผู้ปกครองด้วย

ลงนาม..... (อาสาสมัคร) (.....) วันที่...../...../.....	ลงนาม..... (ผู้ปกครอง) (.....) วันที่...../...../.....

ลงนาม..... (ผู้วิจัยหลัก) (ทพญ. ณัฐกานต์ โพธิ์วิจิตร) วันที่...../...../.....	ลงนาม..... (พยาน) (.....) วันที่...../...../.....

ข้าพเจ้าไม่สามารถอ่านหนังสือได้ แต่ผู้วิจัยได้อ่านข้อความในใบยินยอมนี้ให้แก่ข้าพเจ้าฟังจนเข้าใจดีแล้วข้าพเจ้าจึงลงนาม หรือประทับลายนิ้วหัวแม่มือขวาของข้าพเจ้าในใบยินยอมนี้ด้วยความเต็มใจ

ลงนาม..... (อาสาสมัคร) (.....) วันที่...../...../.....	ลงนาม..... (ผู้ปกครอง) (.....) วันที่...../...../.....
ลงนาม..... (ผู้วิจัยหลัก) (ทพญ. ณัฐกานต์ โพธิ์วิจิตร) วันที่...../...../.....	ลงนาม.....(พยาน) (.....) วันที่...../...../.....

Appendix B Orofacial myofunctional therapy checklist notebook

สมุดประจำตัวบันทึกการบริหารลิ้น

ชื่อ-สกุล.....HN.....

สวัสดีค่ะ!

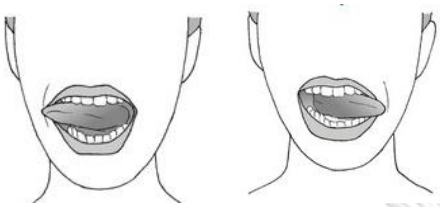
ยินดีต้อนรับทุกท่านสู่แบบฝึกและบันทึกการบริหารลิ้นหลังการผ่าตัดนะคะ

ในสมุดเล่มนี้ประกอบด้วยวิธีบริหารลิ้นและการจดบันทึกการบริหารลิ้นง่ายๆ

ไปดูกันเลยค่ะ

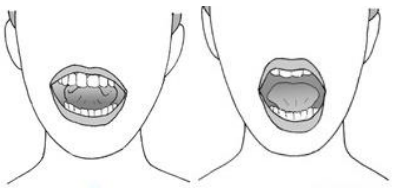
วิธีบริหารลิ้น

ท่า1(Palate scrapes): ใช้ปลายลิ้นแตะบริเวณเพดานด้านหน้าแล้วค่อยๆลากลิ้นจากเพดานด้านหน้าให้ไปทางด้านหลัง.ให้ไกลที่สุดเท่าที่จะทำได้ ค้างไว้ 5 วินาที ทำซ้ำ 5 ครั้ง.



ท่า2(Elephant swing): อ้าปากกว้าง ยืดลิ้นออกมาด้านหน้า แกว่งลิ้นเพื่อแตะมุมปากซ้ายและขวา นับเป็น 1 ครั้ง ทำซ้ำ 5 ครั้ง

ท่า3(Tongue click): ใช้ปลายลิ้นแตะบริเวณเพดานด้านหน้า โดยให้รู้สึกว่าลิ้นดูดติดที่เพดาน กระดกลิ้นลงให้มีเสียงดัง "คลิก" ทำซ้ำ 15 ครั้ง



**** ให้ทำเครื่องหมาย √ ในช่วงเวลาที่ได้ทำการบริหารลิ้นได้ครบเซ็ตคือสามารถทำได้ครบจำนวนครั้งที่กำหนดให้ในแต่ละท่า หากบริหารได้ไม่จำนวนครั้งที่กำหนดให้ในแต่ละท่า ให้เขียนเฉพาะจำนวนครั้งที่บริหารได้ ลงในช่องว่างที่ได้ทำการบริหาร****

ตัวอย่าง คุณ ก.เอ๋ย ก.ไก่ บริหารท่าที่ 1 ครบ 5 ครั้ง ในช่วงเวลา 7.30 น.
คุณ ก.เอ๋ย ก.ไก่ บริหารท่าที่ 2 ครบ 5 ครั้ง ในช่วงเวลา 7.30 น.
คุณ ก.เอ๋ย ก.ไก่ บริหารท่าที่ 3 ครบ 10 ครั้ง ในช่วงเวลา 7.30 น.

		wk1(.../...)
ท่า1 (Palate scrapes)	5.00-9.00	√
	11.00-15.00	
	16.00-20.00	
ท่า2 (Elephant swing)	5.00-9.00	√
	11.00-15.00	
	16.00-20.00	
ท่า3 (Tongue click)	5.00-9.00	√
	11.00-15.00	
	16.00-20.00	

ตารางบันทึกการบริหารกล้ามเนื้อสำหรับผู้ป่วย

เวลา/วันที่หลังหัตถการ		สัปดาห์ที่.....หลังหัตถการ						
		1(.../.../...)	2(.../.../...)	3(.../.../...)	4(.../.../...)	5(.../.../...)	6(.../.../...)	7(.../.../...)
ท่า1 (Palate scrapes)	5.00-9.00							
	11.00-15.00							
	16.00-20.00							
ท่า2 (Elephant swing)	5.00-9.00							
	11.00-15.00							
	16.00-20.00							
ท่า3 (Tongue click)	5.00-9.00							
	11.00-15.00							
	16.00-20.00							

ตารางบันทึกการบริหารกล้ามเนื้อสำหรับผู้ป่วย

เวลา/วันที่หลังหัตถการ		สัปดาห์ที่.....หลังหัตถการ						
		1(.../.../...)	2(.../.../...)	3(.../.../...)	4(.../.../...)	5(.../.../...)	6(.../.../...)	7(.../.../...)
ท่า1 (Palate scrapes)	5.00-9.00							
	11.00-15.00							
	16.00-20.00							
ท่า2 (Elephant swing)	5.00-9.00							
	11.00-15.00							
	16.00-20.00							
ท่า3 (Tongue click)	5.00-9.00							
	11.00-15.00							
	16.00-20.00							

ตารางบันทึกการบริหารกล้ามเนื้อสำหรับผู้ป่วย

เวลา/วันที่หลังหัตถการ		สัปดาห์ที่.....หลังหัตถการ						
		1(.../.../...)	2(.../.../...)	3(.../.../...)	4(.../.../...)	5(.../.../...)	6(.../.../...)	7(.../.../...)
ท่า1 (Palate scrapes)	5.00-9.00							
	11.00-15.00							
	16.00-20.00							
ท่า2 (Elephant swing)	5.00-9.00							
	11.00-15.00							
	16.00-20.00							
ท่า3 (Tongue click)	5.00-9.00							
	11.00-15.00							
	16.00-20.00							

Appendix C Patient demographic and clinical data

ID	Age	Sex	Weight (kg.)	Height (cm.)	Number of teeth	Number of posterior teeth
C1	22	F	53	163	28	16
C2	22	M	73	180	28	16
C3	21	F	53	156	28	16
C4	21	F	65	158	28	16
C5	24	F	44	165	28	16
F1	18	F	47	158	28	16
F2	28	M	71	175	28	16
F3	21	M	89	169	28	16
F4	20	M	65	180	24	12
F5	22	M	56	167	24	12
FM1	29	M	64	175	28	16
FM2	36	F	69	151	21	9
FM3	21	M	63	172	25	16
FM4	22	M	52	163	28	16
FM5	22	M	56	167	28	16

Appendix D Pre-operative clinical data

ID	Op. time (mins)	Free tongue movement (mm)	MIO (mm)	MIOTTIP (mm)	Tongue mobility	Max. tongue pressure	Mixing ability	Left Max. bite force	Anterior Max. bite force	Right Max. bite force
C1	-	33.0	51.0	41.0	14	36.45	5	.4230	.0860	.3220
C2	-	24.0	56.5	27.5	12	37.10	3	.3010	.0920	.2040
C3	-	39.5	47.5	41.0	14	25.10	7	.1600	.0430	.1730
C4	-	26.5	40.5	24.0	14	17.20	7	.4820	.1170	.4430
C5	-	31.0	50.0	30.5	14	26.50	6	.1890	.0660	.1160
F1	33	8.0	47.0	10.0	6	12.46	6	.4250	.0410	.0710
F2	35	20.5	50.0	25.0	12	34.60	8	.2580	.0470	.2220
F3	40	13.5	50.5	17.0	12	26.60	4	.0920	.0010	.1260
F4	33	13.5	45.5	21.0	12	23.30	8	.1660	.0650	.1090
F5	28	9.5	51.0	24.5	10	6.83	7	.5870	.0800	.3270
FM1	45	18.0	46.5	11.5	9	26.70	8	.5870	.1300	.2730
FM2	35	22.5	46.0	15.0	12	20.60	9	.1610	.0700	.1400
FM3	35	8.5	50.0	14.0	8	12.90	6	.1790	.1100	.1790
FM4	40	6.5	44.5	2.5	6	33.67	9	.2910	.0680	.3910
FM5	36	8.5	51.0	15.5	8	42.57	4	.4740	.0590	.4080

Appendix E 1-week Post-operative clinical data

ID	MIO (mm)	MIOTTIP (mm)	Tongue mobility	Max. tongue pressure	Mixing ability	Left Max. bite force	Anterior Max. bite force	Right Max. bite force
F1	42.0	22.0	8	12.96	7	.3480	.0690	.1920
F2	46.5	26.0	12	40.60	3	.2990	.0580	.2000
F3	50.0	23.5	12	29.23	5	.1140	.0160	.1410
F4	51.5	32.0	12	23.47	5	.1800	.0810	.0900
F5	51.0	31.5	8	1.17	7	.5870	.0740	.2820
FM1	39.5	20.5	10	23.05	8	.3730	.1010	.2430
FM2	46.5	12.0	14	17.40	5	.1350	.0580	.1640
FM3	49.5	18.5	8	8.47	3	.1400	.0560	.0830
FM4	42.5	14.0	8	32.63	4	.3210	.0470	.4160
FM5	49.0	22.0	10	35.20	8	.2780	.0470	.2370

Appendix F 2-week Post-operative clinical data

ID	MIO (mm)	MIOTTIP (mm)	Tongue mobility	Max. tongue pressure	Mixing ability	Left Max. bite force	Anterior Max. bite force	Right Max. bite force
F1	56.0	11.0	14	17.63	3	.3080	.0540	.3500
F2	50.0	25.5	14	37.80	4	.2290	.0610	.2110
F3	51.0	21.0	12	37.10	5	.1070	.0180	.1360
F4	54.0	31.5	14	29.43	8	.1320	.0760	.1320
F5	50.0	30.5	12	3.73	5	.5890	.0710	.3500
FM1	35.0	19.0	14	33.25	8	.3720	.1170	.4000
FM2	48.0	20.0	14	30.00	5	.2380	.0770	.1310
FM3	53.5	23.5	10	17.43	5	.1940	.0800	.1040
FM4	44.0	17.0	10	37.93	5	.3960	.0650	.3890
FM5	49.5	29.0	12	38.27	5	.3020	.0350	.3230

Appendix G 1-month Post-operative clinical data

ID	MIO (mm)	MIOTTIP (mm)	Tongue mobility	Max. tongue pressure	Mixing ability	Left Max. bite force	Anterior Max. bite force	Right Max. bite force
F1	56.5	18.5	14	21.00	4	.3450	.0160	.3730
F2	48.5	29.0	14	36.70	5	.2890	.0560	.2010
F3	48.5	28.5	14	28.75	4	.1130	.0190	.1260
F4	54.0	35.0	14	24.76	7	.1470	.0770	.1170
F5	50.0	28.5	14	5.00	4	.4370	.0730	.4140
FM1	39.5	25.0	14	45.20	7	.4700	.1310	.3480
FM2	48.0	28.50	14	44.85	6	.4390	.1080	.5870
FM3	53.0	24.0	10	18.33	5	.1910	.0910	.2130
FM4	45.0	14.0	12	36.50	5	.3480	.0960	.4160
FM5	51.0	29.0	14	42.43	3	.5060	.0440	.4270

Appendix H 3-month Post-operative clinical data

ID	Free tongue movement (mm)	MIO (mm)	MIOTTIP (mm)	Tongue mobility	Max. tongue pressure	Mixing ability	Left Max. bite force	Anterior Max. bite force	Right Max. bite force
F1	26.0	50.0	17.0	14	19.30	5	.2190	.0176	.1360
F2	27.0	51.0	27.5	14	38.30	4	.3520	.0830	.2100
F3	33.0	47.5	31.5	14	30.67	5	.0880	.0210	.1610
F4	33.5	55.0	34.0	14	31.07	7	.2670	.1140	.1630
F5	26.0	51.5	24.5	14	4.60	5	.7270	.0860	.5840
FM1	29.0	39.0	29.0	14	45.30	6	.3680	.1080	.5870
FM2	27.5	49.0	16.0	14	42.20	5	.3680	.1040	.4870
FM3	16.0	57.0	29.0	14	22.13	5	.1540	.0600	.2410
FM4	19.0	42.5	19.5	13	42.20	7	.4110	.0710	.4440
FM5	34.5	52.5	37.0	14	41.40	4	.4000	.0490	.5610

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