Journal of Zhejiang University SCIENCE B
ISSN 1673-1581 (Print); ISSN 1862-1783 (Online)
www.zju.edu.cn/jzus; www.springerlink.com
E-mail: jzus@zju.edu.cn

Pressure from the lips and the tongue in children with class III malocclusion*

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Received Nov. 12, 2006; revision accepted Jan. 18, 2007

Abstract: Objective: To discuss possible relationships between class III malocclusion and perioral forces by measuring the pressure from the lips and the tongue of children with class III malocclusion. Methods: Thirty-one children with class III malocclusion were investigated and their perioral forces were measured at rest and during swallowing under natural head position by a custom-made miniperioral force computer measuring system. Results: The resting pressures exerted on the labial side and palatine side of the upper left incisor, as well as the labial side and lingual side of the lower left incisor, were 0 g/cm^2, 0 g/cm^2, 0.57 g/cm^2 and 0.23 g/cm^2, respectively. Correspondingly, the swallowing forces were 2.87 g/cm^2, 5.97 g/cm^2, 4.09 g/cm^2 and 7.89 g/cm^2, respectively. No statistical difference between muscular pressure and gender existed. During swallowing, the lingual forces were significantly higher than the labial forces ($P<0.01$), however, at rest there was no significantly different force between these two sides. Compared to the normal occlusion patients, children with class III malocclusion had lower perioral forces. The upper labial resting forces ($P<0.01$), the lower labial resting forces ($P<0.05$) and all the swallowing pressures from the lips and the tongue ($P<0.01$) showed statistical differences between the two different occlusion conditions. Meanwhile, no significant difference was found for the resting pressure from the tongue between class III malocclusion and normal occlusion. Conclusion: Patients with class III malocclusion have lower perioral forces and this muscle hypofunction may be secondary to the spatial relations of the jaws. The findings support the spatial matrix hypothesis.

Key words: Deciduous dentition, Perioral force, Pressure transducer, Class III malocclusion
doi:10.1631/jzus.2007.B0296 **Document code:** A **CLC number:** R788

INTRODUCTION

Class III malocclusion is common in children with deciduous teeth and its morbidity is close to 11% in Chinese (Ruan and Huang, 1999) whereas it is only 4% in Whites (van Vuuren, 1991). Although the etiology for this malocclusion is complex, the effect of muscular function is highly regarded (Singh, 1999). Concerning the effect of muscular function on the maxillofacial morphology, many scholars (Jung *et al.*, 2003; Takahashi *et al.*, 1999; Thüer *et al.*, 1999) have studied the perioral forces exerted on the mixed and permanent dentition utilizing various techniques. So far, no report has defined the perioral forces acting on the deciduous dentition. Muscular pressures can influence teeth position and dental arch stability. Measuring of the deciduous muscle pressure showed that orthodontics may impede or even prevent malocclusion development in childhood.

In our previous study, we developed a strain gauge computer-aided measuring device, specifically designed to measure the perioral pressure acting on the deciduous dentition. Data were gathered from children with normal occlusion and their characteristics were discussed (Ruan *et al.*, 2005). This present study was designed to define the perioral forces acting on class III malocclusion patients and to elucidate possible relationships between class III malocclusion and perioral force.

* Project (No. 2002ZX040) supported by the Health Bureau of Zhejiang Province, China

MATERIALS AND METHODS

Subjects

Thirty-one children (17 boys and 14 girls) aged 4~6 years were investigated. The inclusion criteria were an intact deciduous dentition, a crossbite of the four upper incisors by the six lower incisors, and general good health which included no bad oral habits and no history of orthodontic treatment. Children with any loose deciduous teeth and any erupted permanent teeth were excluded.

Measurement apparatus and positions

A strain gauge computer-aided measuring device with a transducer thickness of only 0.7 mm was used for the measurement (Ruan *et al*., 2002). Briefly, the transducer was comprised of strain gauges and a cantilever insulated with silicone rubber. Two 120-ohm strain gauges were positioned on the upper and inferior surfaces of a niobium (Nb) strip respectively, which had one end welded with a multi-layer web-shaped steel base to detect the distortion of the spring strip. The strain gauges were combined with two fine resistors to form a Wheatstone bridge circuit. The fan-out of this bridge was connected to a PCLab biological signal collecting-processing system (Beijing Microsignalstar Technology Company, Beijing, China) that together formed the computer-aided muscular pressure-measuring system.

The transducers were cemented to the central surfaces of the teeth with Jing-jing enamel adhesive (Tianjing Synthesizing Material Institute, Tianjing, China). The measured surfaces included the labial surface of the upper left incisor (LaUI), the palatal surface of the upper left incisor (PaUI), the labial surface of the lower left incisor (LaLI) and the lingual surface of the lower left incisor (LiLI). After placement, all transducer leads were bundled and emerged between the lips at the corner of the mouth.

Measuring procedure

The pressure was measured in the following order before orthodontic treatment: LaUI, PaUI, LaLI, LiLI. Two different oral functions (i.e. resting status and swallowing status) were assessed in this study. For each mouthpiece placement, registrations were recorded at rest, during the swallowing of water, and then repeated in this order three times. For the water-swallowing test, the child was given 3 ml of boiled water via syringe in his or her mouth and asked to swallow on command. At rest, the device recorded the resting pressure, and during swallowing, the device registered a swallowing pressure wave. The maximum value of the pressure wave was used as the functional pressure. In addition, the mean values were calculated in triplicate for the two experimental conditions and the intraindividual mean values were used for further statistical evaluation. All of the measurements were carried out under the natural head position (Leitao and Nanda, 2000).

Statistical analysis

The data were entered into a computer database and SPSS (SPSS 11.5 for Windows, Statistics Package for Social Science, SPSS Inc., Chicago, IL, USA) was used to perform the statistical analysis. The median, maximum and minimum for each variable were calculated.

Mann-Whitney U-test was used to compare genders, oral functions, or occlusion types. Significance was established at the 5% level.

RESULTS

Muscle forces and gender

No statistical difference was identified for the resting perioral forces between boys and girls, whereas the lower lip force from the boys had a tendency to be higher than that of the girls. Also, the upper lip pressure was almost zero for either gender (Table 1).

Table 1 Relationship between perioral forces (g/cm^2) and gender at rest for class III malocclusion*

Measurement sites	Boys		Girls	
	Median	Min/max	Median	Min/max
LaUI	0	−0.63/0.11	0	−1.25/0.78
PaUI	0	−0.11/0.57	0	0/0.37
LaLI	0.69	0/1.67	0.35	−0.28/1.67
LiLI	0.57	−0.79/1.57	0.12	0/1.67

* No statistical difference

Additionally, the pressure exerted on both labial and lingual sides of the lower anterior teeth and on the labial upper anterior teeth during swallowing was almost equivalent between boys and girls (Table 2). However, the tongue pressure on the anterior upper teeth tended to be higher in boys than in girls. So that no significant difference was found between genders for the swallowing perioral forces.

Table 2 Relationship between the perioral forces (g/cm^2) and gender during swallowing for class III malocclusion*

Measurement sites	Boys		Girls	
	Median	Min/max	Median	Min/max
LaUI	2.87	−5.26/15.78	2.81	−0.47/10.83
PaUI	6.76	−1.61/20.48	3.83	2.30/10.21
LaLI	4.09	1.04/28.76	4.39	1.41/17.82
LiLI	7.67	1.86/45.87	8.93	2.33/36.81

*No statistical difference

Muscle forces between the labial side and the lingual side

At rest (Fig.1), the upper lip and tongue pressures on the upper incisor were the same 0 g/cm^2, while the labial and lingual forces on the lower incisor were 0.57 g/cm^2, 0.23 g/cm^2, respectively. For these incisors, there were no significantly different forces between the labial and the lingual sides.

For the upper incisor, the labial force and the lingual force during swallowing (Fig.1) were 2.87 g/cm^2, 5.97 g/cm^2, respectively. There was a statistical difference between the two sides (P<0.01). Likewise, the pressure exerted on the labial and lingual surfaces of the lower incisor was 4.09 g/cm^2 and 7.89 g/cm^2, respectively. A significant difference was found between the two sides (P<0.01).

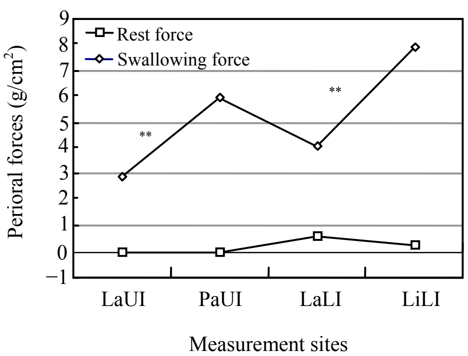

Fig.1 Muscle pressure on the labial side and the lingual side
No significant difference of the rest forces while statistical significance was found in the swallowing forces. $^{**}P$<0.01

Muscle forces and oral functions

Fig.2 shows that the muscle forces vary with different oral functions. While at rest, the pressure from the lips and the tongue was much lower. During swallowing, the perioral forces from the four studied regions obviously increased, dramatically up to 20~30 times. For the four areas, statistically significant differences existed between the different oral functions measured (P<0.001).

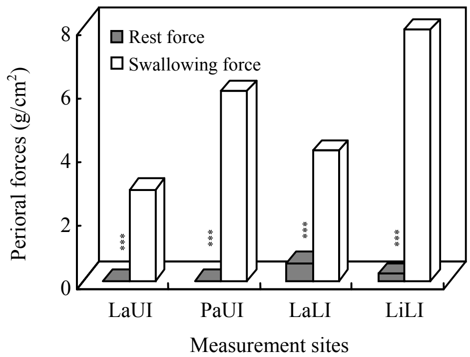

Fig.2 Perioral forces and oral functions
Statistical differences were found between rest status and swallowing status. $^{***}P$<0.001

Class III malocclusion and normal occlusion

In our previous study, we measured the perioral forces exerted on the deciduous teeth with normal occlusion (Ruan *et al.*, 2005). Independent of oral function type, children with class III malocclusion had less perioral forces than children with normal occlusion (Figs.3 and 4). For the upper incisors (Fig.3), the labial pressure at rest was significantly lower for class III malocclusion patients than for normal occlusion patients (P<0.01). At the same time,

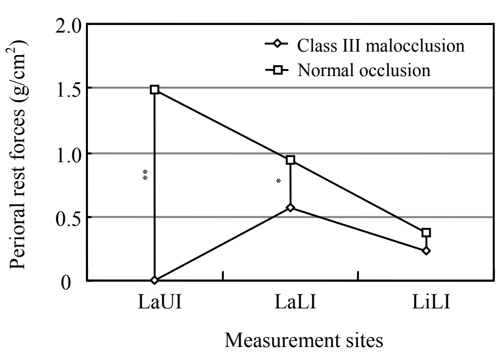

Fig.3 Comparison of the perioral forces at rest between class III malocclusion and normal occlusion
$^{**}P$<0.01, $^{*}P$<0.05

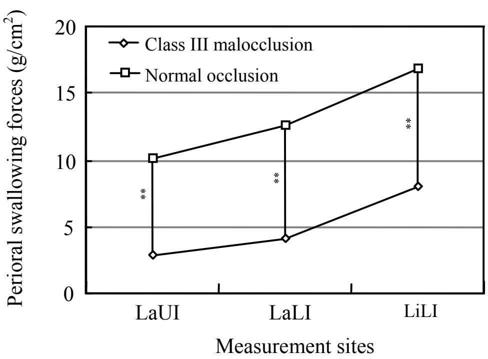

Fig.4 Comparison of the perioral forces during swallowing between class III malocclusion and normal occlusion
$^{**}P<0.01$

the labial pressure at rest for the lower incisor was also statistically reduced for class III malocclusion patients than for normal occlusional children ($P<0.05$). Nevertheless, the lingual pressure at rest for the lower incisor showed no significant difference between the two types of occlusion (Fig.3). Fig.4 illustrates that both labial and lingual pressure on the upper and lower anterior incisors during swallowing showed significant differences between normal occlusion and class III malocclusion ($P<0.01$).

DISCUSSION

Gender distinction

The relationship between perioral forces and gender still remains unclear. Li and Lin (1993) found that in individuals with a normal incisor relationship, the upper lip swallowing pressure tended to be higher in girls than in boys. Conversely, Yuan and Fu (1998) demonstrated obvious variance between forces and sex. They speculated that the perioral forces for males were higher than those for females. In fact, the same trend was displayed in our previous study concerning normal deciduous dentition. For normal primary dentition (Ruan *et al*., 2005), the muscle pressure at rest for boys was higher than for girls, especially for the buccal surface of the upper first deciduous molar ($P<0.05$). In the same study, the labial forces during swallowing were also significantly higher for boys than for girls ($P<0.01$).

Our present study reveals, however, that this is not the case for individuals with various types of malocclusion. According to our results, there was no significant difference between genders at rest even though the lower lip and lingual pressure for boys was slightly higher than those for girls (Table 1). In addition, the labial forces acting on this malocclusion during swallowing were almost equal between boys and girls (Table 2). Our findings concur with that of Thüer and Ingervall (1986) who found no sexual difference for lip pressure of malocclusion patients. Presumably, labial muscle function may be altered when malocclusion occurs. For example, hypofunction of the labial muscle may be a feature of class III malocclusion.

Muscle forces and dentition dynamic equilibrium

Our earlier study (Ruan *et al*., 2005) showed that the forces from the lips and the cheeks at rest are higher than those from the tongue, while the lingual force is larger than labial force during swallowing. The equilibrium state is believed to influence the position and stability of the teeth, to promote the development of jaws and to establish a stable occlusion.

The outcomes from this study for children with class III malocclusion suggest that no significantly different perioral forces exist on the incisors at rest, even though the force from the lower lip are larger than those from the tongue (Fig.1). On the contrary, the lingual forces during swallowing (Fig.1) are statistically higher than the labial pressure ($P<0.01$), which may be due to the various tongue positions for patients with class III malocclusion. Zhou and Fu (1995) compared the swallowing pattern between normal occlusion and skeletal class III malocclusion in adults. They observed that the tongue, the hyoid bone and the mandible for class III malocclusion patients were in a much lower position than normal occlusion subjects. Moreover, a larger gap separation existed between the upper and the lower lips. Apparently, this specific tongue and lip position causes changes in perioral forces.

Possible relationships between class III malocclusion and perioral force

Research on malocclusion indicated that lip pressure exerted on the upper incisors was higher in class II division 1 than in class I malocclusion, and was lowest in children with class II division 2 malocclusion (Thüer and Ingervall, 1986). They considered that class II division 2 malocclusion cannot be caused by a strong upper lip and that the resting lip pressure is a result of the incisors position.

Our present study was in agreement with Thüer and Ingervall (1986)'s findings, as the labial pressure from upper lip in class III malocclusion was very low due to the retrognathic maxilla and incisors. In other words, the retrognathic maxillary position can be related to the lower circumoral pressure. Thus, these findings support the spatial matrix hypothesis developed by Singh (2004), which focuses on the effect of spatial relations on the craniofacial morphology. According to this hypothesis, we can postulate that the muscle hypofunction noted here may be secondary to the spatial relations of the jaws for class III malocclusion. Therefore, craniofacial heterogeneity must be taken into account. Singh *et al*.(1999; 1998) demonstrated that differences in cranial base morphology may be associated with the etiology of the class III malocclusion, and may also account for difference in Asians and Whites with class III malocclusion. This present study supports those findings because decreased upper lip pressure was found, presumably due to maxillary retrognathia secondary to anterior cranial base morphology.

However, due to the complexity of the relationships of the myofunction and craniofacial morphology, hypofunctional perioral musculatures may be also related to the concave midface in the patients with class III malocclusion. According to Frost (1987)'s mechanostat theory, mechanical loading is essential to skeletal health. Subthreshold loading of less than 200 microstrain results in disuse atrophy while physiologic loading of about 200~2500 microstrain is associated with normal, steady-state activities. Of course, if the loading is over 4000 microstrain, bone resorption will be bigger than bone formation and bone remodelling will be inhibited (Roberts, 2000). For example, in cases of repaired cleft lip where muscle function is increased, bone apposition lessens and tends to produce a concave facial profile (Li *et al*., 2006; Singh *et al*., 2004). Space flight studies have established that gravity helps maintain skeletal mass and diminished mechanical forces eliminate signals that maintain osteocyte viability and inhibit bone formation (Aguirre *et al*., 2006).

More importantly, Sinsel *et al*.(1998; 1999) revealed that paralysis of the midfacial musculature can result in decreased anterioposterior growth of the snout and nasofrontal sutural growth activity. Actually, mechanical forces play a fundamental role in tissue differentiation and morphogenesis (Radlanski and Renz, 2006). The findings from this study (Figs.3 and 4) show that perioral forces exerted on the primary dentition of class III malocclusion were apparently less than the normal ($P<0.01$), especially for the upper anterior teeth region with negligible pressure which may cause less bone apposition in this area. Hence, the hypofunctional activities of the perioral musculatures may counteractively aggravate the clinical features of class III malocclusion.

ACKNOWLEDGEMENT

The authors thank Dr. James L. Borke for his reviewing this manuscript and Miss Julie N. Winger for proofreading the manuscript.

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