Statistical analysis of differential lissajous EMG from normal occlusion and Class III malocclusion

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Toshio Deguchi, DDS, PhD, MSD; Lawrence P. Garetto, PhD; Youichi Sato, DDS; Rosario H. Potter, MSD, MS; W. Eugene Roberts, DDS, PhD

Prior electromyographic investigations of the masticatory muscles during normal chewing have found a large variation in timing-onset, amplitude, and duration of myoelectric bursts between subjects.[1,2] This has been shown to be partially related to occlusal morphology[3] and facial structures.[4-6] Natural chewing can be characterized as a random change of chewing side with a constantly changing muscular predominance that controls the extent and direction of mandibular movements. Conversely, unilateral (right or left side) chewing has the ability of demonstrating the relative coordinated activity of the temporal and masseter muscles between the ipsilateral and contralateral chewing cycles.[7]

The differential lissajous electromyographic (DL-EMG) developed by Kumai[8,9] describes the coordinated EMG activity of the bilateral temporal and masseter muscles. Deguchi et al.[10] studied the statistical differences and figure location of DL-EMG for normal occlusion and Class II, division I malocclusion. Their findings suggest that there are statistical differences in EMG voltage, slope of regression line (constructed from the DL-EMG figure), coefficients of correlation, rotational direction of DL-EMG loops, and quadrant location of DL-EMG pattern

Abstract

The method of differential lissajous electromyography (DL-EMG) was applied to investigate the relationship among the integrated EMG activity, timing, and coordination of the bilateral superficial anterior temporal and masseter muscle activities in normal occlusion and Class III malocclusion subjects. In both Class III malocclusion and normal occlusion subjects, the working side muscles showed a higher mean cumulative voltage (MCV) and mean maximum peak voltage (MMPV) compared with the balancing side. In addition, a higher MCV and MMPV of the working side masseter was observed in the normal occlusion group compared with that seen in the Class III group during both right and left side chewing ($p<0.01$). Discriminant analysis applied to examine the distribution, the size and the shape of DL-EMG pattern further indicated a statistical difference between subject groups ($p<0.01$). Finally, there was a significantly higher percentage of clockwise DL-EMG pattern-generation in the normal group compared with that seen for Class III subjects ($p<0.01$). These data indicate that, compared with normal subjects, patients with a Class III malocclusion have a demonstrably abnormal masticatory muscle balance which is well characterized by the DL-EMG method.

Commentary by Pavel Sectakof, DDS, MSC(D)

Key Words

Differential Lissajous pattern • EMG • Normal occlusion • Class III malocclusion.

Submitted: June 1993 **Revised and accepted:** January 1994 Angle Orthod 1994; 65(2):151-160.

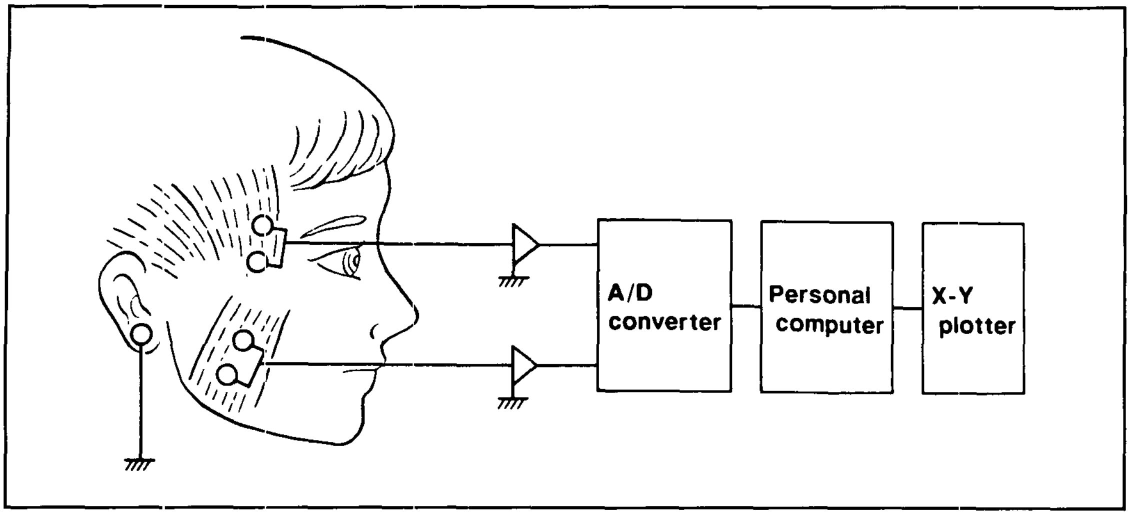

Figure 1A

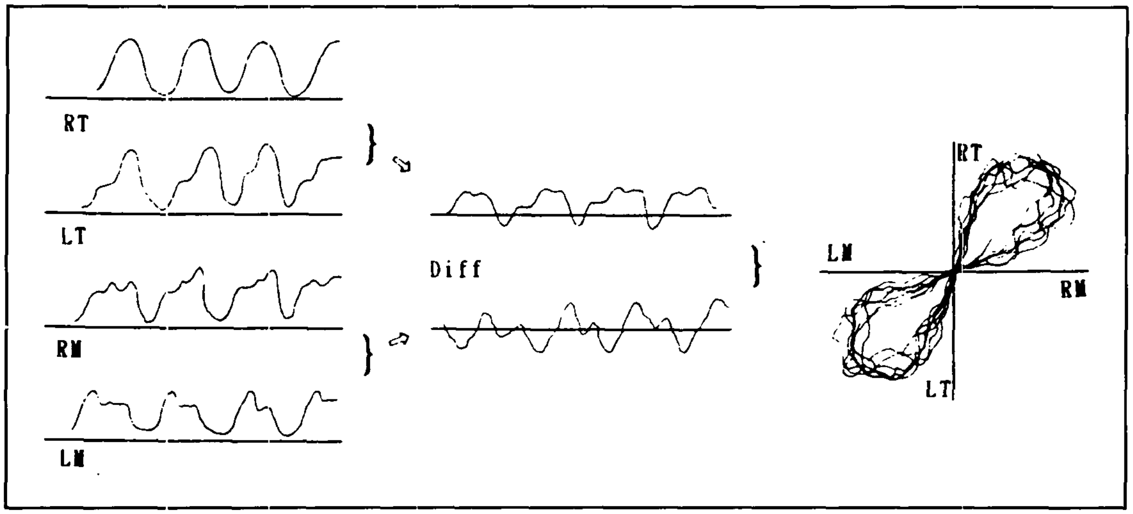

Figure 1B

Figure 1A-B
(A) Schematic depiction of the conversion process from raw EMG signals to DL-EMG pattern using X-Y plotter. (B) Arrows indicate that the difference between the two temporal muscle signals was plotted on the Y axis and the difference between the two masseter signals was plotted on the X axis. The DL-EMG pattern in the 1st quadrant (upper right portion of the X-Y plot) was developed during right-side chewing. The pattern in the third quadrant (lower left portion of the X-Y plot) is plotted during left-side chewing. RT: right temporalis; LT: left temporalis; RM: right masseter; LM: left masseter; Diff: the resultant plot of the difference between right and left paired muscles (see references 8 and 9 for complete details).

Table 1. Comparison of cephalometric measurements of normal occlusion and Class III malocclusion among Japanese female adults

Cephalometric measurements	Japanese female adults ideal*	Normal occlusion subjects		Class III subjects	
		mean	S.D.	mean	S.D.
SNA	82.0°	82.3°	1.3	81.3°	4.7
SNB	79.0°	78.8°	1.4	83.3°	4.6
ANB	3.0°	3.5°	1.1	-2.0°	3.3
NPg-FH	88.0°	86.5°	2.1	91.0°	3.5
FMA	25.0°	26.7°	5.0	28.5°	7.0
L1 to APg (mm)	4.0	4.0	2.8	7.9	2.3
Overjet (mm)	3.0	3.0	1.1	-2.8	2.0
Overbite (mm)	3.0	2.9	1.2	1.1	3.7

*Deguchi et al.[10]

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between these two subject groups.

There is little information on EMG activity in patients with Class III malocclusion corresponding with Class III skeletal pattern.[1,11-13] Ahlgren[12] found that the specific EMG coordination pattern and integrated EMG activity of the masseter and temporal muscles during chewing in Class III patients were statistically different from that of normal occlusion subjects.

The purpose of this study was to statistically analyze the differential lissajous EMG data obtained from Japanese female adults having either normal occlusion or Class III malocclusion.

Materials and methods

Subjects

The normal occlusion sample comprised 20 Japanese females, aged 19 to 27 years, selected from students at Matsumoto Dental College. All of the students showed acceptable profiles with normal occlusal and skeletal morphology. Clinically, they had no oral pain related to temporomandibular joint (TMJ) problems. Twenty adult Japanese females were selected as the Class III malocclusion sample. These patients, aged 16 to 24 years, were waiting for orthodontic/surgical treatment in the Department of Orthodontics at Matsumoto Dental Hospital. Each patient had a Class III skeletal pattern primarily with mandibular protrusion and an edge-to-edge or bilateral posterior crossbite, which is morphologically common among Japanese Class III malocclusion patients (Table 1). As was the case with the normal occlusion group, the Class III patients did not exhibit any signs or symptoms of TMJ disorder.

Electromyography

Simultaneous bilateral surface EMG of the superficial masseter muscle and the anterior part of temporal muscles during unilateral gum chewing was reported in a previous study.[10] In the present investigation, paired superficial masseter and anterior temporal myoelectric activities were recorded using bipolar disk electrodes with an interelectrode distance of 25 mm (Figure 1A). A ground electrode was attached to the right ear of the subject and the electrode was oriented to the direction of the muscle fibers.

During 18 seconds of bilateral chewing (9 seconds on each side), EMG signals were amplified, sent through a rectifying and smoothing circuit, and converted to numerical values in the range of 0 to 5 volts at 10-millisecond intervals. The digitized data were then processed in the manner reported by Kumai[9] and the completed differential lissajous patterns were drawn using the X-Y plotter (Figure 1B). The reproducibility of the repeated electrode placement was statistically examined in the previous study[10] and a significant difference was found in only two out of 32 measurements.

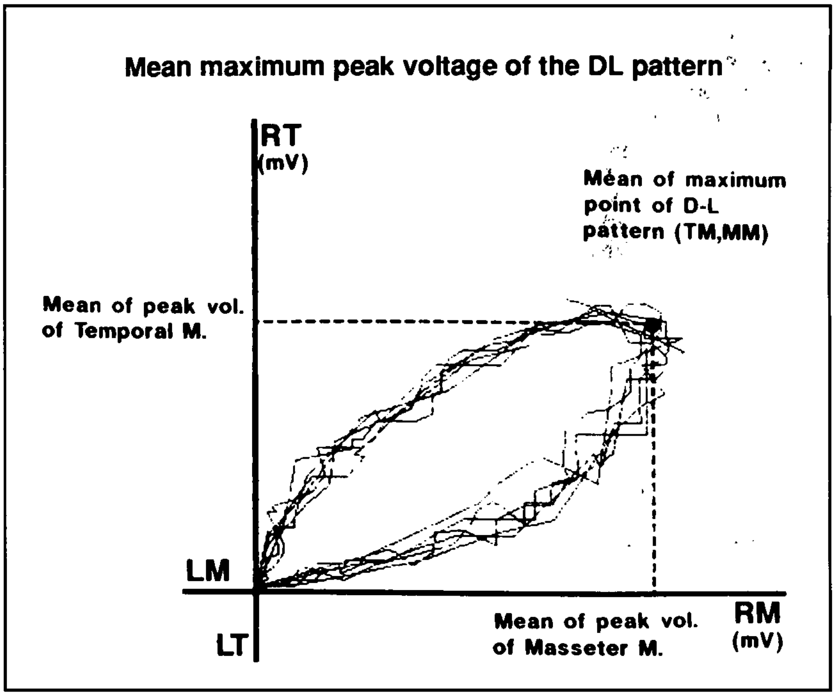

Figure 2

Figure 2
Each maximum voltage of a cycle for the masseter and temporal muscles was obtained from the mathematical difference between the maximum peak voltage of the working side and balancing side muscles. The mean maximum peak voltage point for each muscle (TM, MM) corresponds to the farthest point of the DL pattern from the origin (X=0=Y).

For each subject, the following parameters were evaluated for both right and left side chewing patterns: (1) comparison of the mean cumulative voltage (MCV) and the mean maximum peak voltage (MMPV) of the EMG signals for each of the four muscles in both subject groups; (2) discriminant analysis of peak EMG activity points of DL-EMG patterns obtained from MMPV data; (3) directional analysis of rotational loops for the DL-EMG pattern. MCV was obtained from the total cumulative voltage divided by the number of cycles for each subject. As described in Figure 2, MMPV was calculated to represent the mean of the distribution and the size and inclination of DL-EMG pattern for each subject. Each maximum voltage of a cycle for the temporal and masseter muscles was obtained from the mathematical difference between the maximum peak voltage of the working side muscle and balancing side muscle during unilateral chewing. The rotational direction of the DL-EMG pattern during each cycle of right and left side chewing was assigned by the investigator while watching the development of the loop pattern on the oscilloscope.

Statistical analysis

The analysis of variance (ANOVA) for MCV and MMPV data was a repeat measures design

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Figure 3
Typical example of the original EMGs for the four muscles (A) and the constructed DL-EMG (B) in a normal subject. RT: right temporal muscle; LT: left temporal muscle; RM: right masseter muscle; LM: left masseter muscle.

Figure 4
An example of the original four EMGs (A) for a Class III subject. (B) the DL-EMG pattern for left side chewing is located in the upper left quadrant and closer to the origin than in patients with normal occlusion (compare with Figure 3).

Figure 5
Another example of a Class III subject. Note the DL-EMG pattern is irregular, of a linear type, and located closer to the y-axis than in normal subjects (compare with Figure 3).

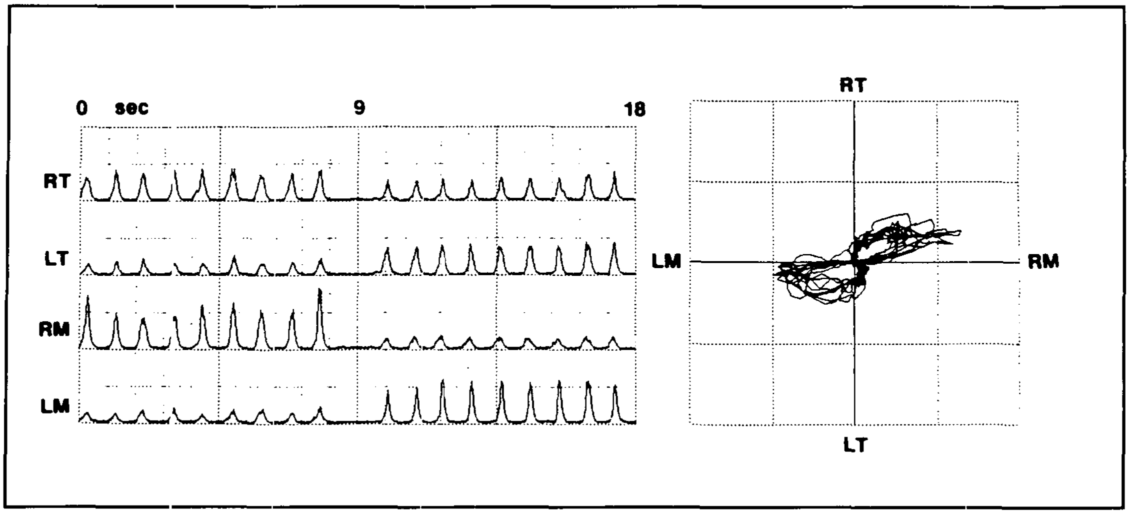

Figure 3

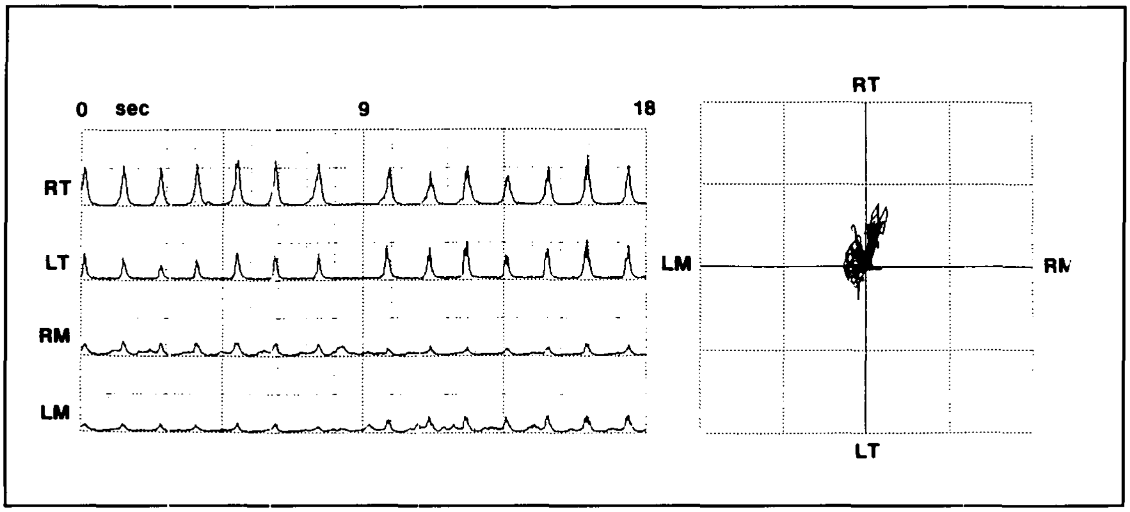

Figure 4

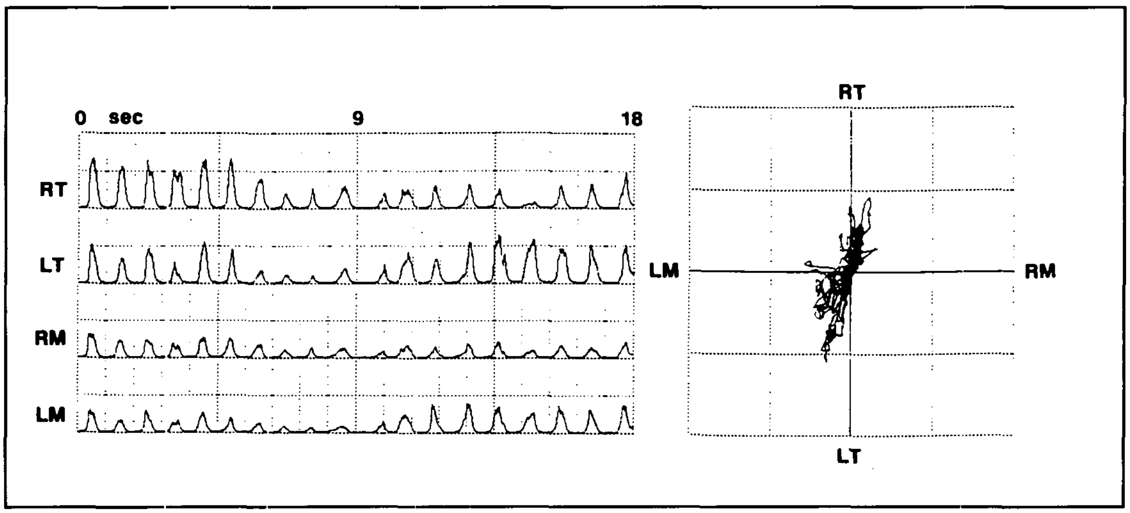

Figure 5

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Table 2. Mean cumulative voltage (MCV) of EMG signals during right chewing in normal and Class III

Table 2a. Normal vs Class III at each muscle-side

Variation between groups	MCV ; mean (S.D.) normal	ClassIII
Temporal right (working)	22.30 (6.74)	19.17 (7.70)
Temporal left (balancing)	15.53 (4.98)	13.78 (5.22)
Masseter right (working)	24.88 (8.66)	17.28 (7.59)**
Masseter left (balancing)	8.55 (3.02)	8.47 (3.70)

** : p<0.01 (unit ; mV·s)

Table 2b. Temporal vs masseter at each group-side level

Variation between muscles	MCV ; mean (S.D.) temporal	masseter
Normal right	22.30 (6.74)	24.88 (8.66)
Normal left	15.53 (4.98)	8.55 (3.02)**
Class III right	19.17 (7.70)	17.28 (7.59)
Class III left	13.78 (5.22)	8.47 (3.70)**

** : p<0.01 (unit ; mV·s)

Table 2c. Right vs left side at each group-muscle

Variation between sides	MCV ; mean (S.D.) right side	left side
Normal temporal	22.30 (6.74)	15.53 (4.98)**
Normal masseter	24.88 (8.66)	8.55 (3.02)**
Class III	19.17 (7.70)	13.78 (5.22)**
Class III masseter	17.28 (7.59)	8.47 (3.70)**

** : p<0.01 (unit ; mV·s)

Table 3. Mean cumulative voltage (MCV) of EMG signals during left side chewing in normal and Class III groups

Table 3a. Normal vs Class III at each muscle-side level

Variation between groups	MCV ; mean (S.D.) normal	ClassIII
Temporal right (balancing)	15.34 (6.27)	13.57 (6.26)
Temporal left (working)	22.21 (7.71)	17.33 (6.90)**
Masseter right (balancing)	8.25 (3.34)	9.13 (3.84)
Masseter left (working)	23.77 (6.18)	16.59 (6.39)**

** : p<0.01 (unit ; mV·s)

Table 3b. Temporal vs masseter at each group-side level

Variation between muscles	MCV ; mean (S.D.) temporal	masseter
Normal right (balancing)	15.34 (6.27)	8.25 (3.34)**
Normal left (working)	13.57 (6.26)	23.77 (6.18)
Class III right (balancing)	22.21 (7.71)	9.13 (3.84)**
Class III left (working)	17.33 (6.90)	16.59 (6.39)

** : p<0.01 (unit ; mV·s)

Table 3c. Right vs left side at each group-muscle level

Variation between sides	MCV ; mean (S.D.) right side	left side
Normal temporal	15.34 (6.27)	22.21 (7.71)**
Normal masseter	8.25 (3.34)	23.77 (6.18)**
Class III temporal	13.57 (6.26)	17.33 (6.90)*
Class III masseter	9.13 (3.84)	16.59 (6.39)**

** : p<0.01 , * : p<0.05 (unit ; mV·s)

consisting of three factors: group (normal vs. Class III), muscle (temporal vs. masseter), and chewing side (right vs. left). Muscle and side were the repeated factors measured in each subject (variation between muscles and between sides were components within subjects). Whenever the F-test in the ANOVA was significant, specific post-hoc, pairwise comparisons within each factor were performed by Student Newman Keuls multiple comparison test. The distribution of x and y components of the MMPV points for each subject during unilateral chewing is shown in Figure 6. Group differences (normal occlusion vs. Class III malocclusion) were analyzed using Fisher's Linear Discriminate Function test.[14] Directional analysis of the rotational loop pattern (clockwise, counterclockwise or indeterminant direction) for DL-EMG figures was determined during actual plotting on the computer display. Data obtained for rotational direction are expressed in percent. Arcsine transformation of the percent data was performed to satisfy distribution assumptions of ANOVA. Following this, a two-factor ANOVA for group and direction was performed on these data with direction being the factor repeated within subjects. As described above, whenever F was significant, specific differences in rotational direction between groups were located using the Student Newman Keuls test.

Results

Differential Lissajous EMG

Typical examples of the original four EMGs (Figure 3A) and the DL-EMG (Figure 3B) synthesized from the gum chewing test of a normal subject (Figure 3) and two Class III subjects (Figures 4 and 5) are presented. As seen in the original integrated EMG data, the peaks of EMG activity for the four muscles from Class III subjects (Figures 4A and 5A) were more irregular than the smooth peaks of EMG activity in the normal subject (Figure 3A).

The DL-EMG pattern consists of loops corre-

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sponding to the chewing cycles, which lie predominantly in the first quadrant for the right side chewing and in the third quadrant for left side chewing. The type of pattern illustrates the relative timing of muscle contraction. The essentially smooth, continuous tear-drop shaped pattern of the normal group (Figure 3B) indicates a consistent contraction of each muscle with a specific time-span. The DL-EMG patterns in the Class III group (Figures 4B and 5B) showed a large range of pattern distribution which were more irregularly shaped than those observed in the normal occlusion group.

Mean cumulative voltage (MCV)

Data for MCV are presented in Tables 2 and 3. In each table, the data has been grouped in three different ways to facilitate comparison of the three factors of the ANOVA.

Differences between groups

The normal group showed higher EMG activity levels on the working side masseter during both the right and left side chewing ($p<0.01$). A statistically higher EMG activity of the working side temporal muscle was also seen in normal subjects during left side chewing ($p<0.01$). This pattern was apparent during right side chewing, but this trend in the data did not reach statistical significance (Table 2a, 3a).

Differences between muscles

The balancing side temporal muscles of the two groups showed higher EMG activity than those of the balancing side masseter during both right and left side chewing ($p<0.01$, Table 2b, 3b).

Differences between chewing sides

In all cases, when analogous right and left side muscles were compared, the EMG activity on the working side was greater ($p<0.01$-0.05). This was observed regardless of whether the chewing was performed on the right (Table 2c) or left (Table 3c) side.

Mean maximum peak voltage (MMPV)

The mean maximum peak voltage was calculated to represent the distribution, size, and inclination of DL-EMG pattern (Figure 2). Each maximum voltage of a cycle for the masseter and temporal muscles was obtained from the mathematical difference between the maximum peak voltage of the working side muscle and the balancing side muscle during unilateral chewing. As for MCV, the data are presented in three different ways in Tables 4 and 5 to facilitate comparison of the three factors from the ANOVA.

Differences between groups

During both right and left side chewing, the normal group showed a higher peak EMG activity than the Class III group on the working side ($p<0.01$) and balancing side ($p<0.05$) temporalis as well as on the working side masseter ($p<0.05$). However, no difference was observed between the balancing side masseters in the two groups (Table 4a, 5a).

Differences between muscles

The balancing side temporal muscle showed a higher peak EMG activity than the balancing side masseter ($p<0.01$) during both unilateral chewing in normal and Class III groups. There were no statistical differences among the working side muscles (Table 4b, 5b).

Differences between chewing sides

As was the case for the MCV data, comparison of the MMPV data for analogous right and left side muscles consistently showed a greater peak activity (i.e. left side greater during left side chewing and vice versa) on the working side than the balancing side ($p<0.01$ - 0.05; Tables 4c, 5c).

Discriminant analysis of MMPV date

When plotted as individual points, the Class III subjects tended to be distributed closer to the origin and in a more scattered pattern than were subjects in the normal occlusion group (Figure 6). Discriminant analysis of these data also resulted in a significant difference ($p<0.01$) between the two subject groups.

Rotational direction

There were three different rotational direction patterns. The normal group showed the highest percentage of clockwise rotation. Conversely, rotational direction of the Class III group was predominantly indeterminate (Table 6). These data were statistically different between the two subject groups for both right and left side chewing ($p<0.01$ and $p<0.05$; Table 6).

Discussion

Angle Class III malocclusion is usually consistent with a Class III skeletal pattern having mandibular protrusion, maxillary retrusion, and a combination of both skeletal discrepancies. However, the dental morphological pattern of Class III malocclusion is complicated and shows a variety of discrepancies including anterior crossbite and openbite, edge-to-edge occlusion, unilateral, bilateral posterior crossbite, and dental compensation. Furthermore, Class III malocclusion may show macroglossia, tongue thrust with swallowing difficulty, and TMJ disorders which greatly affect the EMG recordings of masticatory muscle activity. The 20 Class III subjects in the current study were selected because they exhibited anterior crossbite, edge-to-edge, or bilateral posterior crossbite and a true skeletal

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Table 4. Mean maximum peak voltages (MMPV) of EMG signals during right side chewing in normal and Class III groups

Table 4a. Normal vs Class III at each muscle-side level

Variation between groups	MMPV ; mean (S.D.) normal	MMPV ; mean (S.D.) ClassIII
Temporal right (working)	2.436 (0.720)	1.818 (0.756)**
Temporal left (balancing)	1.737 (0.709)	1.293 (0.503)*
Masseter right (working)	2.756 (0.795)	1.477 (0.659)**
Masseter left (balancing)	0.842 (0.245)	0.669 (0.350)

** : p<0.01 , * : p<0.05 (unit ; mV)

Table 4b. Temporal vs masseter at each group-side level

Variation between muscles	MMPV ; mean (S.D.) temporal	MMPV ; mean (S.D.) masseter
Normal right (working)	2.436 (0.720)	2.756 (0.795)
Normal left (balancing)	1.737 (0.709)	0.842 (0.245)**
Class III right (working)	1.818 (0.756)	1.477 (0.659)
Class III left (balancing)	1.293 (0.503)	0.669 (0.350)**

** : p<0.01 (unit ; mV)

Table 4c. Right vs left side at each group-muscle level

Variation between sides	MMPV ; mean (S.D.) right side	MMPV ; mean (S.D.) left side
Normal temporal	2.436 (0.720)	1.737 (0.709)**
Normal masseter	2.756 (0.795)	0.842 (0.245)**
Class III temporal	1.818 (0.756)	1.293 (0.503)**
Class III masseter	1.477 (0.659)	0.669 (0.350)**

** : p<0.01 (unit ; mV)

Table 5. Mean maximum peak voltages (MMPV) of EMG signals during left side chewing in normal and Class III groups

Table 5a. Normal vs Class III at each muscle-side level

Variation between groups	MMPV ; mean (S.D.) normal	MMPV ; mean (S.D.) ClassIII
Temporal right (balancing)	1.792 (0.747)	1.289 (0.714)*
Temporal left (working)	2.518 (0.790)	1.661 (0.541)**
Masseter right (balancing)	0.873 (0.462)	0.685 (0.408)
Masseter left (working)	2.877 (0.709)	1.516 (0.604)**

** : p<0.01 , * : p<0.05 (unit ; mV)

Table 5b. Temporal vs masseter at each group-side level

Variation between muscles	MMPV ; mean (S.D.) temporal	MMPV ; mean (S.D.) masseter
Normal right (balancing)	1.792 (0.747)	0.873 (0.462)**
Normal left (working)	2.518 (0.790)	2.877 (0.709)
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Class III left (working)	1.661 (0.541)	1.516 (0.604)

** : p<0.01 (unit ; mV)

Table 5c. Right vs left side at each group-muscle level

Variation between sides	MMPV ; mean (S.D.) right side	MMPV ; mean (S.D.) left side
Normal temporal	1.792 (0.747)	2.518 (0.790)**
Normal masseter	0.873 (0.462)	2.877 (0.709)**
Class III temporal	1.289 (0.714)	1.661 (0.541)*
Class III masseter	0.685 (0.408)	1.516 (0.604)**

** : p<0.01 , * : p<0.05 (unit ; mV)

Class III pattern. In retrospect, it would have been interesting to assess them for postural shifts as well. Patients with postural shifts might exhibit a different muscle activity pattern than those who do not shift during function.

Earlier EMG studies of unilateral chewing for normal occlusion subjects indicated that the EMG levels for both the masseter and the temporal muscles are normally higher on the working side than on the balancing side and that this difference is more pronounced for the masseter than for the temporal muscle.[1,2] The current result from the mean cumulative voltage (MCV) of the normal occlusion was quite similar to that found by Ahlgren[1] and Moeller[2] (Tables 2a, 2b, 3a and 3b). In addition, the MCV data from the normal subjects showed higher EMG activity for the balancing temporalis than for the balancing masseter (Tables 2c, 3c).

Ahlgren[1] and Moeller[2] also reported that the temporal muscle on the working side is the first to be activated during the chewing stroke, followed by a simultaneous contraction of the balancing temporal and the bilateral masseter muscles. Kumai[9] noted that this earlier and stronger contraction of the ipsilateral temporal muscle was reflected in the predominantly clockwise rotation of the DL-EMG pattern, which he obtained for a single normal subject.

There was a statistical difference in the mean MMPV of working side temporalis for the normal versus the Class III groups during both unilateral chewing cycles. Discriminant analysis of MMPV data showed a clearly separated distribution of MMPV points between the two groups (Figure 6) with a significant linear discriminant function ($p<0.01$). These data indicate that the normal and Class III groups can be separated based on the location, size and inclination of the DL-EMG pattern. Distribution of points from normal subjects suggest that DL-EMG patterns are located in the first quadrant during the right

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Figure 6
Distribution of x and y components of the MMPV points.
Right side chewing:
●—Normal group
○—Class III group.
Left side chewing:
▲—Normal group
△—Class III group.

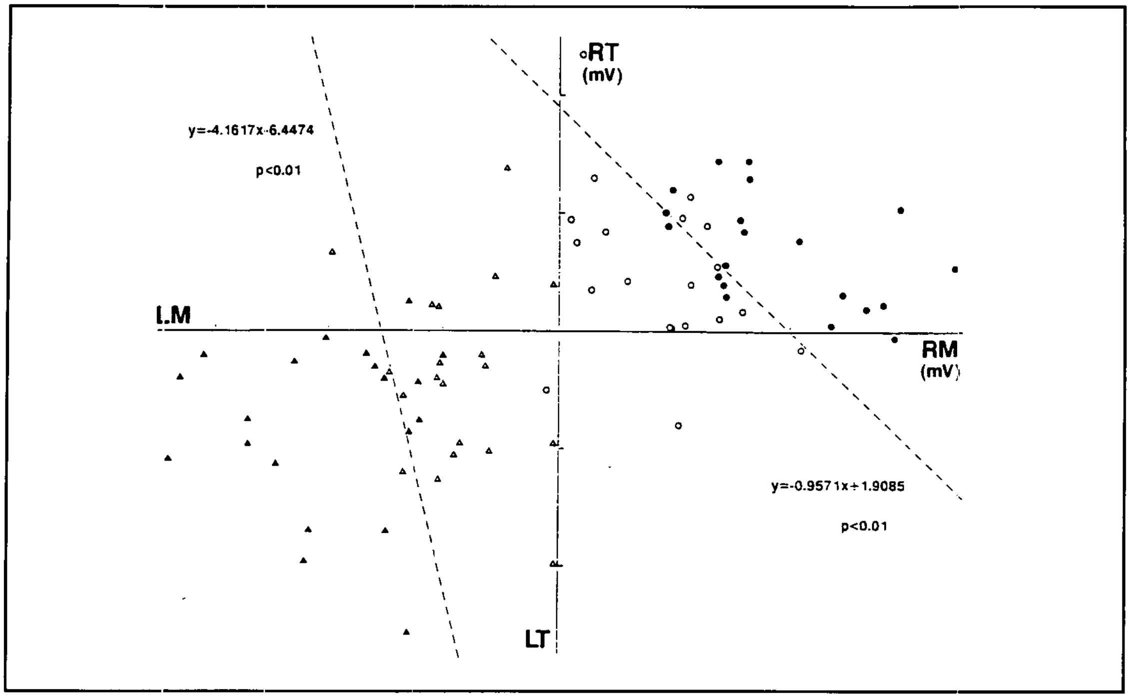

Table 6. Rotational direction of differential lissajous EMG figures for normal and Class III groups

		Rotational Direction (%); mean (S.D.)		
Occlusion	Chewing side	Clockwise	Counterclockwise	Indeterminate
Normal	Right	86.9 (14.2)	1.3 (2.6)	11.7 (13.0)
	Left	91.7 (17.1)	2.3 (7.7)	6.0 (12.3)
Class III	Right	29.7 (28.9)**	15.2 (20.4)**	55.2 (25.6)**
	Left	34.1 (33.4)**	16.2 (23.4)*	49.8 (27.9)**

**P<0.01, **P<0.05

side chewing and in the third quadrant during left side chewing.[10] In addition, the normal subjects show a DL-EMG pattern that is more extended away from the origin and more inclined toward the X axis than those of Class III subjects.

The rotational direction of the DL-EMG loop pattern (Table 6) was statistically different between the two groups ($p<0.05$- 0.01). A high percentage of clockwise rotation for the normal group reflected the respective "positioner" and "worker" actions for the temporal and masseter muscles as discussed in a previous study.[10] The high percentage of clockwise rotation loops in the normal group indicated that the ipsilateral (working side) temporal muscle is normally the first to be contracted during the unilateral chewing stroke.

The DL-EMG pattern drawn on the computer display starts from the origin with the initial portion of the closing phase followed by the late closing phase. During the maximum chewing phase, the highest EMG activity of the masseter muscle is reached. At the initiation of opening, EMG activity in the four muscles rapidly decreases and the trajectory pattern returns to the

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origin. The simultaneous analysis of the rotational loop direction and size, as well as the shape and inclination of the DL-EMG pattern, permitted a reliable assessment of normal muscle balance in each masseter and temporal muscle of the normal group.

Results from the Class III sample in the present study were the same as those reported by Ahlgren:[12] a specific EMG coordination pattern occured during the chewing cycle in Angle Class III cases. In addition, the integrated EMG activity of the masseter and temporal muscles in Class III cases was less than in normal occlusion subjects. In the present study, the results of the Class III group showed less activity of the working side muscles than observed in the normal group ($p<0.01$).

In this current study, the mean maximum peak voltage (MMPV) was first calculated to examine the shape and the inclination of DL-EMG pattern in the normal and Class III groups. Distribution of the points obtained from the MMPV data is more scattered in Class III subjects compared with normal subjects. In addition, Class III subjects showed a lower percentage of clockwise rotation of DL-EMG patterns. This suggests an irregular coordination of EMG activity in the four muscles of the Class III patients.

Ahlgren[12] reported that the analysis of muscle coordination in Class III malocclusion indicated a "chopping" pattern during chewing with simultaneous contraction of the temporal and masseter muscles. This up-down chewing pattern occurred in 67% of his 12 cases. In the present study, the "chopping" pattern was suggested by appearance of the linear shape of loops resulting from simultaneous contractions of the muscles in Class III subjects. No statistical differences could be found between normal and Class III groups when correlation coefficients of constructed lines along the long axis of the DL-EMG loops were compared (data not shown). The reason for this may be that the distribution of irregularly-shaped loop patterns in Class III group resulted in a mean value similar to that of the normal occlusion group.

In conclusion, DL-EMG patterns provide useful quantitative and statistical information assessing the functional masticatory muscle activity of Class III patients. These data indicate that, compared to normal subjects, patients with a Class III malocclusion have a demonstrably abnormal masticatory muscle balance that is well characterized by the DL-EMG method. This method represents a means for objectively assessing orthodontic correction of Class III malocclusion.

Author Address

Dr. Toshio Deguchi
Department of Orthodontics
Matsumoto Dental College
1780 Gohbara Hirooka
Shiojiri, Nagano, 399-07 Japan.

Toshio Deguchi is a Professor and Chairman in the Department of Orthodontics, Matsumoto Dental College.

Lawrence P. Garetto is an Assistant Professor of Orthodontics and Physiology/Biophysics, Indiana University Schools of Dentistry and Medicine.

Youichi Sato is an Instructor in the Department of Orthodontics, Matsumoto Dental College.

Rosario H. Potter is a Professor Emeritus of Oral Facial Genetics, Indiana University School of Dentistry.

W. Eugene Roberts is Professor and Chairman of the Department of Oral Facial Development, Indiana University School of Dentistry.

This research was supported in part by a scientific research grant (766-85023-01771886) provided by the Ministry of Education, Japan.

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Commentary: Differential lissajous EMG from normal occlusion and Class III malocclusion

Pavel A. Sectakof, DDS, MSC(D)

This study examines the EMG activity of the temporalis and masseter muscles in normal (Class I) and Class III subjects. The study has certain methodological problems: the criteria used in choosing the normal occlusion and Class III malocclusion groups, the possibility of unstable bite in the Class III group, the comparison of EMG signals between subjects, the shortcomings of bipolar disk electrodes, and the absence of a baseline of comparison. Postural EMG activity can be used to describe the mastication or swallow-related EMG activity as a percentage and thus allows the standardization and comparison of EMG between subjects.

In spite of these problems, the conclusion of the study, i.e., that EMG activity of Class III individuals differs from that of normal individuals, is still valid. This is certainly expected since previous studies (Deguchi et al., and Ahlgren) suggest that EMG patterns of subjects with Class II and III malocclusions are different from the EMG pattern of subjects with normal occlusion.

However, the usefulness of these EL-EMG patterns in assessing the functional masticatory muscle activity in Class I, II, or III subjects is open to discussion.

Pavel A. Sectakof, Department of Orthodontics, University of Toronto.

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