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Original Article

Tongue myofunctional exercises improve tongue posture of children with class III malocclusion

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Abstract: The purpose of this study was to investigate the changes of craniofacial morphology and tongue position in children with Class III malocclusion after tongue myofunctional exercises (TME). TME were applied to 25 patients with class III malocclusion for 1.01 ± 0.02 years. Lateral cephalograms were taken and cephalometric analysis was evaluated. Compared with the control group, facial angle, S-Ti length and S-Tu length increased significant in class III subjects. However, significant reductions of SNA angle, ANB angle, Y axis angle, the angle of convexity, S-Go length, NSTu angle and NSTi angle were noted. The cephalometric variables such as mandibular plane angle, ANS-Me length, S-Tu length and S-Ti length were significantly reduced after TME in class III subjects. Meanwhile, the S-Go length, the NSTu angle and the NSTi angle increased significant. TME may change tongue position and craniofacial morphology. Furthermore, it may be particularly beneficial for treatment of class III malocclusion.

Keywords: Myofunctional exercises, tongue posture, cephalograms, class III malocclusion

Introduction

Class III malocclusion is one of malocclusions in deciduous, mixed and permanent dentition and occurs from 1.7 percent to 3.4 percent in different countries [1, 2]. The etiology of class III malocclusion has been attributed to both genetic inheritance and environment [3, 4].

Muscular imbalance is one of the most important environmental contributing factors [5, 6]. The tongue is a powerful muscle and in direct contact with dental arches and jaws, therefore the equilibrium of the tongue and the perioral muscle at rest could affect the dental arch form [6]. Hikita et al. have shown that a tongue body volume reduction can lessen mandibular protrusion and mandibular inclination [5]. Proffit believed that tongue posture is more important than tongue function because the total time the tongue exerts pressure on the teeth during swallowing is too brief to affect the balance of the teeth and bone [6].

Prior research has demonstrated that lower tongue posture affects dental arch and craniofacial growth and contributes to class III malocclusion [7, 8]. Meenakshi et al suggested that the subjects with lower tongue posture due to by ankyloglossia have a tendency toward skeletal class III malocclusion [8]. Görgülü et al reported that when compared to other malocclusions, the root of the tongue was found more inferior and anterior while the tip of the tongue was more anterior in class III malocclusion [7].

Tongue myofunctional exercises (TME) were introduced in the 1960's by the speech pathologists to correct the habit of tongue thrust [9]. Presently TME are now used in conjunction with orthodontic treatment. Kondo reported that TME effects for adult males with skeletal class III malocclusion, prognathic mandibles, anterior open bites, large tongues and temporomandibular disorders were effective and maintained long-term orthodontic stability [10]. In addition, there have been cases reports of anterior open bites treated with TME that were more effective and stable than conventional orthodontic therapy [11]. Given these positive findings, TME are rarely implemented in children with class III malocclusion. The aim of this study is to evalu-

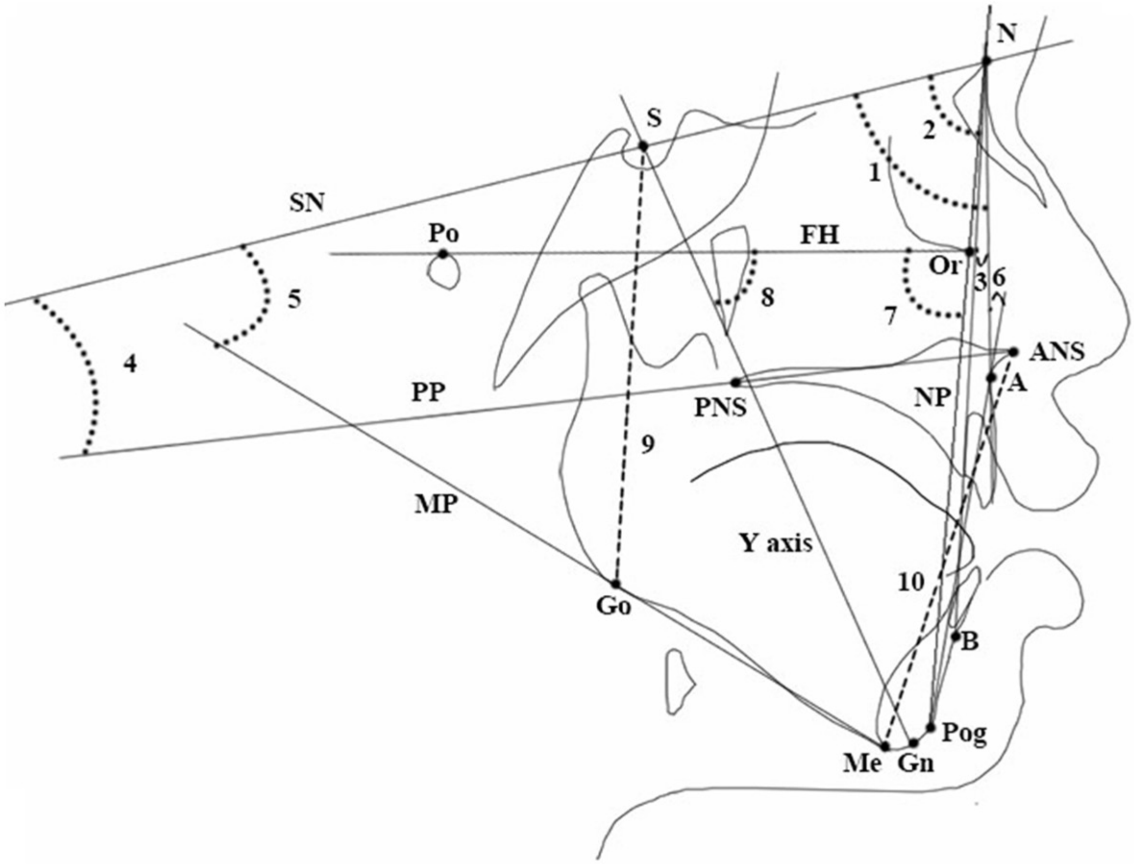

Figure 1. Schematic diagram for the craniofacial morphology. (1) ∠SNA (°); (2) ∠SNB (°); (3) ∠ANB (°); (4) PP-SN (°); (5) The mandibular angle: MP-SN (°); (6) The convexity angle: NA-PA (°); (7) The facial angle: NP-FH (°); (8) The Y axis angle: SGn-FH (°); (9) S-Go (mm); (10) ANS-Me (mm).

ate changes following myofunctional exercise in craniofacial morphology and the tongue position for subjects with class III.

Materials and methods

Subjects

The experimental group consisted of 25 patients with class III malocclusion (T0 group) in the primary dentition stage, included 14 males and 11 females (average age of 4.68 ± 0.59 years). Selection criteria for the experimental group included all of the following: crossbite of anterior teeth; no systemic disease; no history of orthodontic treatment. All the parents of the participants signed informed consents. TME was applied to all these children and 0.91-1.08 years (average 1.01 ± 0.02 years) later TME treatment was completed (T1 group).

The control group was comprised of 25 children in the deciduous dentition who had class I occlusion. There were 12 males and 13 females with an average age of 4.77 ± 0.71. Selection criteria for the control group included the following: normal dental occlusion; no systemic disease; no history of orthodontic treatment. This study was conducted in accordance with the declaration of Helsinki. This study was conducted with approval from the Ethics Committee of Zhejiang University School of Medicine. Written informed consent was obtained from all participants.

Treatment protocol

A mixture of 5.2 g Barium Sulfate (type II, Qingdao East Wind Chemical Industry Ltd., Qingdao, China) and 100 ml water were mixed to form the diagnostic paste. This paste was used to draw a 5 mm wide line down the center of the tongue in order to show the contour of

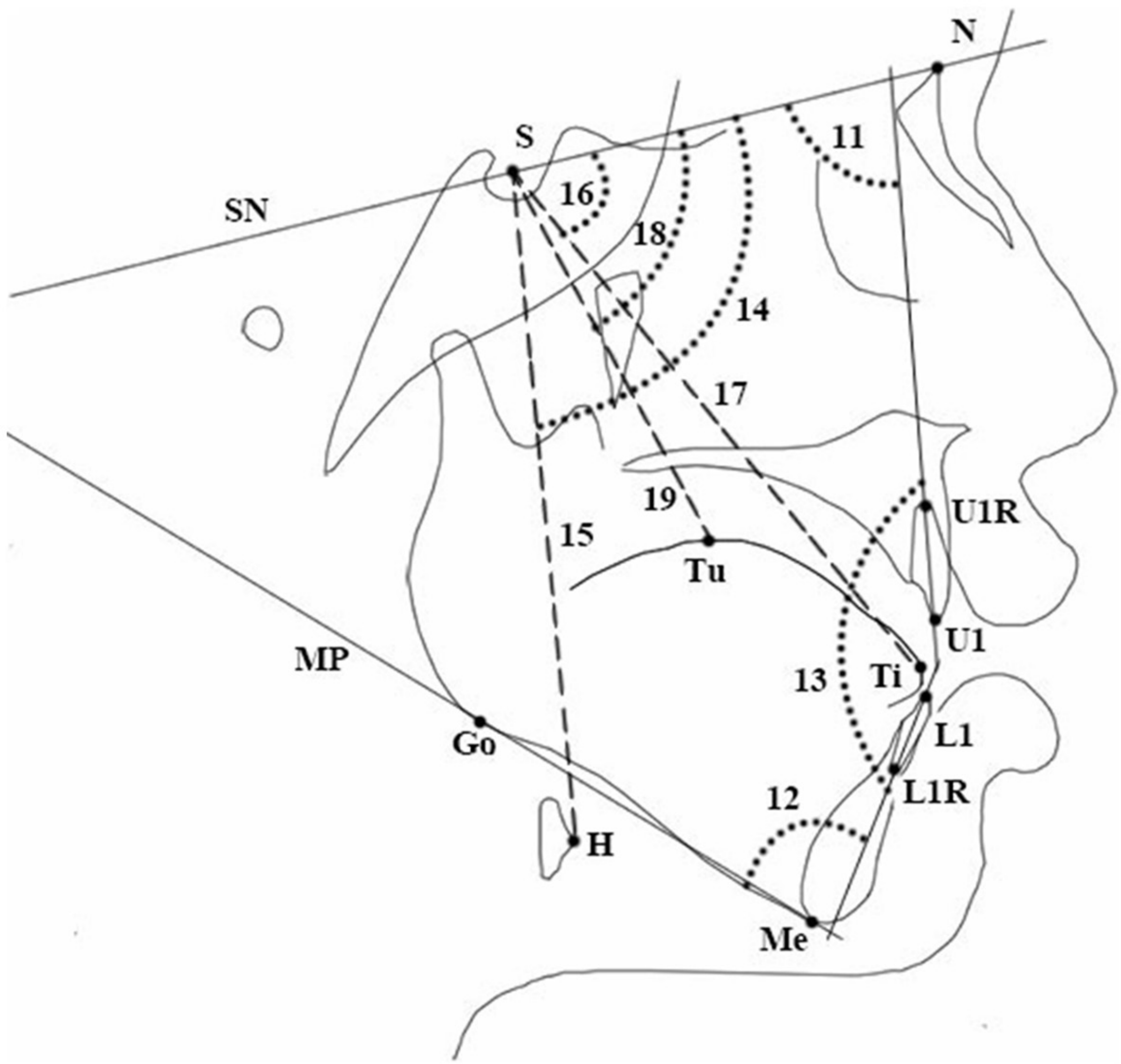

Figure 2. Schematic diagram for the anterior teeth position and the tongue position. (11) U1-SN (°); (12) L1-MP (°); (13) L1-U1 (°); (14) ∠NSH (°); (15) S-H (mm); (16) ∠NSTi (°); (17) S-Ti (mm); (18) ∠NSTu (°); (19) S-Tu (mm).

the tongue clearly on the cephalometric radiographs. Cephalometric radiographs were then taken on all subjects positioned in natural head position. Natural head position at rest is defined as the optical axis being parallel with the horizontal plane after adjusting the head and this position having a close relationship with craniofacial morphology [12]. The technique used was similar to that used by Solow where children were asked to stand in the middle of the cephalostat and adjust their head position up and down while looking into their eyes in a mirror 2.5 meters away [13]. In our study, this device was specially designed to uniform motion of the tongue muscle during the myofunctional exercise and the subjects were instructed to perform tongue myofunctional exercise using the device four times a day, and for five minutes per session. For the exercise, subjects lift up the tip of the tongue and make the bead rolled forward and upward by its pushing, finally press the bead to swallow. In order to adherence to TME, the children were awarded toys after they performed exercise per month successfully.

Cephalometric analysis

The Veraviewpocs X 550 (Morita Corp., Tokyo, Japan) was used to take the cephalometric radiographs (tube voltage 71 kv, current 6.3 mA). The distance between film and the tube

Table 1. Cephalometric landmarks and planes used in this research

	Points	Definition
Osseous landmarks	S	The midpoint of the cavity of sella turcica
	N	The anterior point of the intersection between the nasal and frontal bones
	Po	The midpoint of the upper contour of the metal ear rod of the cephalometer (machine porion)
	Or	The lowest point on the inferior margin of the orbit
	ANS	The tip of the anterior nasal spine
	PNS	The tip of the posterior spine of the palatine bone
	A	The innermost point on the contour of the premaxilla between anterior nasal spine and the incisor tooth
	B	The innermost point on the contour of the mandible between the incisor tooth and the bony chin
	Go	The midpoint of the contour connecting the ramus and body of the mandible
	Me	The most inferior point on the mandibular symphysis
	Gn	The center of the inferior point on the mandibular symphysis
	Pog	The most anterior point on the contour of the chin
Teeth landmarks	U1	Incisal edge of upper central incisor
	U1R	Root apex point of upper central incisor
	L1	Incisal edge of lower central incisor
	L1R	Root apex point of lower central incisor
Tongue position landmarks	H	The anterior point on the hyoid bone
	Tu	The top point on the dorsum of the tongue
	Ti	The most anterior point on the tip of the tongue
Cephalometric planes	SN	The plane through S and N
	FH	The plane through Po and Or
	MP	The plane through Go (L) and Me
	NP	The plane through N and Pog
	Y axis	The plane through S and Gn
	PP	The plane through ANS and PNS

NS = Non Significant.

Table 2. Reliability test of the experiment

	Repeated measuring (n=25)		*P* value
	d	Si	
∠SNA (°)	0.13	4.18	NS
∠SNB (°)	0.01	0.55	NS
∠ANB (°)	-0.03	0.3	NS
PP-SN (°)	0.08	0.5	NS
MP-SN (°)	0.01	0.58	NS
NA-PA (°)	-0.08	0.43	NS
NP-FH (°)	0	0.57	NS
SGn-FH (°)	-0.13	0.71	NS
S-Go (mm)	-0.04	0.67	NS
ANS-Me (mm)	0.14	0.65	NS
U1-SN (°)	-0.17	0.61	NS
L1-MP (°)	-0.01	0.72	NS
L1-U1 (°)	-0.07	0.56	NS
∠NSH (°)	-0.08	0.53	NS
S-H (mm)	0.19	0.44	NS
∠NSTi (°)	0.13	0.62	NS
S-Ti (mm)	0.1	0.43	NS
∠NSTu (°)	-0.65	2.23	NS
S-Tu (mm)	0.05	0.58	NS

NS = Non Significant.

focus was 165 cm. The distance between tube focus and patient was 150 cm. To confirm the true vertical line, a 0.18 inch stainless steel round wire with a plumb was fixed on the side of the ear rod.

WinCeph7.0 software (Rise Corp., Tokyo, Japan) was used to perform the cephalometric analysis. In this study, nineteen points and six reference planes were selected for analysis (**Figures 1**, **2**; **Table 1**). Ten parameters were used to quantify and describe the craniofacial skeleton including eight angular and two linear variables (**Figure 1**). There were three angular parameters to show the anterior teeth position and six parameters including three linear and three angular variables to express the tongue position (**Figure 2**).

Statistical analysis

Reliability was calculated to evaluate the accuracy of the method. Statistical analysis was conducted by SPSS software, Version 20.0 for Windows (SPSS Inc. Chicago, IL, USA). The films' landmarks of 25 patients were located and measured repeatedly at one week interval

Table 3. Descriptive statistics of craniofacial morphology and tongue position between the T0 group and control group

	T0 group (n=25)		Control Group (n=30)		*P* value
	Mean	SD	Mean	SD	
∠SNA (°)	80.01	4.39	83.11	5.24	0.023*
∠SNB (°)	79.05	4.73	76.8	3.66	0.052
∠ANB (°)	1.04	2	6.15	2	**
PP-SN (°)	5.82	3.67	7.72	4.06	0.077
MP-SN (°)	38.58	5.85	37.99	6.36	0.724
NA-PA (°)	4.45	4.19	13.54	3.11	**
NP-FH (°)	84.9	2.94	81.61	3.36	**
SGn-FH (°)	62.74	4.26	66.44	3.73	**
S-Go (mm)	55.17	3.91	60.2	5.13	**
ANS-Me (mm)	56.59	4.64	58.38	4.23	0.141
U1-SN (°)	96.79	10.4	95.24	5.92	0.491
L1-MP (°)	86.11	8.34	91.02	11.04	0.073
L1-U1 (°)	139.87	14.95	135.77	15.2	0.32
∠NSH (°)	89.21	6.06	90.13	5.6	0.561
S-H (mm)	77.8	5.81	80.16	7.31	0.197
∠NSTi (°)	57.71	4.86	61.15	2.95	**
S-Ti (mm)	75.17	5.32	72.93	2	0.037*
∠NSTu (°)	64.57	5.47	70.44	4.11	**
S-Tu (mm)	48.61	2.95	45.52	4.82	**

*$P < 0.05$; **$P < 0.01$.

by the same doctor, then the paired sample t test was used to evaluate the reliability. The differences between T0 group and the control group were tested by the independent sample t test. The differences between T0 group and T1 group were tested by the paired sample t test. All procedures were performed by one certified orthodontist.

Results

Measuring method reliability

There were no differences between the two times when the cephalometric radiographs of the 25 patients with class III malocclusion were measured after one week by the same observer (**Table 2**).

The differences between the T0 group and the control group

Statistical differences were seen between the subjects with class III malocclusion (T0) and the children with normal occlusion (**Table 3**). Compared with the control group, the S-Ti length ($P < 0.05$), the facial angle ($P < 0.01$) and the S-Tu length ($P < 0.01$) significantly increased, while the SNA angle ($P < 0.05$), the ANB angle, the Y axis angle, the convexity angle, the NSTu angle, the NSTi angle and the S-Go length statistically decreased ($P < 0.01$).

The differences between the T0 group and the T1 group

After 1.01 ± 0.02 years of TME, there seemed to be significant differences between T0 and T1 group (**Table 4**). The mandibular plane angle and the inferior face length decreased ($P < 0.05$), while the S-Go length increased ($P < 0.05$). The S-Tu length and the S-Ti length significantly decreased ($P < 0.01$). On the other hand, the NSTu angle and the NSTi angle significantly increased ($P < 0.01$).

Discussion

So far, a number of studies have attempted to explain the etiology of class III malocclusion. Some authors believed that it is inherited in a polygenic manner [4]. However, more and more researches have disclosed that the effect of environment, particularly the posture and pressure of the oral soft tissues, is closely related to class III malocclusion. The hypothesis put forward by Meenakshi et al suggested that skeletal class III malocclusion is related to long median lingual frenulum or a tongue-tie [8]. They found that the median lingual frenulum length was significantly longer in skeletal class III malocclusion than the skeletal class I and class II subjects. Moreover, Liu et al concluded that reducing tongue body volume in young pigs could slow craniofacial skeletal growth and anterior dental arch expansion during rapid growth, particularly mandibular symphysis portion and the anterior dental arch width [14]. Furthermore, Ruan et al stated that children with class III malocclusion have lower pressure of perioral forces compared to normal occlusion patients [15], they also found that the upper labial resting forces and the lower labial resting forces showed statistical differences between the two groups.

Table 4. Descriptive statistics of craniofacial morphology and tongue position between pre-(T0) and post-TME (T1) sessions in experimental group

	T0 (n=25)		T1 (n=25)		*P* value
	Mean	SD	Mean	SD	
∠SNA (°)	80.01	4.39	79.93	4.75	0.78
∠SNB (°)	79.05	4.73	78.58	4.39	0.31
∠ANB (°)	1.04	2.00	1.34	2.38	0.46
PP-SN (°)	5.82	3.67	6.58	4.04	0.32
MP-SN (°)	38.58	5.85	37.24	5.98	0.03*
NA-PA (°)	4.45	4.19	4.95	5.36	0.52
NP-FH (°)	84.90	2.94	84.56	3.88	0.72
SGn-FH (°)	62.74	4.26	63.72	4.68	0.34
S-Go (mm)	55.17	3.91	56.82	4.28	0.04*
ANS-Me (mm)	56.59	4.64	53.76	4.76	0.04*
U1-SN (°)	96.79	10.40	96.61	9.20	0.92
L1-MP (°)	86.11	8.34	86.16	8.77	0.97
L1-U1 (°)	139.87	14.95	138.64	13.91	0.46
∠NSH (°)	89.21	6.06	88.51	4.73	0.43
S-H (mm)	77.80	5.81	79.52	4.79	0.17
∠NSTi (°)	57.71	4.86	61.54	5.42	**
S-Ti (mm)	75.17	5.32	71.54	4.76	**
∠NSTu (°)	64.57	5.47	71.27	5.31	**
S-Tu (mm)	48.61	2.95	44.73		**

*$P < 0.05$; **$P < 0.01$.

Lower tongue posture may be one of the factors contributing to class III malocclusion [8, 16, 17]. Findings in this study demonstrated that the dorsum of the tongue was more inferior and the tip of the tongue was more anterior in class III malocclusion group compared with the control group. This is consistent with the previous research [7, 8, 14, 17, 18]. Liu et al and Ruan et al concluded that the tongue resting pressures on lingual side of the mandible and teeth are larger than the palatal side of the maxilla and teeth because of the abnormal tongue position that could lead to the mandibular protrusion [14, 18]. Also, Gross et al found that the abnormal craniofacial morphology including a narrow maxillary arch and long facial height was caused by a lower tongue position and that redirecting the pressure of the muscles enhanced treatment response [9]. In this research, the craniofacial morphology and tongue position in subjects with class III malocclusion treated with almost one year of TME were compared between pre-(T0) and post-TME (T1). It was found that the tongue position was lifted up as demonstrated by the NSTi and the NSTu angle significantly increasing, while the S-Ti length and the S-Tu length significantly decreasing.

Many methods to evaluate the tongue position have been used such as three-dimensional ultrasound, dynamic magnetic resonance imaging (MRI) or a pressure sensor [17, 19, 20]. Unfortunately, each of these methods has certain drawbacks such as complex operation, larger radiation doses, and high cost. Cephalometric radiographs are commonly used to evaluate craniofacial morphology and clarify the relationship between the teeth and jaws [21]. However, cephalometric radiographs have seldom been used to describe the tongue posture because the outline of the tongue is not clearly evident on the radiographs. The present study was asked to evaluate the method reliability. We found that there were no differences between the two times when the cephalometric radiographs of the 25 patients with class III malocclusion were measured after one week by the same doctor. In the research, the patients were more comfortable when we covered barium sulfate in the middle of tongue surface as 5 mm wide in comparison with covering the paste in the dorsum surface of tongue and it made the research more likely to be proceeded in spite of the subjects were too young. So this study demonstrated a simple and effective way using a barium sulfate paste to effectively identify the outline of the tongue on cephalometric radiographs.

The present study addressed the issue of how TME affects functional balance. The results demonstrate that TME changed not only the tongue position, but also craniofacial morphology. According to the equilibrium theory, pressures between the lips, cheeks and tongue should be in balance. If the dental arch were subjected to unequal forces, they would reposition to reestablish another balance [5]. Taslan et al found that a tongue crib appliance placed during the mixed dentition in open bite patients altered tongue position after one year which decreased tongue pressure on the maxillary incisors [22]. Also, Ozbek et al showed that maxillary expansion resulted in a higher tongue posture improving the pressure balance for children with maxillary constrictions and bilateral buccal crossbite [21]. According to the measurements performed on TME, it was found that the angle of the mandibular plane and the anterior low facial height decreased, while the posterior lower facial height increased, which seems to be adverse to treatment. Obviously, because of long-term pressure between the wire and tongue muscle, the maxillary second primary second molars were intruded, so that counterclockwise mandibular rotation was noted. Although there seems to be a complication, we believe that the rotation is helpful to the treatment of Class III malocclusion especially for the patients with high-angle.

However, considering other information found in the study, we must provide the limitations before getting these following conclusions. First, it should be noted that, because of collaboration of the subjects, duration of TME may not last enough time. Another important factor to be considered is the growth, which may influence tongue position and change the dentofacial morphology. However, according to the equilibrium theory, abnormal lower tongue position must be balanced by mandibular prognathism [6], so it is difficult to improve tongue position and the craniofacial morphology by growth. Iwasaki et al. [8] demonstrated that tongue position was raised by rapid maxillary expansion resulting in improvement of maxillary constriction in children with obstructive sleep apnea.

Conclusion

The tongue myofunctional exercises may change the tongue position and the craniofacial morphology. It could be an auxiliary therapy during the treatment of class III malocclusion.

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Disclosure of conflict of interest

None.

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