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Case Presentation

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Two-Stage Treatment for a Growing Patient with Severe Skeletal Class III Malocclusion and Open Bite: A Case Report

Shiqi Sun, Tianjiao Huang, Yutong Cui, Yujia Han and Yulou Tian*

Department of Orthodontics, School of Stomatology, China Medical University, China

***Corresponding author:** Yulou Tian, Department of Orthodontics, Stomatological Hospital Affiliated to China Medical University, No. 117, Nanjing North Street, Shenyang, Liaoning, China, Tel: 024-31927709; E-mail: yltian@cmu.edu.cn

Abstract

The etiology and mechanism should be paid more attention to in the diagnosis and treatment of Class III malocclusion in childhood. Bad tongue habits may cause forward and downward displacement of the mandible, resulting in the skeletal effect of mandibular sagittal and vertical overgrowth development, which finally manifests as a skeletal Class III malocclusion with open bite. This case report describes the early interceptive orthodontic treatment and growth improvement of a 9-year-old female patient with a skeletal Class III malocclusion, open bite, poor posture of the tongue and tongue thrusting habit. Instead of the conventional tongue crib, we use modified tongue crib to increase the comfort and use the strength of tongue muscle to promote the growth of maxilla, combined with chin cup to control the sagittal and vertical growth of the mandible, followed by a simple stage II fixed orthodontic treatment. We corrected the open bite and crossbite, established a normal overjet and overbite of anterior teeth, and created ideal occlusion with Class I relationship. The correction effect was satisfactory, and remained stable for a long period. This case shows that modified tongue crib combined with chin cup is a simple and efficient treatment option for children with a skeletal Class III malocclusion, so as to avoid the surgical treatment in adulthood.

Keywords: Early treatment; Class III treatment; Retention and stability; Modified tongue crib

Introduction

The incidence of Class III malocclusion in Asian population is up to 13% **[1,2],** higher than that in white population **[3-6].** Skeletal Class III malocclusion is characterized by craniofacial and dental imbalance **[7],** which is excessive mandibular development, insufficient maxillary development, or both **[8-10].** The etiology of skeletal Class III malocclusion involves two factors: heredity and environment. The latter includes unfavorable growth, bad oral habits such as tongue habits **[6].** This malocclusion is of the most complex to diagnose and treat. Therefore, making a clear diagnosis is primary to start orthodontic treatment as soon as possible, so as to avoid further skeletal deformities. Treatment methods include growth modification in early growing period, dental camouflage and orthognathic surgery once the growth stops **[11].** For patients who are still in the growth and development stage, orthodontists should actively take early treatment measures to reduce the possibility of surgery in adulthood. Some studies have indicated that it is recommended to monitor tongue posture, especially in skeletal Class III patients, and a comprehensive treatment for them should include the correction of improper tongue posture in order to improve treatment efficiency and post-treatment stability **[12].** It has been confirmed that tongue cribs can effectively correct bad tongue posture, promote maxillary forward growth, and combined with chin cup, prevent the mandible from going ahead **[13].** Anterior Open Bite (AOB) is defined as the lack of vertical overlap between the upper and lower incisors **[14].** Bad tongue habits such as lower tongue posture and tongue thrusting have been reported as pathogenic factors **[15-17]** and secondary tongue habits will make open bite worse. Therefore, orthodontic treatment should be started as soon as possible to correct bad tongue habits and prevent serious skeletal deformities **[18].** Early treatment of AOB is implemented by preventing mechanical factors that lead to open bite (such as tongue thrusting) and limiting the excessive vertical growth of craniofacial bones **[19-22].** Some studies claim that tongue cribs achieve long-term stability by correcting bad tongue posture and tongue thrusting **[23].**

In this case report, we describe an early interceptive orthodontic treatment and a following fixed orthodontic treatment of a 9.5-year-old female patient with a skeletal Class III malocclusion, open bite, poor posture of the tongue and tongue thrusting habit. We used a modified tongue crib combined with chin cup to treat her so that the insufficient maxilla can grow forward and the mandible can return to normal position, while the mandibular vertical growth was controlled. Then we used fixed appliances to adjust and refine the occlusal relationship. The outcome of treatment was significantly improved and a long-term stability was achieved. In conclusion, this

case provides a new way to treat a skeletal Class III malocclusion with open bite in childhood effectively and efficiently and avoid the surgical treatment in adulthood.

Diagnosis and Etiology

The patient was a 9.5-year-old girl without family history of similar malocclusion. According to her mother's description, there was no occlusal contact between upper and lower anterior teeth, which gradually got worse and the girl had tongue thrusting and mouth breathing habit for 5 years. Facial photographs showed a Class III profile with a protruded mandible and an everted lower lip. The patient's smile exposed a lower tongue posture **(Figure 1A and B).** Intraoral photographs and dental casts showed a bilateral Class III molar and canine relationship with open bite in anterior teeth and premolars area (maximum reaches 5.5 mm) as well as anterior crossbite. More importantly, lower tongue posture can be seen in the mouth floor. In addition, 13 did not erupt completely, four second primary molars did not fall off, and none of the second permanent molars was seen yet. The midlines of maxillary and mandibular dental arch were not aligned **(Figure 2 and 3).** The panoramic radiograph showed no congenital missing teeth, no supernumerary teeth, normal root development of permanent teeth and good periodontal condition. Besides, four third molar germs were shown **(Figure 1D).** The cephalometric analysis showed a skeletal Class III malocclusion (ANB: 0.2°; Wits: -7.3mm) due to maxillary insufficiency (SNA: 77.6°) with higher mandibular angle (GoGn-SN: 40.7°). The maxillofacial region had a vertical growth pattern (S-Go/N-Me: 58.1%) and a Class III with open bite growth tendency (A.P.D.I: 89.6°; O.D.I: 56.6°; the three angle: 402.6°). The upper and lower incisors were labially inclined (U1-SN: 111.3°; L1-MP: 100.7°). Alveolar bone in upper and lower anterior teeth area was vertical hypoplasia (U1-PP length: 22.1 mm; L1-MP length: 34.9 mm). Soft tissue showed a severe skeletal Class III profile with protruded lower lip (LL-Eline: 9.0 mm). The lower edges of the third and fourth cervical vertebrae were still flat, while the lower edge of the second cervical vertebrae was slightly curved, which indicated CVMS2 according to Baccetti T's improved Cervical Vertebra Maturation method. There was still a certain growth potential and the peak in mandibular growth might come more than one year after this stage. We also observed suspected adenoid hypertrophy, which was diagnosed by the ENT Department in The First Hospital of China Medical University, but the girl and her mother refused surgical operation **(Figure 1C and Table 1).** On the basis of above medical records, the patient was diagnosed with a skeletal Class III malocclusion, open bite, poor posture of the tongue and tongue thrusting habit.

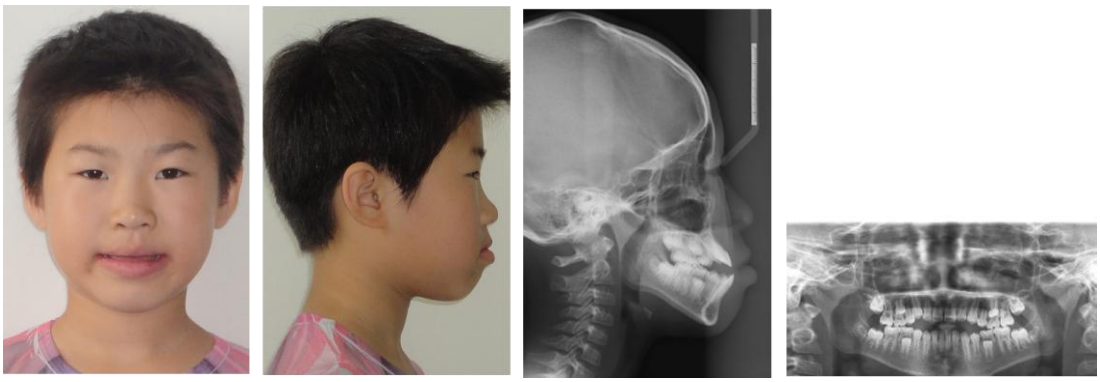

Figure 1: Pretreatment (extraoral): (A) Front view; (B) Profile view. Pretreatment (radiography) (C) cephalometric; (D) Panoramic.

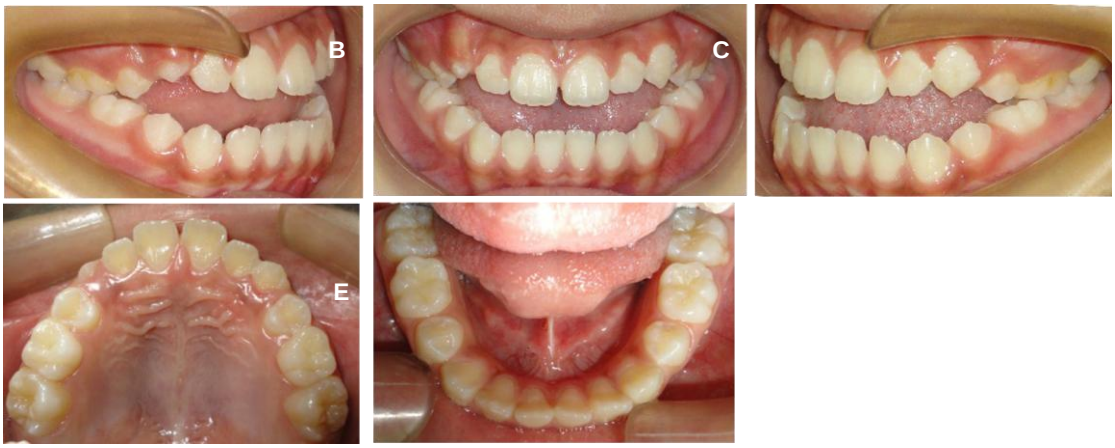

Figure 2A-E: Pretreatment (intraoral).

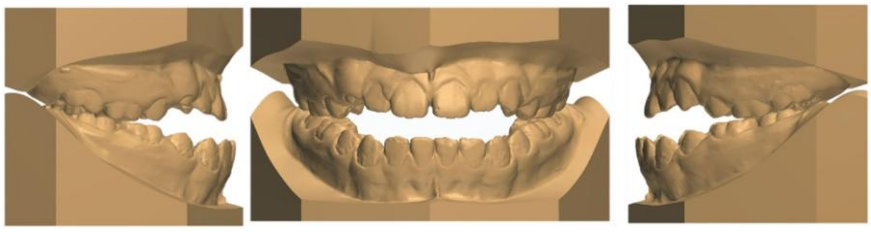

Figure 3A-C: Pretreatment (digital).

Table 1: Cephalometric analysis.

Measurement	Pre-treatment	Stage-1 finished	Post-treatment	Norm
Skeletal analysis				
SNA(°)	77.6	78.9	80.6	82.3±3.5
SNB(°)	77.4	77.8	79.1	77.6±2.9
ANB(°)	0.2	1.1	1.5	4.7±1.4

GoGn-SN(°)	40.7	41.3	39.5	36.1±4.6
A.P.D.I(°)	89.6	87.8	88.5	81.0±4.0
O.D.I(°)	56.6	58.7	62.1	73.0±5.0
Wits(mm)	-7.3	-3.5	-3.8	-1.4±2.6
The three angle(°)	402.6	402.2	401.2	396.0
S-Go/N-Me(%)	58.1	59.3	60.4	63.5±1.5
Dental analysis				
U1-SN(°)	111.3	114.1	111.7	104.8±5.3
U1-PP(mm)	22.1	22.9	25.9	26.0±2.0
L1-MP(°)	100.7	86.7	90.4	94.7±5.2
L1-MP(mm)	34.9	37.7	41.1	38.0±2.2
Overbite(mm)	-5.5	-0.9	2.1	2.0±1.0
Overjet(mm)	-2.9	1.0	1.0	2.0±1.0
Facial analysis				
UL-Eline	2.2	2.9	2.5	1.0±2.0
LL-Eline	9.0	6.0	5.0	2.0±2.0

Norm values are presented as numbers or mean ± standard deviation.

SNA, Sella-Nasion-A point; SNB, Sella-Nasion-B point; ANB, A point-Nasion-B point; GoGn-SN, the angle between the SN plane and Gonion-Gnathion plane; A.P.D.I, the sum of facial angle, AB plane angle and palatal plane angle, an indicator reflecting the coordination of the sagittal relationship between the maxilla and the mandible; O.D.I, the angle between the AB plane and the mandibular plane+palatal plane angle, an indicator reflecting the coordination of the vertical relationship between the maxillary and the mandible; The three angle, the sum of Saddle angle (Nasion-Sella-Articulare), Artical angle (Sella-Articulare-Gonion), and Gonial angle (Articulare-Gonion-Menton),an indicator reflecting growth pattern; S-Go/N-Me, the ratio of back height (Sella-Gonion) to front height (Nasion-Menton), used to evaluate facial height and growth pattern; U1-SN, the angle between the upper incisor axis and the Sella-Nasion plane; U1-PP, the perpendicular length from the edge of the upper incisor projected to the palatal plane; L1-MP(°), the angle between the lower incisor axis and mandibular plane;L1-MP (mm), the perpendicular length from the edge of the lower incisor projected to the mandibular plane; Eline, a straight line connecting the tip of nose and the chin button; UL-Eline, upper lip to Eline; LL-Eline, lower lip to Eline.

Treatment Objectives

- Eliminate the functional cause of open bite and anterior crossbite.

- Coordinate skeletal sagittal relationship by promoting maxillary growth and inhibiting mandibular growth in early treatment.
- Create an ideal overbite and overjet and adjust the midline.
- Establish a Class I molar relationship.
- Improve skeletal Class III soft tissue profile.

Treatment Alternatives

The first alternative was not to start any treatment in this period and take combined orthodontic and orthognathic surgery in adulthood. Preoperative orthodontic treatment was dental decomposition, which could establish normal upper and lower anterior teeth inclination. And the surgery could correct Class III relationship and achieve an ideal soft tissue profile. However, the patient's parents expected to start treatment early to avoid surgery if possible. The second alternative was early interceptive orthodontic treatment that obtains growth modification of maxilla and mandible by making full use of the growth potential. One appliance option was the maxillary protraction facemask, but many clinical cases had shown that face mask was too uncomfortable for children to cooperate, which had an uncertain effect. Another appliance option was the modified tongue crib combined with chin cup. The modified tongue crib was more comfortable and makes children easier to cooperate which were also more suitable for patients with tongue habits. Open bite and anterior crossbite could be corrected by eliminating the functional cause. Sagittal relationship could be coordinated and soft tissue profile could be improved. Considering the requirement of patient's parents and the indication of appliance, the second appliance option was suggested. Besides, fixed orthodontic camouflage treatment was necessary to adjust molar relationship after early interceptive treatment.

Treatment Progress

In stage 1, the modified tongue crib was used as intraoral appliance and chin cup was used in combination as extra oral appliance. Intraoral appliance consisted of arrow clasps, tongue cribs and plastic base. The arrow clasps were clamped on two upper first molars, using undercut to achieve retention. Two tongue cribs should be bent into proper radians, and separated in the middle to avoid tongue frenulum **(Figure 4A-C).** Intraoral appliance required patient to wear it except tooth brushing period. Tongue should be placed in the cribs all the time to use the force of tongue muscle to promote maxillary forward growth.

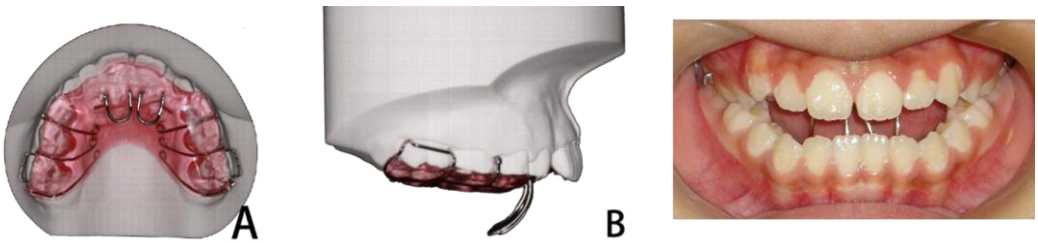

Figure 4: the modified tongue crib: (A) Front view; (B) Lateral view; (C) Intraoral view.

Two 3/8, 3.5 oz elastics were used on each side to connect the first and second hooks of head cap with the hooks of chin cup. Through the high traction, the vertical relationship was controlled while the excessive growth of mandible was inhibited. Extra oral appliance required patient to wear it at least 14 hours every day. After 3 months, open bite was improved significantly and the second primary molars on both sides began to establish occlusal contact, but the bad tongue posture still existed **(Figure 5A-C).** After 10 months, open bite and anterior crossbite was corrected and the upper and lower incisors established slight overbite and overjet. The profile was improved a lot and the tongue returned to the normal position **(Figure 6-8).** The first stage treatment was completed after 4 months of retention and the treatment effect was stable.

Figure 5A-E: 3months (intraoral).

Figure 6: Stage 1 finished (extraoral and radiography): (A) Front view; (B) Profile view; (C) cephalometric.

Figure 7A-C: Stage 1 finished (intraoral).

Figure 8A-C: Stage 1 finished (digital).

After another 8 months of observation, non-extraction orthodontic camouflage treatment with Straight Arch Wire Technique was taken in stage 2. 0.014 and 0.016 inch Ni-Ti arch wires were used for leveling and aligning and the tongue crib was still worn at night. Then 0.014×0.025 inch Ni-Ti wires, 0.016×0.022 and 0.017×0.025 inch stainless steel wires with Class I and Class III intermaxillary traction were used to retract lower anterior teeth and adjust the midline. After 28 months of fixed treatment, the patient and her parents were satisfied with the effect and agreed to end the treatment **(Figure 9-11)**. Hawley retainer with tongue cribs was required to wear every day to prevent the relapse of open bite caused by poor tongue posture.

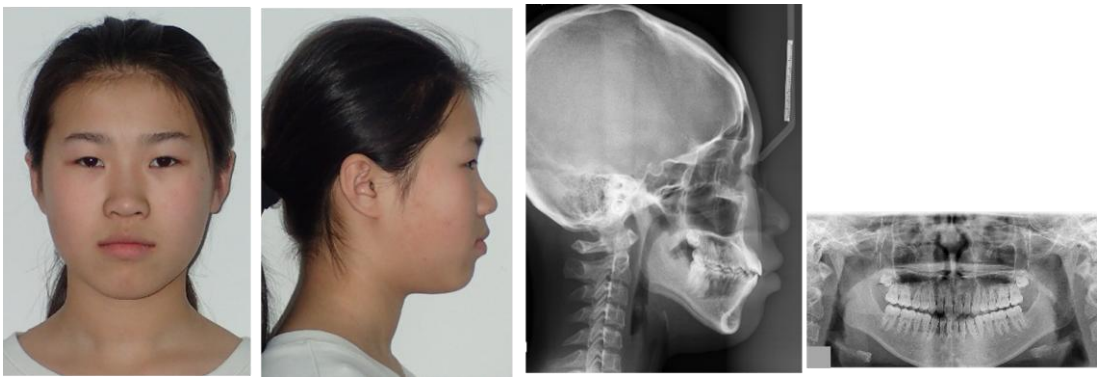

Figure 9: Post treatment (extraoral): (A) Front view; (B) Profile view. Post treatment (radiography) (C) cephalometric; (D) Panoramic.

Figure 10A-E: Post treatment (intraoral).

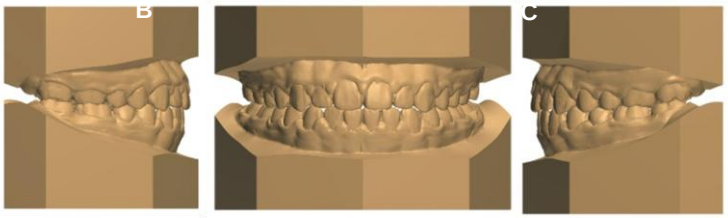

Figure 11A-C: Post treatment (digital).

Treatment Results

After stage 1, the open bite and anterior crossbite was improved by eliminating bad tongue habits. The cephalometric results showed that the growth of the posterior facial height was more than that of the anterior

and the facial height ratio was improved. Therefore, the vertical growth pattern was controlled to a certain extent. In the sagittal aspect, the development of maxilla was promoted, and the skeletal Class III deformities were intervened. After stage 2, the anterior overbite and overjet was basically back to normal (OB from -5.5 to 2.1 mm, OJ from -2.9 to 1.0 mm) and the posterior occlusal relationship achieved stability with the bilateral first molars reaching Class I relationship. The profile was obviously improved through the retraction of lower lip. Comparing the cephalometric results before and after the treatment, Wits and SNA was significantly improved because of maxillary alveolar point A moving forward relatively, suggesting the sagittal development of maxilla. Although it cannot be used as a prognostic evaluation standard, the improvement of APDI and ODI can also indicate the forward movement of point A. The cephalometric superimposition showed the forward and downward growth of the alveolar bone in the maxillary anterior teeth area and the retraction of the lower anterior teeth **(Figure 12).** Since the patient was with a serious skeletal Class III malocclusion, the occlusal stability should be closely observed after treatment in the future. A 2.5-year return visit showed a slight relapse, but the soft tissue profile was still ideal **(Figure 13-14).**

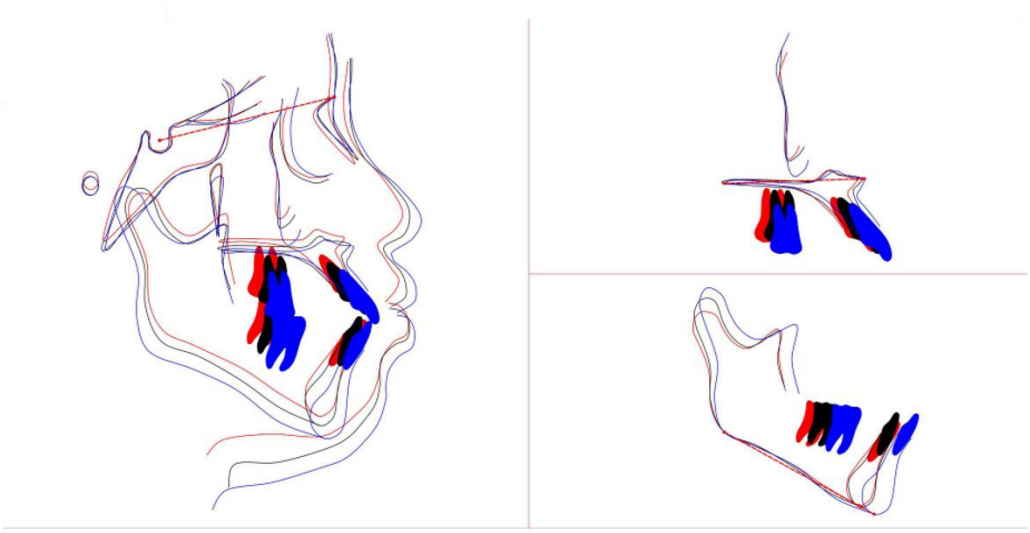

Figure 12: cephalometric superimposition (red lines: pretreatment; black lines: after Stage 1; blue lines: post treatment).

Figure 13: 2.5-year return visit (extraoral): (A) Front view; (B) Profile view.

Figure 14 A-C: 2.5-year return visit (intraoral).

Discussion

The mechanism of open bite and anterior crossbite caused by poor tongue posture and habits

The tongue not only plays an important role in chewing, swallowing, speaking, respiring and other aspects, but also participates in maintaining the internal and external dynamic balance of the dental arch [24]. Under normal circumstances, the muscle strength of lips and tongue maintains the balance. Wang et al. [25] found that the total tongue area, tongue body area and tongue body length were greater in patients with Class III malocclusion than in patients with Class II malocclusion, and concluded that the sagittal size of tongue body was different between patients with Class II and Class III malocclusion, and was closely correlated with the length of mandible. Taslan et al. [26] found that the pressure of the tongue on the teeth was significantly lower after being treated with tongue crib appliance than before, and was still significantly lower after the orthodontic treatment. All these studies suggest that the size, position and habit of tongue are closely related to the formation of anterior crossbite and the stability of orthodontic treatment. Large tongue, poor tongue posture and habits can break the balance. The tip of the tongue is habitually placed between the upper and lower anterior teeth, impeding the eruption of the upper and lower anterior teeth and alveolar bone, causing the labial inclination of the upper and lower anterior teeth, the separation of the occlusal plane, and the upper arch and maxilla to lose their original

tongue stimulation, while the lower arch and mandible to receive abnormal muscle strength, resulting in open bite and anterior crossbite or even severe skeletal Class III malocclusion.

Orthodontic treatment principle of the modified tongue crib appliance

In the past, the tongue crib appliance was mostly used to treat the open bite in clinical practice **[23],** and was effective in preventing relapse **[27].** In a study by Liu et al. **[28],** the orthodontic efficacy of the modified tongue crib appliance and the maxillary protraction facemask was compared by analyzing the changes in indicators before and after the orthodontic treatment of anterior crossbite, and the results showed that both could promote maxillary development and rotate the mandible clockwise, effectively correcting anterior crossbite. Thus, it implies that the modified tongue crib appliance can achieve good orthodontic effect and stability when treating open bite and anterior crossbite with poor tongue posture and habits. The research of Tian et al. **[29]** demonstrates that the modified tongue crib appliance makes the tongue be forced to lift upward behind the cribs, and the muscle strength of tongue is transmitted to maxilla through the plastic base and cribs, producing a continuous forward and downward force on it, thus promoting the growth and development of maxilla. Besides, wearing the appliance eliminates the abnormal forward and downward force of tongue on the lower anterior teeth, dental arch and mandible, which contributes to the correction of open bite and anterior crossbite. It must be emphasized that regardless of the patient's dental stage, as long as the bad habits are not removed, there is a possibility of relapse. Therefore, functional training of tongue should be carried out throughout the orthodontic treatment. A study concluded that the tongue should be tightly attached to the palate. Tongue muscle training is a functional orthodontic training that could effectively enhance the function of digastrics, masseter and temporal muscles, restore normal tongue muscle function, and then enhance the treatment effect, promote the recovery of occlusal function **[30].** Return visit showed that the anterior overjet and overbite was reduced. The main reason considered to be the vertical growth pattern and the tongue still having a low frequency of poor posture. We took some measures to maintain the stability of the orthodontic effect, firstly, we performed appropriate overcorrection to increase the anterior overbite; secondly, tongue cribs were added to the retainers, and the patient was instructed to insist on functional training of tongue to prevent relapse.

Summary and Conclusions

The most important aspect of this case report was the early interceptive orthodontic treatment of Class III malocclusion with open bite and anterior crossbite in mixed dentition. Early treatment is widely advocated by most orthodontists. Several treatment appliances have been used for this type of patients in clinical practice and

the modified tongue crib has been proved to be a simple and efficient treatment option.

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