คลื่นไฟฟ้ากล้ามเนื้อแมสซีเตอร์และเทมโพราลิส
ในผู้ป่วยที่มีความสัมพันธ์ของโครงกระดูกแบบที่สาม

Masseter and Temporalis Muscle Activity
in Patients with Class III Skeletal Relationships

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บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาการทำงานของ
กล้ามเนื้อแมสซีเตอร์และเทมโพราลิส ในกลุ่มผู้ป่วยที่มี
โครงสร้างแบบที่สาม โดยวัดด้วยเครื่องวัดคลื่นไฟฟ้า
กล้ามเนื้อชนิดพื้นผิว ในผู้ที่ไม่เคยได้รับการจัดฟันที่มี
โครงสร้างแบบที่สาม 30 ราย อายุ 18-34 ปี (เฉลี่ย 22.4 ปี)
เทียบกับกลุ่มควบคุมที่มีโครงสร้างแบบที่หนึ่ง 30 ราย อายุ
18-35 ปี (เฉลี่ย 22.6 ปี) โดยวัดคลื่นไฟฟ้ากล้ามเนื้อ
ในขณะกัดแรงเต็มที่บนสำลีม้วน และขณะกัดแรงเต็มที่
นำค่าที่สูงสุดจากการกัดสำลีมาใช้เป็นค่ามาตรฐานเทียบ
กับค่าที่ได้จากการกัดแรงเต็มที่ หลังจากนั้นนำข้อมูลหลัง
เทียบค่ามาตรฐานแล้วมาคำนวณเป็นค่าเปอร์เซ็นเทจ

Abstract

This study aimed to evaluate the masseter and
temporalis muscle activity in patients with Class III
skeletal relationships, using surface electromyography
(SEMG). The study group consisted of 30 subjects
with Class III skeletal relationships, aged 18-34 years
(mean 22.4 years) and 30 subjects with Class I skeletal
relationships aged 18-35 years (mean 22.6 years).
All subjects had normal vertical configuration, no
temporomandibular disease and no previous
orthodontic treatment. The SEMG activity was
recorded from the masseter and temporalis muscles

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โอเวอร์แลปปิง โคเอฟฟิเชียน (พีโอซี) และค่าทอร์ค โคเอฟฟิเชียน (ทีซี) และนำค่าที่ได้มาวิเคราะห์ทางสถิติ การทดสอบทีสองกลุ่ม จากการศึกษาพบว่ากลุ่มโครงสร้างแบบที่สามมีค่าพีโอซีของกล้ามเนื้อแมสซีเตอร์ น้อยกว่ากลุ่มโครงสร้างแบบที่หนึ่งอย่างมีนัยสำคัญ แต่ไม่พบความแตกต่างในค่าพีโอซีของกล้ามเนื้อเทมโพราลิส และทีซี สรุปว่ากลุ่มโครงสร้างแบบที่สามมีความไม่สมมาตรของการทำงานของกล้ามเนื้อแมสซีเตอร์มากกว่ากลุ่มโครงสร้างแบบที่หนึ่ง

while in maximum clenching on cotton rolls and in maximum voluntary contraction (MVC). The values for maximum clenching on cotton rolls were used to standardize and normalize all MVC data. Then, the percentage overlapping coefficient (POC) index and the torque coefficient (TC) index were calculated from the standardized MVC data. The POC and TC indices from both groups were compared using the two-sample t-test. The masseter POC in the patients with Class III skeletal relationships was less than that in those with Class I skeletal relationships with statistical significance (p<0.01). The temporalis POC and TC were not different between groups. This study shows that patients with Class III skeletal relationships have lower symmetry in the masseter muscle function than do patients with Class I skeletal relationships.

Introduction

The goal of orthodontic treatment is to create harmony of form and function, and this cannot be achieved without a sufficient understanding of the etiology of both disharmony and malocclusion.[1] The masticatory muscles have great influences on the craniofacial structures in the form of tension and pressure forces.[2] Many studies have reported a close relationship between masticatory muscle function and the craniofacial structures,[3,4] in contradiction to some other studies where no correlations between masticatory muscle function and the craniofacial structures were reported.[5,6] Due to a variety of recording techniques, it is difficult to make a comparison between the different findings of these various studies.

Masticatory muscle function can be evaluated by various methods, for example, bite force,[7] mandibular movement analysis,[8] distribution of occlusal contacts[7] and electromyographic activity of the masticatory muscles.[5,9-11] Electromyography (EMG) is the study of the action potentials that bring a muscle to contract. EMG can study muscle function in a direct way and in specific muscles.[10] There are two types of EMG: needle, or intramuscular EMG (IEMG) and surface EMG (SEMG). IEMG gives better specificity and fewer artifacts than does SEMG; however, SEMG is

preferable because of its painlessness and non-invasiveness.[10] Because of error from wrong or misleading protocols,[9,12] therefore the protocol for SEMG use has been standardized. Nowadays, SEMG is suggested as a useful tool for recognizing various pathological and dysfunctional conditions of masticatory muscle, such as postural hyperactivity, functional hyperactivity, muscle spasm and muscle imbalance.[9]

There is a controversy about the efficiency of masticatory muscle in patients with different skeletal relationships. Some studies[5,6,13] found no correlation between normal subjects and patients with skeletal discrepancies. However, other studies[3,14,15] found that patients with mandibular prognathism had poorer masticatory efficiency than did normal subjects. The understanding of the differences between Class III skeletal relationship and normal skeletal relationship give benefits in treatment strategies, such as treatment planning, treatment mechanics, prognosis and treatment prediction.

Evaluation of masticatory muscle activity with SEMG is a valuable tool for diagnosing dysfunction of the masticatory system. However, standardized data for patients with Class III skeletal relationship have not been obtained. The purpose of this study was to evaluate and compare electromyographic activity of the temporalis and masseter muscles in patients with Class III skeletal relationships, using the standardized method.

Materials and Methods

The subjects were selected from patients of the Department of Orthodontics and Pediatric Dentistry, Faculty of Dentistry, Chiang Mai University, Thailand. This study was approved by the Human Experimentation Committee of the Faculty of Dentistry, Chiang Mai University (No. 12/2016). Informed consent was obtained from all patients.
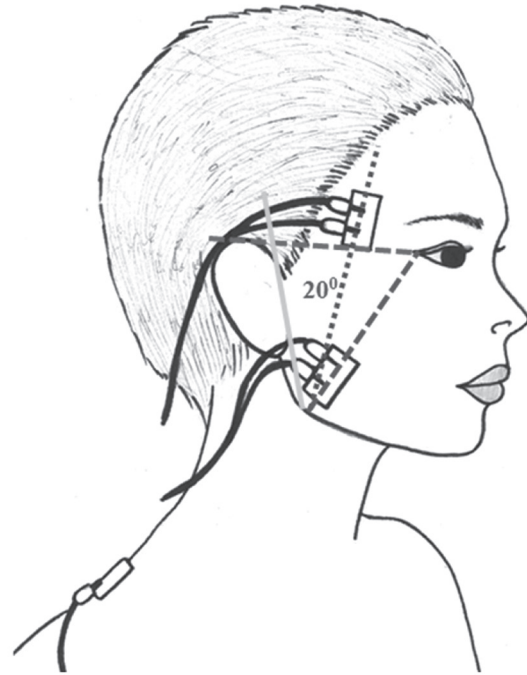
The subjects consisted of 60 Thai patients aged 18-35 years who came to receive orthodontic treatment from October 2015 to March 2016. These patients were separated into two numerically equal groups, Class I and Class III skeletal relationships, based on theirs sagittal skeletal relationships. The mean ages of the patients groups were 22.6±5.1 and 22.4±4.3 years old for the patients with Class I and Class III skeletal relationship, respectively. There was no significant difference in age between both groups. The demographic data, such as sex and age, were recorded. The oral status, such as crossbite and functional shift were examined. All subjects had no previous orthodontic treatment, and no temporomandibular disorders. All cephalometric tracings were performed and measured by the same author. Then the subjects were classified into study groups. (Patients with Class III skeletal relationship presented with normal SNA angle, SNB angle higher than normal and ANB angle less than 0 degree.) (Patients with Class I skeletal relationship presented with normal SNA, SNB and ANB angles.) All subjects presented with normal vertical relationships based on at least 3 of the following 5 criteria: SN-PP angle, SN-GoGn angle, PP-GoGn angle, ArGoGn angle and PFH:AFH value. All cephalometric parameters from the subject groups are shown in Figure 1. Surface electromyography (SEMG: BioEMGII, BioResearch Assoc. Inc., Milwaukee, Wisconsin, USA, 8-channels, EMG range 0-2000 microvolts, noise<0.1 microvolts, input impedance > 100 GigaOhms, common mode rejection ratio >130 dB at 60 Hertz (>120 dB, 30-500 Hertz), sensitivity<1.0 microvolt) with the Biopak program running on a personal computer was used. A disposable electrode (Bioflex, D.L.Medica S.P.A., Milan, Italy) was used in this study (Figure 1).
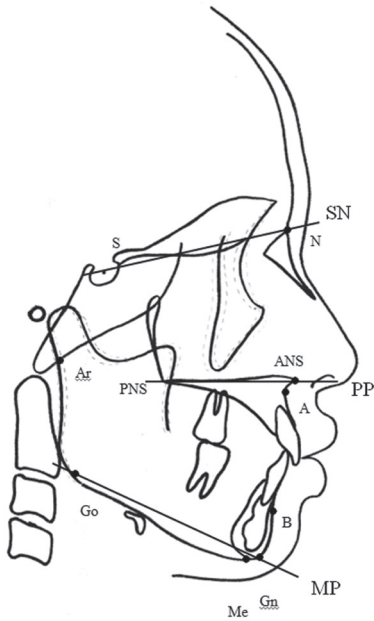
รูปที่ 1   จุดกำหนดภาพรังสีวัดศีรษะ

Figure 1   *Cephalametric landmarks.*

รูปที่ 2   ตำแหน่งของอิเล็กโทรด

Figure 2   *The positions of electrodes.*

The SEMG experiment was conducted according to the methods of Ferrario *et al.*[12] and Ko *et al.*[11] prior to the orthodontic treatment. Firstly, the patients were rested and relaxed for 15 minutes before starting the test. Then, the SEMG was tested on bilateral anterior temporalis and masseter muscles. The patients sat on a comfortable chair without head support, with the trunk in an erect posture and with the head in the natural head position. The eyes were fixed on a target in front of the patients, 1 meter away. The facial skin above the muscles was prepared by cleaning with 70% ethyl alcohol until all grease was removed. The electrodes were applied on the skin in the position according to Ko *et al.*[11] (Figure 2). For the masseter muscle, the electrode was applied along a line from the gonion to the outer canthus of the eye. For the temporalis muscle, two reference lines were identified. The first line was inclined 20° forward from the posterior mandibular

border, and the second line was a tangent line to the superior surface of the auricle of the ear and passing through the outer canthus of the eye (Figure 2).

The SEMG data was recorded after the SEMG activity was stable without changing the electrodes or moving the cables. First of all, the standard potential was recorded. A 10 millimeter-thick cotton roll was placed on the left and right mandibular premolars and molars, and a three-second MVC was recorded. Each subject was rested for 3 minutes before biting in habitual intercuspation without cotton rolls for 3 episodes of a 2-second MVC.

For each muscle, the maximum EMG potential while biting on the cotton rolls (Figure 3 and Figure 5) was set as the standard potential at 100%, and all further EMG potentials (Figure 4 and Figure 6) were expressed as a percentage of this value using the following equation.
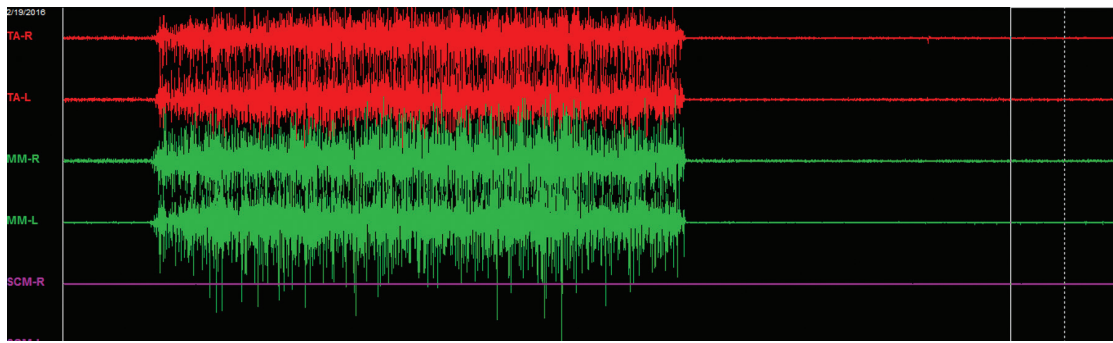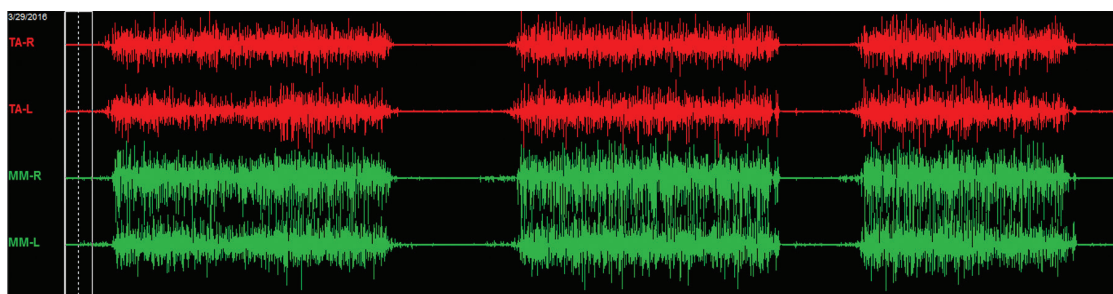
รูปที่ 3 คลื่นไฟฟ้ากล้ามเนื้อชนิดพื้นผิวในผู้ป่วยกลุ่มที่มีความสัมพันธ์ของโครงกระดูกแบบที่หนึ่งขณะกัดสำลีม้วน

Figure 3 SEMG potential in patients with class I skeletal relationships while clenching on cotton rolls
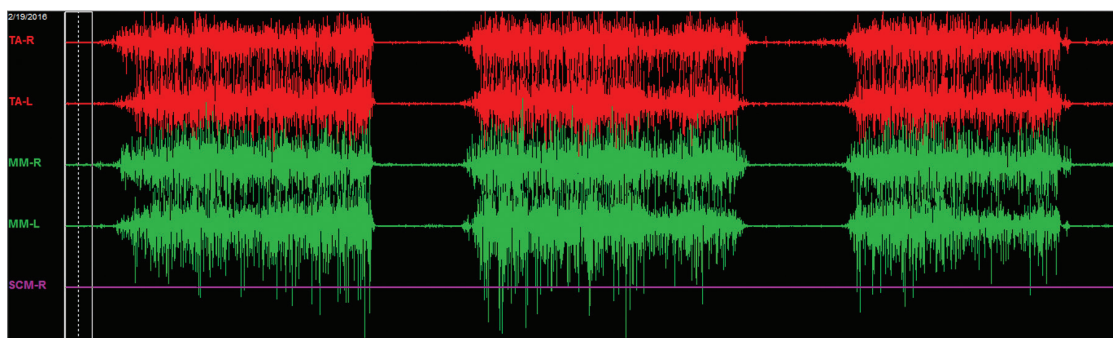
รูปที่ 4 คลื่นไฟฟ้ากล้ามเนื้อชนิดพื้นผิวในผู้ป่วยกลุ่มที่มีความสัมพันธ์ของโครงกระดูกแบบที่หนึ่งขณะกัดเอ็มวีซี

Figure 4 SEMG potential in patients with Class I skeletal relationships while clenching during MVC
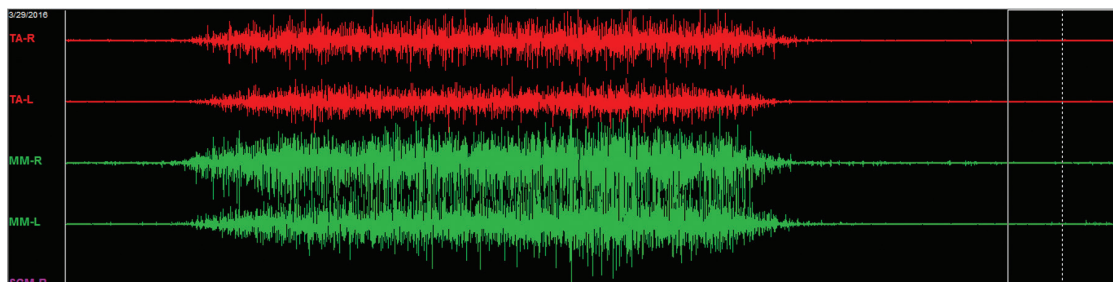
รูปที่ 5 คลื่นไฟฟ้ากล้ามเนื้อชนิดพื้นผิวในผู้ป่วยกลุ่มที่มีความสัมพันธ์ของโครงกระดูกแบบที่สามขณะกัดบนสำลีม้วน

Figure 5 SEMG potential in patients with Class III skeletal relationships while clenching on cotton rolls

รูปที่ 6 คลื่นไฟฟ้ากล้ามเนื้อชนิดพื้นผิวในผู้ป่วยกลุ่มที่มีความสัมพันธ์ของโครงกระดูกแบบที่สามขณะกัดเอ็มวีซี

Figure 6 SEMG potential in patients with Class III skeletal relationships while clenching during MVC

$$\text{Relative MVC potential (\%)} = \frac{\text{(Potential during MVC (μV)}}{\text{(Potential during maximum biting on cotton roll (μV)}} \times 100$$

The relative MVC potential after comparing with the standard potential were calculated for POC and TC indices according to the methods of Ferrario *et al.*[12]

The POC index showed relative bilateral muscle symmetry and was calculated using the following equation:

$$POC = \left(1 - \sum_{i=1}^{N}|Ri-Li| \Big/ \sum_{i=1}^{N}|Ri + Li|\right) \times 100$$

Ri was relative potential of the right masseter or temporalis muscle

Li was relative potential of the left masseter or temporalis muscle

Perfect symmetry between contralateral muscles was indicated by a POC index of 100%.

The TC index represented the possible lateral deviating effects on the mandible by unbalancing the right temporalis (TR) and left masseter (ML) and the left temporalis (TL) and right masseter (MR) muscles. The equation for the calculation was:

$$TC = \sum_{i=1}^{N}|\delta Ti-\delta Mi| \Big/ \sum_{i=1}^{N}(MRi + MLi + TRi + TLi)$$
$$\times 100$$

$$\delta Ti = TRi - TLi, \quad \delta Mi = MRi - MLi$$

TRi was the relative potential of the right temporalis muscle

TLi was the relative potential of the left temporalis muscle

MRi was the relative potential of the right masseter muscle

MLi was the relative potential of the left masseter muscle

Perfect balance of the TR, TL, MR, ML muscles was indicated by a TC index of 0%.

Statistical analysis

The error of the method and the intra-observer reliability of the measurements were statistically tested. After one week, the SEMG recording of 10 subjects were randomly selected and re-measured by the same examiner. The intra-class correlation coefficient (ICC) was used to assess reliability of the first and second measurements.

The statistical analyses were performed using the SPSS program (SPSSV17.0, SPSS Inc., Chicago, Illinois, USA). The means and standard deviations of the masseter muscle POC, the temporalis muscle POC and the TC of both groups were compared by two-sample *t*-test at 95% confidence interval.

Results

The statistical analysis showed that intra-class correlation coefficient (ICC) values obtained for the temporalis POC, the masseter POC and the TC indices were 0.660, 0.724 and 0.692, respectively.

The means and standard deviations of cephalometric parameters of the subjects are shown in Table 1.

The means and standard deviations of the relative MVC potentials in patients with Classes I and III skeletal relationships are shown in Table 2.

The comparison of the means and standard deviations of the temporalis POC, the masseter POC and TC of the patients with Class I and with Class III skeletal relationships are shown in Table 3.

The masseter POC in patients with Class III skeletal relationships was lower than in patients with Class I skeletal relationships with statistical significance (p<0.01), whereas the temporalis POC and the TC in patients with Class III skeletal relationships were not different from those in patients with Class I skeletal relationships.

Discussion

A useful tool for studying masticatory muscle function is SEMG, which enables the activity in

individual muscles to be measured directly.[10] Several studies have claimed that the use of SEMG in research produced unreliable results.[5,16,17] Such unreliability could be due to the effects of many test variations, e.g., sample selection, inadequate control subjects, test protocols, analyzing processes or the equipment used. However, following the standard protocol, SEMG presents an efficient analytical method with good reproducibility. One of the standardized methods is normalizing the raw SEMG values with the reference value.[12] Ferrario et al.[12] normalized all potentials by comparing them with the reference data from MVC on cotton rolls. They found that during clenching on cotton rolls, the cotton rolls increase the vertical dimension but they become thinner after clenching and the increase in vertical dimension is negligible. Moreover, Ferrario et al.[12] also reported that this standardized method produced low inter-individual variability because of the use of relative data instead of raw data. Therefore, this method reduced biological differences between

ตารางที่ 1 ค่าเฉลี่ยและส่วนเบี่ยงเบนมาตรฐานของค่าการวัดกะโหลกศีรษะในผู้ป่วยกลุ่มที่มีความสัมพันธ์ของโครงกระดูกแบบที่หนึ่ง และแบบที่สาม

Table 1 *Means and standard deviations of the cephalometric parameters in patients with Class I and patients with Class III skeletal relationships.*

	Class I		Class III	
	Mean	SD	Mean	SD
SNA (Degree)	84.40	±1.54	84.18	±2.52
SNB (Degree)	81.27	±1.74	88.07	±2.47
ANB (Degree)	3.13	±0.84	-3.87	±1.99
PP-GoGn (Degree)	23.20	±4.74	25.20	±4.30
SN-PP (Degree)	7.87	±2.27	6.87	±2.45
SN-GoGn (Degree)	31.10	±3.99	32.03	±4.11
ArGoGn (Degree)	121.05	±5.87	123.83	±8.45
PFH:AFH (%)	66.06	±3.19	65.15	±3.99

ตารางที่ 2 ค่าเฉลี่ยและส่วนเบี่ยงเบนมาตรฐานของค่าเอ็มวีซีสัมพัทธ์ในผู้ป่วยกลุ่มที่มีความสัมพันธ์ของโครงกระดูกแบบที่หนึ่งและแบบ ที่สาม

Table 2 *Means and standard deviations of the relative MVC potentials in patients with Class I and III skeletal relationships*

Muscles	Class I		Class III	
	Mean (%)	S.D.	Mean (%)	S.D.
Right temporalis	93.53	±18.82	88.10	±42.53
Left temporalis	94.57	±21.05	82.22	±30.67
Right masseter	82.22	±22.78	82.19	±42.68
Left masseter	83.29	±23.02	75.16	±34.87

electrode and muscle, and technical difficulties, such as electrode positioning and possible electrical interferences. The POC and TC indices were used in this study because these indices made possible the assessment of the activity, coordination, and symmetry of the homologous, synergistic and antagonistic muscles. Also, the reproducibility was high because the electrodes were positioned based on anatomical landmarks. Moreover, these indices provided more dynamic information than do other indices, because they calculated every interval over the analyzed time span.[12] Nevertheless, this method can be used to compare subjects because the indices are used instead of raw data.[11]

In dental applications, masseter and temporalis muscle activity indicate jaw position and strength of bite force.[18] The locations of the masseter and temporalis muscles are superficial; for this reason, their activity is often used to represent masticatory muscle activity in SEMG testing. Several studies[2,12,19,20] have reported the anterior temporalis and masseter muscle activity in normal populations. Ferrario et al.,[20] using

different indices from those used in this study, investigated muscle activity in young people with sound dentitions, and they found a physiological asymmetry of both muscles of up to 18% during clenching. In addition, Ferrario et al.[12] used the same standardized method as used in this study, to measure muscle activity in patients with normal occlusion. They found that the temporalis POC, the masseter POC and the TC indices were 89.34%, 88.06% and 6.36%, respectively. The findings support those of this study, which found that the same indices were 87.88%, 85.93%, and 1.65%, respectively. This study confirms that patients with Class I skeletal relationships have a slight, physiological, muscular asymmetry in the temporalis and masseter muscles and have well-balanced temporalis and masseter muscle function.

There are few studies of masticatory muscle function in patients with skeletal Class III relationships. Moreover, those studies used different methods and reported different findings. Several previous studies have found abnormal patterns and imbalance of muscle functions in patients with Class III relationships. Also,

ตารางที่ 3 *การเปรียบเทียบค่าเฉลี่ยและส่วนเบี่ยงเบนมาตรฐานของค่าพีโอซีของกล้ามเนื้อเทมโพราลิส พีโอซีของกล้ามเนื้อแมสซีเตอร์ และ ทีซี ระหว่างกลุ่ม*

Table 3 *Means and standard deviations of the temporalis muscle POC, the masseter muscle POC and the TC and the comparisons between the groups*

Indices	Class I skeletal		Class III skeletal		The two-sample t-test
	Mean (%)	SD	Mean (%)	SD	*P*-values
Temporalis POC	87.88	±1.9	86.91	±2.68	0.142
Masseter POC	85.93	±3.50	82.62	±4.52	0.003**
TC	1.65	±1.10	2.02	±1.83	0.359

POC, Percentage overlapping coefficient

TC, Torque coefficient

** Significance: p < 0.01

some studies have found correlations between facial skeletal morphology and muscular functionality.[14,15,21] In contrast, other studies have reported no correlations between the craniofacial morphology and muscular activity, corroborating the hypothesis that occlusal stability is the only reason for the EMG differences.[6,13] Di Palma *et al.*[15] studied neuromuscular imbalance in patients who were candidates for orthognathic surgery. They showed that post-surgical stability after orthognathic surgery may be affected by the balance of masticatory muscles. Youssef *et al.*[6] found that patients with Class III skeletal relationships had lower muscle activity than normal but it increased after surgery. In contrast, Moreno *et al.*[22] found the highest activity of the masseter and temporalis muscles in Class III dental malocclusion. Cha *et al.*[14] studied muscle activity in patients with Classes I, II and III skeletal relationships with normodivergent or hyperdivergent vertical relationships. They found higher activity in the resting position in the temporalis muscle in patients with Class III skeletal relationships with open bite than in other patients. However, these previous studies compared the amplitude of the SEMG activity of muscle pairs during only a single time period. Furthermore, the SEMG activity in the temporalis muscle of the subjects in those studies were recorded after wearing braces which can confound the actual function of the muscles due to pain and discomfort.[23]

Di Palma *et al.*[15] studied the temporalis and masseter muscle function in patients with skeletal discrepancies. They found greater functional asymmetry in patients with skeletal discrepancy than in those with normal skeletal patterns. However, subjects in this study cannot be compared with those in that study because Di Palma *et al.*[15] studied patients with Class II and Class III skeletal relationships as one group, whereas we did not include patients with Class II

skeletal relationships. By comparing SEMG activity between patient groups with varying occlusal parameters, Moreno *et al.*[22] found that a unilateral crossbite decreased ipsilateral masseter muscle activity. This decrease can explain the finding in this study, i.e., the lower symmetry in the masseter muscle in patients with Class III skeletal relationships than in those with Class I skeletal relationships, because 20% of patients with Class III skeletal relationships presented with left unilateral crossbite that reduced left masseter muscle activity, whereas no patients with Class I skeletal relationships presented with crossbite. By comparing the masseter POC index between normal patients and patients with mandibular asymmetry, Dong *et al.*[24] reported that mandibular asymmetry obviously decreased the masseter POC. Mandibular asymmetry commonly presents in patients with Class III skeletal relationships[25] as in this study, that found slight asymmetry in most patients with Class III skeletal relationships.

This study found no difference in the temporalis POC and TC indices between the patients with Class III skeletal relationships and those with Class I skeletal relationships. However these indices were lower than those in previous studies. A possible reason may be the sample selection in this study, which was limited to the vertical and transverse skeletal relationships. Moreover, the neuromuscular adaptation of these muscles could overcome slight asymmetry.[26,27]

Conclusions

The results obtained show lower symmetry of function in the masseter muscle in patients with Class III skeletal relationships than in those with Class I skeletal relationships. No significant differences were found between the function in the temporalis muscle and the synergistic activity in both muscles bilaterally.

Acknowledgements

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เปิดบริการ

ศูนย์เอกซเรย์ทางทันตกรรม

โรงพยาบาลทันตกรรม คณะทันตแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่

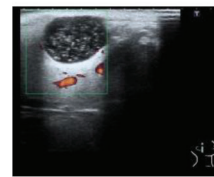ให้บริการถ่ายภาพรังสี ทางทันตกรรม (เอกซเรย์) แก่ผู้ป่วยทั้งใน-นอกเวลาราชการ

Panoramic

► บริการถ่ายภาพรังสีทางทันตกรรมทั่วไป (<u>ชนิดภาพรังสีนอกช่องปาก</u>) ด้วยระบบดิจิตอล (Digital Radiograph)

Ultrasound
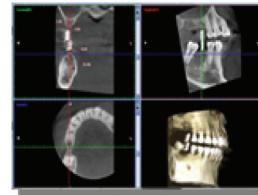
► การตรวจด้วยอัลตราซาวด์ (บริเวณขากรรไกร-ใบหน้า)

Cephalometric

► ภาพถ่ายรังสีโคนบีมซีที (Cone beam CT : CBCT) ด้วยเครื่องถ่ายภาพซึ่งเป็นเทคโนโลยีอันทันสมัย สามารถแสดงภาพของฟัน กระดูกขากรรไกรและใบหน้า ได้ในหลายระนาบและสร้างเป็นภาพสามมิติ พร้อมรายงานผลอ่านภาพโดยทันตแพทย์เฉพาะทาง
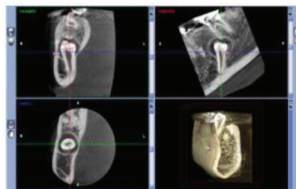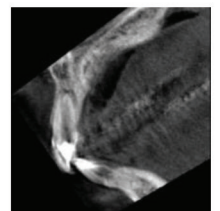

การวางแผนเพื่อฝังรากเทียม

PA

เปิดให้บริการ

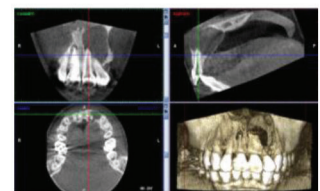|		
จันทร์-ศุกร์	:	เวลา 09.00 - 20.00 น.
เสาร์-อาทิตย์	:	เวลา 09.00 - 16.00 น.

ระบุตำแหน่งของฟันฝังคุด

การตรวจการแตกหักของรากฟัน

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การตรวจรอยโรคของฟันและกระดูก

ศูนย์เอกซเรย์ทางทันตกรรมเป็นสถานพยาบาลของทางราชการ สามารถเบิกค่ารักษาพยาบาลจากทางราชการได้ตามระเบียบกระทรวงการคลัง