# *Association between balance of masticatory muscle activity during usual daily life and transverse craniofacial morphology or tooth contact area in patients with transverse jaw deformity: An electromyographic evaluation*

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## ABSTRACT

**Introduction:** It is considered now-a-days that patients with transverse craniofacial deformity might have differences in masticatory muscle activity between both sides; and as masticatory muscle activity takes place throughout the usual daily life; therefore, it might have some relation with the transverse craniofacial morphology. The present study was carried out to find out any association between balance of masticatory muscle activity during usual daily life and transverse craniofacial morphology or tooth contact area in patients with transverse jaw deformity.

**Subjects and Methods:** All the controls and patients for the study were selected from our staffs and patients coming to Orthodontic Clinic, Hiroshima University Dental Hospital, respectively. Thirteen males and two females (mean and s.d. of ages: 28.6 ± 1.9 years) served as the controls. They had Angle's Class I molar relationship, no severe malocclusion, no complaints of temporomandibular disorder (TMD).The patient group was consisted of 10 males and five females (mean and s.d. of ages: 19.9 ± 5.3 years) with lateral shift of the mandible. They had malocclusion such as cross-bite and severe crowding, but no complaints of TMD.

Portable digital EMG recording device were used to record the EMG from the bilateral masster and anterior temporal muscles. The diurnal recording was carried out for consecutive 142 minutes and divided into two periods of usual daytime and mealtime for analysis. After the diurnal recording, the subjects were allowed to go back home with the electrodes in position and then nocturnal EMG recording was performed again at night with the usual sleeping posture for 142 minutes. Posteroanterior cephalometric analysis and tooth contact area were measured for all the subjects.

**Result:** No significant correlations were found for both the muscles neither with transverse craniofacial morphology nor with the tooth contact area for all the three periods of usual daily life, although a significant correlation was detected between the A-B distance and AI of the anterior temporal muscle during usual daytime.

**Conclusion:** It is suggested that masticatory muscle activity during usual daily life in patients with transverse craniofacial deformity may not be related only to such factors as skeletal deformity or tooth contact area but governed by other important factors like occlusal interference, premature contacts, instability and so on.

**Key words:** Masseter muscle, temporal muscle, transverse craniofacial deformity, electromyography (EMG)
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## INTRODUCTION

Currently it is widely accepted that masticatory muscle activity is associated with the craniofacial morphology. There have been many studies investigating the relationship between masticatory muscle activity and vertical craniofacial morphology, however, only a limited number of studies have been undertaken to find out the correlation between the bilateral balance of masticatory muscle activity and transverse craniofacial morphology. Moreover, those studies were designed to examine the balance of activity during maximal voluntary clenching for a short time in the laboratory and it's relation to transverse craniofacial morphology. But it has to be remembered that masticatory muscle activity takes place throughout the usual daily life, not only during meals. It is also considered that patients with



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transverse craniofacial deformity might have differences in masticatory muscle activity between both sides; hence it might have some relation with the transverse craniofacial morphology.

However, difficulties in executing reliable measurements of masticatory muscle activity using Electromyographic (EMG) recording system have been indicated because of such uncontrolled factors as skin resistance, topographic location of the electrodes and electrodes relocation (Angelone, Clayton & Brandhorst, 1960; Frame, Rothwell & Duxbury, 1973; Garnick, 1975; Burdette & Gale, 1990; Cecere, Ruf & Pancherz, 1996).[1-5]

Given the above mentioned facts, the normalization of EMG activity of masticatory muscle was designed with a reference to the activity at a constant bite force of 98-N (Newton) by Saifuddin et. al. (2001).[6] This analysis made it possible to estimate the muscle activity in proportion to a standard muscle activity at 98-N biting and thereby to reduce the influence of electrode relocation. Using the normalized value of muscle activity the reproducibility of the method was verified.

With these considerations, an effort was made further to study the masticatory muscle activity for a longer period of time by Saifuddin et.al. (2003).[7] This study tried to evaluate the bilateral symmetry and nature of masticatory muscle activity in jaw deformity patients during normal daily activities by using portable Electromyographic (EMG) recording system.

It is well accepted nowadays that premature contact or occlusal interference can reduce or inhibit the masticatory muscle activity. In a previous EMG study (Jiménez, 1987),[8] examining the masticatory muscle activity during maximum clenching at retruded contact position (RCP) with and without a stabilizing splint, revealed that clenching at RCP without the splint inhibited the masseter muscle activity and reduced the temporal muscle activity. Likewise, Ingervall and Carlsson (1982),[9] showed that patients with a balancing-side interference exerted significantly lower postural activity of both the masseter and anterior temporal muscles than the normal controls without the interference. Meanwhile, Sheikholeslam and Riise (1983).[10] simulating an experimental occlusal interference during sub-maximal bite, showed that the occlusal interference also disturbed the symmetrical pattern of masticatory muscle activity, for the anterior temporal muscle during sub-maximal biting in particular. However, all these experiments were carried out for a short period of time and either with experimentally induced occlusal interference or patients with slight premature contacts.

It is also known that patients with transverse jaw deformity might have severe occlusal interference or premature contacts (Hirose, 1990),[11] and that the masticatory muscle activity takes place throughout the usual daily life (Miyamoto et al. 1996).[12]

The present study was thus carried out to find out any association between balance of masticatory muscle activity during usual daily life and transverse craniofacial morphology or tooth contact area in patients with transverse jaw deformity.

## SUBJECTS AND METHODS

### Subjects

All the controls and patients for the present study were selected from our staffs and patients coming to Orthodontic Clinic, Hiroshima University Dental Hospital, respectively. Thirteen males and two females (mean and s.d. of the ages: 28.6 ± 1.9 years) served as the controls. They had Angle's Class I molar relationship, no severe malocclusion, no complaints of temporomandibular disorder (TMD), no history of bruxism, with slightest mandibular shift evaluated radiographically (P-A view, ranging from 0 to 3 mm from the midline with mean and s.d. of 1.5 ± 1.1 mm).

The patient group was consisted of 10 males and five females (mean and s.d. of the ages: 19.9 ± 5.3 years) with lateral shift of the mandible, confirmed by clinical and radiographic examination (P-A view, ranging from 5 to 14 mm from the midline with mean and s.d. of 9.2 ± 3.0 mm). They had malocclusion such as cross-bite and severe crowding, but no complaints of TMD and no history of bruxism. Informed consents were obtained from all the subjects prior to the experiments.

### EMG recording procedure

Digital EMG recording device (Muscle Tester ME3000P, Mega Electronics Ltd., Kuopio, Finland) and bipolar silver/silver-chloride electrodes (Blue sensor, type-N-00-S, Medicotest A/S, Ølstykke, Denmark) were used to record the EMG from the bilateral masster and anterior temporal muscles. To position the electrodes at the proper location, one line was drawn from the inferior border of ear tragus to the angle of the mouth. The masseter muscle width was measured by palpation and an ink spot was marked at the middle of the muscle on the line. Electrodes were placed on both sides of the line around the ink spot in parallel to the main direction of master muscle fibers. The anterior temporal muscle was also palpated at the antero-superior border and one electrode was placed 5-mm posterior to this point and the other one at the temporal fossa in parallel to the direction of muscle fibers. An inter-electrode distance of 30 mm was maintained for both the muscles (Fig. 1). Before placing the electrodes, skin was scrubbed by an alcohol soaked gauze pad to reduce the impedance between skin and electrodes. The EMG data were recorded with a sampling frequency of 1 kHz. The mean of rectified EMG data for every 0.02-sec was stored in the recording device. Prior to each recording session, the subjects were instructed to bite on an occlusal force meter (GM 10, Nagano Keiki Seisakusho, Tokyo, Japan) with a 98-N bite force on each of the first molar regions. Then, they were allowed to do what they wanted while carrying the portable EMG recording device. As the recorder is small (170x78x31 mm) and light (530 grams including batteries), it is quite easy for subjects to carry without any trouble during daily normal activities. The diurnal recording was carried out for consecutive 142 minutes (which includes speaking, taking meal, drinking etc.) and divided into two periods of usual daytime and mealtime for the analysis. After the diurnal recording, the subjects were allowed to go back home with the electrodes in position and then the nocturnal EMG recording was performed again at night with the usual sleeping posture. The data for the first 30-minutes sleeping were excluded because of the unstable sleep status, and then the analysis was executed for the following consecutive 142 minutes.

Figure 1: An Overall view of portable EMG recording system

**Quantitative EMG analysis**

After recording, the data were transmitted to a personal computer (Aptiva E58, IBM, New York, USA) and the absolute integrated EMG values (μVs) for all the muscles were calculated automatically for all the periods by means of a software provided together with the device. In order to quantify the muscle activity in an objective manner, the EMG amplitude for each of the muscles obtained during biting with 98-N force was used as a reference of the standard muscle activity for the corresponding muscle. The bite force level was controlled by visual feedback. The standard muscle activity (μV) for each of the muscles was thus the averaged rectified EMG value for 1 sec during biting at 98-N force. The averaged rectified values (μV) of different periods for 1 sec were obtained by dividing the absolute integrated EMG values with the time interval for each of the periods for all of the muscles. Then, the averaged rectified values (μV) of different periods for each of the muscles were divided by the standard muscle activity (μV) of the corresponding muscle to obtain the normalized value of muscle activity, as shown below.

Normalized value of muscle activity = Averaged rectified values of different periods (for 1 Sec) (μV) / Standard muscle activity (for 1 Sec) (μV) (the averaged rectified value at 98-N bite force)

The reproducibility of the method has been verified in a previous study (Saifuddin et al., 2001).[6]

In order to investigate the bilateral balance of masticatory muscle activity between controls and patients of transverse jaw deformity an AI (Asymmetry Index) was established in a further study by Saifuddin et al., 2003 as mentioned earlier.[7] The AI for the controls was a ratio of the subtraction of the left value from the right one to their sum, as shown in the following equation.

Asymmetry Index (AI) = (R—L) / (R + L)

Where, R is the right side value, L is the left side value.

Meanwhile, the AI for the patients with transverse jaw deformity was calculated as a ratio of the subtraction of the non-deviated side value from the deviated one to their sum, as shown in the following equation.

Asymmetry Index (AI) = (Dev—Non-dev.) / (Dev + Non-dev.)

Where, Dev is the deviated side value and Non-dev is the non-deviated side value.

In that study, it was revealed that normalized activity of the masseter and anterior temporal muscle during usual daily life was lower in patients with transverse craniofacial deformity. AIs in patients were significantly greater during usual daytime and sleep for the anterior temporal muscle and significantly smaller during sleep for the master muscle as compared to the controls. The differences in AI of anterior temporal muscle between usual daytime and mealtime or sleep were significantly greater in patients than in the controls.

**Cephalometric analysis**

Posteroanterior (PA) cephalogram was taken of all the controls and patients at the intercuspal position. Landmarks, and linear and angular measurements used in this study are depicted in Fig. 2. Eight variables, Me-P, A-B, MeO‘M’line, Are-Me and Are'-Me, Go-Me and Go'-Me, Are- Go and Are'-Go', OGoGo' and OGo'Go, and MeGoGo' and MeGo'Go were established to evaluate the transverse morphology of the craniofacial skeleton.

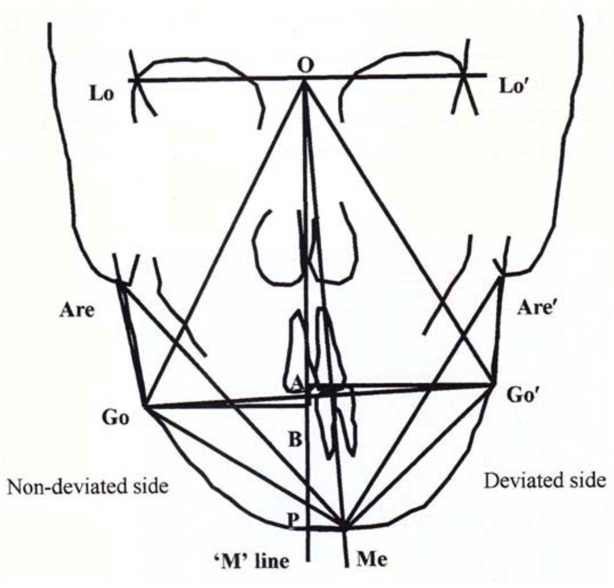


Figure 2: Landmarks and linear and angular measurement items in P-A view

(1) Me-P (transverse deviation of Me from the midline); (2) A-B (difference in the height between Go and Go'); (3) MeO‘M’line (deviation of Me from the midline); (4) Are-Me and Are'-Me (the length of mandible on non-deviated and deviated sides respectively); (5) Go-Me and Go'-Me (the length of mandibular corpus on non-deviated and deviated sides respectively); (6) Are- Go and Are'-Go' (the ramus height on non-deviated and deviated sides respectively); (7) OGoGo' and OGo'Go; and (8) MeGoGo' and MeGo'Go.

The analysis of PA cephalogram was accomplished according to previous methods (Hirose, 1990; Letzer and Kronman, 1967; Kondo, 1972).[11,13,14] Ratios of the right- and left-side measurements were used for morphologic comparison between the controls and patients, except for the first three items. In the patient group, meanwhile, ratios of the subtraction of the non-deviated side value from the deviated one to their sum were used to examine the correlation between AIs for both the muscle activity and transverse craniofacial morphology.

**Measurement of Tooth contact area**

Dental prescale system (FUJIFILM, FPD-703, Tokyo, Japan) was used for measuring the tooth contact area for controls and patients. Tooth contact area was registered at the functional contact position of the models under constant pressure from a press to provide the same force level for controls and patients as shown in Fig. 3. In order to examine the difference between controls and patients, total tooth contact area was measured and compared. However, a ratio of the subtraction of the non-deviated side tooth contact area from the deviated one to their sum was calculated for the patients to examine the correlation between AIs for both the muscle activity and tooth contact area.

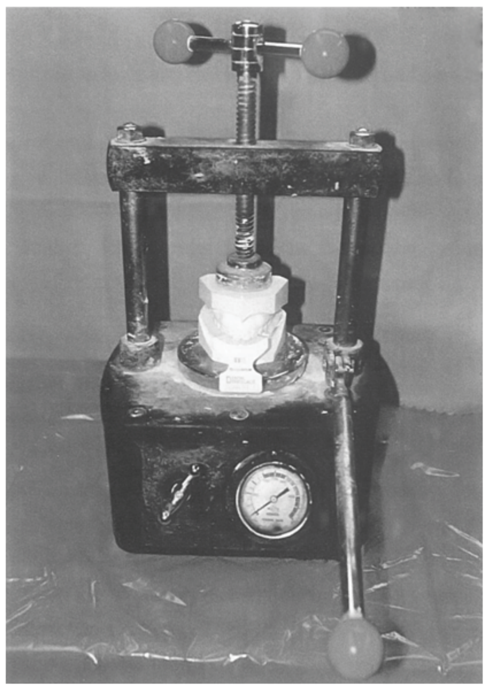

Figure 3: Functional contact position of the models under constant pressure from a press

**Statistical Treatment**

Student's t-test was applied to examine the difference in AIs, normalized values of muscle activity and tooth contact area between the controls and patients. To examine the association between balance of masticatory and transverse craniofacial morphology or tooth contact area in patients, Pearson's correlation analysis was employed.

## RESULTS

Comparison of transverse craniofacial morphology between controls and patients

Means and standard deviation of eight cephalometric variables are presented in Table 1. Significant differences were found between controls and patients, specially in the measurements of the lower part of the face, such as the linear and angular measurements of mandibular deviation, e.g. Me-P, MeO'M'Line, and the ratios of mandibular effective length Are-Me / Are'-Me, Mandibular corpus length Go-Me / Go'-Me and MeGoGo'/ MeGo'Go.

Table 1: Comparison of transverse craniofacial morphology between controls and patients

| Cephalometric measurement items | Controls | Patients | *t*-test |
|---|---|---|---|
| Me – P (mm) | 1.48 ± 1.14 | 9.15 ± 3.06 | ** |
| A– B (mm) | 3.60 ± 2.84 | 4.05 ± 2.75 | NS |
| ∠MeO'M'line (degrees) | 0.73 ± 0.57 | 3.97 ± 1.38 | ** |
| Are-Me / Are'-Me | 1.01 ± 0.04 | 1.07 ± 0.08 | * |
| Go-Me / Go'-Me | 1.01 ± 0.07 | 1.08 ± 0.09 | * |
| Are- Go / Are'-Go' | 1.05 ± 0.13 | 1.05 ± 0.18 | NS |
| ∠OGoGo' / ∠OGo'Go | 0.98 ± 0.05 | 1.01 ± 0.05 | NS |
| ∠MeGoGo' / ∠MeGo'Go | 1.00 ± 0.08 | 0.92 ± 0.09 | * |

NS: No significant difference (two-tailed paired *t*-test, p>0.05)

**: Significant difference (two-tailed paired *t*-test, p<0.01)

*: Significant difference (two-tailed paired *t*-test, p<0.05)

Comparison of tooth contact area between controls and patients

When tooth contact area was compared between controls and patients, the patient group showed significantly smaller tooth contact area than the controls as shown in Fig. 4.

Association between balance of masticatory muscle activity during usual daily life and transverse craniofacial morphology or tooth contact area in patients

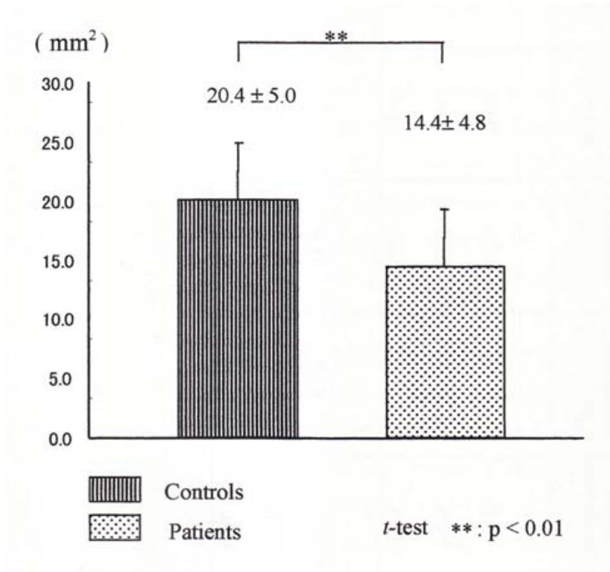


Figure 4: Comparison of total tooth contact area between controls and patients (t-test**: p< 0.01)

Correlation between balance of masticatory muscle activity and transverse craniofacial morphology or tooth contact area in patients during usual daytime, mealtime and sleep are presented in Table 2. No significant correlations were found for both the muscles neither with transverse craniofacial morphology nor with the tooth contact area for all the three periods of usual daily life, although a significant correlation was detected between the A-B distance and AI of the anterior temporal muscle during usual daytime.

Table 2: Correlation coefficients between AIs of masticatory muscle activity and transverse craniofacial morphology or tooth contact area in patients

| | | | | (Dev. – Non-dev.) / ((Dev. + Non-dev.) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| AI | Me – P (mm) | A – B (mm) | ∠MeO'M'line (degrees) | Are-Me/ Are'-Me | Go-Me/ Go'-Me | Are-Go/ Are'-Go' | ∠OGoGo'/ ∠OGo'Go | ∠MeGoGo'/ ∠MeGo'Go | Tooth contact area |
| **Masseter** | | | | | | | | | |
| Usual daytime | -0.33 | -0.31 | -0.33 | 0.07 | 0.01 | -0.02 | -0.01 | 0.05 | -0.08 |
| Mealtime | -0.34 | -0.34 | -0.32 | 0.18 | 0.30 | 0.11 | -0.22 | -0.29 | 0.26 |
| Sleep | -0.16 | -0.06 | -0.20 | 0.16 | 0.36 | -0.28 | -0.03 | -0.31 | 0.45 |
| **Ant. Temporal** | | | | | | | | | |
| Usual daytime | -0.45 | -0.63* | -0.43 | 0.35 | 0.17 | 0.04 | -0.11 | -0.14 | 0.06 |
| Mealtime | -0.40 | -0.12 | -0.40 | 0.38 | 0.10 | 0.23 | 0.31 | -0.14 | 0.02 |
| Sleep | -0.07 | 0.16 | -0.06 | 0.20 | -0.10 | 0.38 | 0.32 | 0.06 | -0.29 |

## DISCUSSION

Association of muscle activity with morphological factors or tooth contact area:

There is a general tendency in the vertebrates to form bilateral structures as mirror images of each other over the midline. However, slight amount of asymmetry appears as a common feature. Although slight amount of morphological asymmetries were accepted as a natural outcome rather than exception in many previous studies (Letzer and Kronman, 1967; Fischer, 1954; Shah and Joshi, 1978; Williamson and Simmons, 1979; Farkas and Cheung, 1981; Pirttiniemi, 1994),[13, 15-19] the normal range of asymmetry has not been defined at all.

In the present study, some of the control subjects had little amount (1-3 mm) of lateral deviation of mandible radiographically but they did not show any appearance for clinical lateral deviation of mandible. Moreover, as they met most of the remaining criteria for normal healthy subjects with sound dentition, they were accepted as the controls.

For posteroanterior cephalometric analysis, use of the absolute bilateral measurements is always involved with lack of reliability. Therefore, the ratios of right- and left side values were used for the morphologic comparison between controls and patients. In the patient group, meanwhile, ratios of the subtraction of the non-deviated side values from the deviated one to their sum were used to examine the correlation between AIs for both the muscle activity and transverse craniofacial morphology. Functional contact area does not represent the tooth surface areas that may contact during lateral movements (Wilding et al., 1992).[20] However, it was not possible to identify the tooth contacts occurred during usual daily life, therefore, only the functional tooth contact area was registered with the casts under constant pressure from a press in the present study.

Although, significant correlations were found between balance of masticatory muscle activity and transverse craniofacial morphology in previous studies (Hirose, 1990; Colangelo et al., 1987; Hidaka et al., 1996),[11, 21, 22] no associations were found in the present study. The reason might be because the recording in this study was carried out for a considerable longer time under usual daily condition. Recording of EMG under such condition might be influenced by psychological and physical status (Rugh and Solberg, 1976).[23] Therefore, activity of masticatory muscles might vary between individuals because of no restrictions for their usual daily life activities. Moreover, morphological adaptation of the muscles to the skeletal deformities might be another reason for no significant correlation because the subjects were well grown adults.

However, an existence of asymmetry in masticatory muscle activity, especially in the anterior temporal muscle requires a logical explanation. A greater asymmetry found in the anterior temporal muscle might be due to the change of mandibular position caused by the lateral deviation or occlusal interference. We could not find any correlation between most of muscular asymmetry and transverse craniofacial deformity or tooth contact area. It may be speculated that rather than skeletal deformity or tooth contact area, occclusal interference or irregular tooth contact might be a responsible factor for asymmetrical activity of these muscles. Occlusal interference can influence the muscle response in acute or chronic way. As the patients had malposition of teeth for a considerably long time, the occlusal interference can influence the muscle response only by chronic interference. It is well accepted that when an occlusal interference becomes chronic, the muscle response may be modified (Okeson, 1995).[24] A chronic occlusal interference may affect functional activity in one of two ways. The most common way is to alter the muscle activity so as to avoid the potentially damaging contact and get on with the task of function. This alteration is likely to be controlled by the central pattern generator in the brain stem and represents an adaptive response. If altered muscle activity does not take place, a significant muscle pain may be induced. As the patients in the present study had no history of muscular pain symptom, it can be reasonably assumed that the muscle activity had been altered. This logic is also reinforced by the results found in the present study. Therefore, it could be speculated that greater asymmetric activity of the anterior temporal muscle might be an effect of the chronic occlusal interference and instability of teeth in the patients with transverse jaw deformity in this study.

## CONCLUSION

In the present study, significant difference in the craniofacial morphology was found between controls and patients, however, any significant association between bilateral balance of masticatory muscle activity and transverse craniofacial morphology was not found in the patient group. Although the degree of tooth contact area was significantly different between controls and patients, significant association between bilateral balance of masticatory muscle activity and tooth contact area could not be demonstrated in patients.

In conclusion, it is suggested that masticatory muscle activity during usual daily life in patients with transverse craniofacial deformity may not be related only to such factors as skeletal deformity or tooth contact area but governed by other important factors such as occlusal interference, premature contacts, instability and so on.

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