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Original Article

The analysis of the masticatory muscle activity in patients with skeletal class III jaw deformity

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Abstract: Objectives: Explore the relationship between abnormal jaw morphology and masticatory muscle electromyography (EMG) activity. Methods: Three dimensional spiral CT was used to diagnose the patients with skeletal class III jaw deformity. The EMG was used to record the masticatory muscle activity. Results: The EMG was stronger at relatively short side for temporal muscles, masseter muscles in specific positions. The EMG was stronger at relatively long side for Digastricus muscles in the all four positions. Asymmetry indexes and correlation analysis were also used and there were significant differences between bilateral masticatory muscles in specific positions. Conclusion: The incoordination of masticatory muscle function is related to the skeletal characteristics of mandibular deformity.

Keywords: Electromyography, masticatory muscle, asymmetry index, correlation analysis

Introduction

Facial morphology is influenced by both genetic and environmental factors. Many researchers believed that the function of masticatory muscles was related to craniofacial morphology [1]. The different occlusal relationship and bone morphology are due to the effects of facial muscle function, and regulation of muscular system before deformity correction surgery can change the facial morphology [2].

Generally, the change of electromyograph (EMG) can reflect the strength of muscle function and this method can be used to detect the masticatory muscle function quantitatively [3-5]. EMG can detect the normal physiological activity of masticatory muscles, monitor the changes of masticatory function passively and evaluate the effects of some deformity treatments. Many studies focused on the relationships between electrical activity of masticatory muscles and mandibular asymmetry have been reported in recent years. However, the results were in consistent. Some researchers reported that the masseter muscle activity was greater on the non-deflected side [6], while other researchers found that the greater masseter muscle activity existed on the deflected side [7, 8]. However, the relationship between mandibular deviation degree and masticatory muscle activity is still unclear.

In this study, we detected bilateral masticatory muscle activities in patients with skeletal class III jaw deformities and our aim was to explore the relationship between abnormal morphology and masticatory muscle EMG activity.

Methods and procedures

Patients and data collection

A total of 21 patients including 7 males and females diagnosed as skeletal Class III jaw deformity in our hospital from January 2008 to December 2008 were recruited. The normal

Table 1. Comparison of EMG values of bilateral temporal muscles in different positions in patients with skeletal class III jaw deformity

	The long side of mandible				The short side of mandible				P
	Mean	SD	Min	Max	Mean	SD	Min	Max	
ROP	2.233	0.806	1	3.3	2.378	1.132	1.3	4.5	>0.05
CP	49.878	42.582	18.9	96.1	57.011	26.585	31.9	156.1	<0.05
PP	3.811	2.743	1.4	10.3	3.044	1.646	1.5	7.1	>0.05
RP	8.444	5.354	1.2	19.3	12.456	6.1	5.2	41.5	>0.05

ROP: Rest occlusal position, CP: clenching position, PP: protrusive position, RP: retruded position.

Table 2. Comparison of EMG values of bilateral masseter muscles in different positions in patients with skeletal class III jaw deformity

	The long side of mandible				The short side of mandible				P
	Mean	SD	Min	Max	Mean	SD	Min	Max	
ROP	1.489	0.333	1	2	2.067	1.045	1.1	3.7	<0.05
CP	48.389	22.127	20.4	85.4	54.344	29.923	10.6	103.1	<0.05
PP	13.822	10.464	2.7	33.8	15.433	11.131	3	32.8	<0.05
RP	6.978	4.928	2.3	17.9	8.989	8.022	1.8	22.9	>0.05

ROP: Rest occlusal position, CP: clenching position, PP: protrusive position, RP: retruded position.

control group included 10 students aged 20 to 21 years old. Three dimensional spiral CT was performed before operation and the electromyography of masticatory muscles was detected. Informed consent was obtained for all participating patients.

Inclusion and exclusion criteria

Inclusion criteria for cases: 1. We detected the vertical distance between the submental point and the median sagittal plane by 3D measurement software and class III jaw deformity was diagnosed if the distance was greater than 4 mm [9, 10]. 2. All cases belonged to the jaw asymmetry bilateral hemimandibular elongation deformity. Exclusion criteria for cases: 1. Patients with unilateral or bilateral condylar hypertrophy and hyperplasia. 2. Patients with hemifacial atrophy or bimaxillary protrusion. 3. Acquired mandibular asymmetry caused by trauma or tumor. Inclusion criteria for normal controls: facial symmetry with no deformity and normal mouth opening degree and open type, without temporomandibular joint pain and snapping. The dentition was complete, and the teeth were arranged orderly. The occlusal plane was not skewed, and the occlusion and coverage of the first molar were normal. There was no history of tooth extraction and dental pulp disease in the past year. No periodontitis and oral mucosal disease, no orthodontic treatment history, no history of facial myopathy, neuropathy and drug treatment, and plastic surgery.

Parameters evaluation

1. Potential value of masticatory muscle: muscle contractile can cause multiple muscle motor unit discharge at the same time. The average value of EMG amplitude in 10 seconds was collected as potential value of masticatory muscle. 2. Asymmetry index of temporalis muscle (AsITM):(RTM-LTM)/(RTM+LTM)×100% (RMT: mean peak potential of right temporalis muscle, LMT: mean peak potential of left temporalis muscle). 3. Asymmetry index of masseter muscle (AsIMM):(RMM-LMM)/(RMM+LMM)×100%. 4. Asymmetry index of Digastricus muscle (AsIDM):(RDM-LDM)/(RDM+LDM)×100%.

Statistical analysis

Data were analyzed by a student-t test and correlation analysis was used. Statistical analysis was performed using sigmaPlot10.0 software.

Results

The EMG comparisons between bilateral temporal muscles, masseter muscles and Digastricus muscles in patients with skeletal Class III jaw deformity showed that the temporal muscle EMG was stronger at the relatively short side when the bilateral temporal muscles were in the mandibular intercuspal position (**Table 1**). Next, the masseter muscle EMG was stronger at the relatively short side when the bilateral masseter muscles were in the rest occlusal mandibular position, protrusive position and intercuspal position (**Table 2**). The results also showed that the Digastricus muscles EMG was stronger at the relatively long side in the all four positions (**Table 3**).

Table 3. Comparison of EMG values of bilateral Digastricus muscles in different positions in patients with skeletal class III jaw deformity

	The long side of mandible				The short side of mandible				P
	Mean	SD	Min	Max	Mean	SD	Min	Max	
ROP	2.489	2.037	1.1	7.6	1.978	1.544	1	5.9	<0.05
CP	7.089	6.252	2.7	23.1	6.267	3.905	2.4	15.2	<0.05
PP	12.044	6.151	3.6	25	8.000	3.566	4.1	15	<0.05
RP	7.756	7.869	2.5	26.4	6.511	5.160	2.1	15.2	<0.05

ROP: Rest occlusal position, CP: clenching position, PP: protrusive position, RP: retruded position.

Table 4. Comparison of asymmetry index of masticatory muscles between case group and normal group

	Group	AsITM	AsIMM	AsIDM
ROP	Control	0.08±0.04	0.07±0.05	0.15±0.10
	Case	0.14±0.11	0.19±0.16*	0.12±0.13
CP	Control	0.10±0.04	0.14±0.06	0.15±0.07
	Case	0.17±0.04*	0.24±0.21*	0.08±0.07
PP	Control	0.06±0.04	0.08±0.06	0.07±0.03
	Case	0.12±0.10*	0.13±0.08*	0.13±0.06*
RP	Control	0.18±0.15	0.07±0.03	0.07±0.05
	Case	0.23±0.21	0.18±0.12*	0.20±0.15*

*P<0.05.

Significant differences of asymmetry indexes were found between case group and control group when the temporal muscle was in intercuspal position and protrusive position. The asymmetry indexes of masseter muscles also showed significant differences in the all four positions. Besides, the asymmetry indexes of Digastricus muscles showed significant differences when the muscles were in protrusive position and retruded position (**Table 4**).

Last, mandibular deviation degree was positively related to the asymmetry indexes of temporal muscle in intercuspal position and mandibular position, masseter muscle in intercuspal position and protrusive position and two in abdominal muscle in protrusive position (**Table 5**).

Discussion

As an important part of the gnathostomatic system, masticatory muscle is an important factor in the occlusal relationship establishment and growth and development of craniofacial morphology. In addition, the muscle may also be involved in the development of malocclusion and craniofacial deformity [11]. The strength of the masticatory muscle can improve the blood circulation around the craniofacial skeletal and control the sutural bone deposition to affect the growth type of the face [12, 13]. EMG was first used to measure the activity of masticatory muscles since 1949. A large number of experiments showed that EMG could reflect the functional status and the morphological changes of the neuromuscular system [14]. In 1970, EMG amplitude ratio was first used to analyze the state of masticatory muscle more comprehensively [15].

Our results showed that the activity of the relatively long side of mandibular muscles was significantly weaker than the relative short side in the intercuspal position in patients with skeletal Class III jaw deformity. Similar results were found in masseter muscles when the muscle was in the rest occlusal mandibular position, protrusive position and intercuspal position. This phenomenon might be caused by the changes of muscle length, abnormal occlusion relationship or abnormal occlusal contact area. On the other hand, patients with skeletal Class III usually represented longer mandibular ramus and mandibular body at the long side, which would cause muscle fatigue and incoordination of masticatory muscle at the long side. In addition, the results showed the mandibular ramus oblique degree was positively correlated with the asymmetry index of the bilateral inclination from the front view. The masticatory muscles were attached to the bone surface, so the strength of bilateral masticatory muscles might be differed. The long term muscle dysfunction would gradually affect the morphology of teeth and jaw. Contrary to the temporalis and masseter muscles, the main function of Digastricus muscles was pulling down the chin, participating in the mouth opening. The EMG results of Digastricus muscles might be related to the incoordination between the two sides of the muscles caused by the deviation of the chin.

Table 5. Correlation analysis between mandibular deviation degree and masticatory muscle asymmetry index

	Temporal muscle				Masseter muscle				Digastricus muscle			
	ROP	CP	PP	RP	ROP	CP	PP	RP	ROP	CP	PP	RP
Deviation degree	0.425	0.672*	0.564*	0.207	0.356	0.679*	0.596*	0.221	0.336	0.187	0.667*	0.187

ROP: Rest occlusal position, CP: clenching position, PP: protrusive position, RP: retruded position. *P<0.05.

The results of asymmetry indexes showed that the masticatory system varied in different forms at different functional positions in patients. Many scholars believed that the morphology of masticatory muscles was associated with face type and the masticatory muscle played an important role in bone growth and development [16, 17]. Analysis on the correlation between mandibular deviation degree and masticatory muscle asymmetry index indicated that there was a connection between the severity of the mandible deformity and the incoordination degree of the masticatory muscle. From this experiment, we found an evaluation method for the diagnosis of jaw deformity and the formulation of orthodontic treatment program, which could be used for further investigations.

Disclosure of conflict of interest

None.

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