Changes in masseter muscle activity during orthodontic treatment evaluated by a 24-hour EMG system

Keisuke Miyamoto, DDS, PhD; Yasuo Ishizuka, DDS; Kazuo Tanne, DDS, PhD

During orthodontic treatment, patients usually experience various degrees of discomfort or pain resulting from tooth movement or from the orthodontic appliance. Such discomfort may be unavoidable because, to some extent, periodontal inflammation always accompanies tooth movement that is induced by orthodontic stimuli. Orthodontists naturally want to minimize this discomfort.

Little information is available on the association between discomfort or pain and orthodontic tooth movement because of the difficulty in evaluating the problem quantitatively. In previous studies,[1-4] the degree of discomfort or pain during orthodontic treatment was assessed using a questionnaire. Some studies were designed to investigate an ability to differentiate the intensity of forces,[5] while others examined maximum occlusal force of tolerance of each tooth,[6] pain thresholds,[7] or masseter muscle activity.[8,9]

Clinical experience in orthodontic practice suggests that jaw closing muscle activity may decrease during treatment because discomfort or pain causes changes in the frequency and duration of occlusal contacts. Lund and associates[10] proposed a theoretical model to explain the mechanism of changes in masseter muscle activity. The model was verified by Goldreich et al.,[8] who demonstrated that the adjustment of orthodontic archwires caused a reduction in masseter muscle activity for 48 hours after the activation. However, the nature of varying masticatory

Abstract

This study was conducted to investigate changes in masseter muscle activity during orthodontic treatment. Data was collected using a 24-hour electromyogram (EMG) system. Bursts of masseter muscle activity were counted over 24-hour periods approximately weekly before, during, and after an 18-month period of active orthodontic treatment. The patient, a 25-year-old male, was treated with a multibracket appliance. The number of bursts decreased substantially during the initial leveling period when the archwires were adjusted and then recovered to near the original preactivation level. No remarkable changes in masseter muscle activity were recorded during the latter half of treatment, although masseter muscle activity fell again when the appliance was removed. Six months after the end of treatment, relatively stable masseter muscle activity—similar to that recorded before treatment—was maintained. These changes in masseter muscle activity during orthodontic treatment were probably due to discomfort or pain or to changes in the occlusal relationship between the maxillary and mandibular dentitions produced by tooth movement or by the orthodontic appliance itself.

Key Words

Masseter muscle activity • 24-hour EMG system • Electromyography • Orthodontic tooth movement • Multibracket appliance

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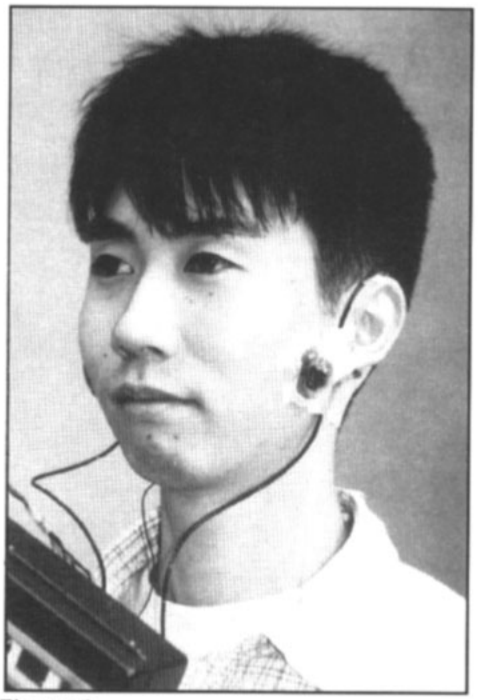


Figure 1

Figure 2A

Figure 2B

Figure 2C

Figure 1
A 24-hour EMG system. Bipolar surface electrodes and a preamplifier were placed over the masseter muscles and connected to a portable data recorder.

Figure 2A-C
Occlusal relationship: A-before treatment; B-during initial leveling; and C-after treatment.

muscle activity during long-term orthodontic tooth movement has not been elucidated.

This study was thus conducted to investigate changes in masseter muscle activity over longer periods than in previous studies.[8,9] To this end, a portable measuring system, developed for recording and analyzing the electromyogram (EMG) during a 24-hour period,[11,12] was used.

Materials and methods

A 25-year-old male with slight Class II molar relationship and skeletal pattern was the subject (Figures 1 and 2A). After initial periodontal treatment, the maxillary right canine and left first premolar and mandibular second premolars were extracted in order to correct the crowding and the Class II molar relationship. Orthodontic treatment was initiated with a multibracket appliance and transpalatal arch (Figure 2B). During orthodontic treatment, the archwires were adjusted every 4 weeks. After 18 months, active treatment was completed and bonded lingual retainers were placed for retention (Figure 2C).

A 24-hour EMG system, which was developed by Yamada and associates,[11,12] was employed for the measurement of masseter muscle activity during 24-hour periods. Bipolar surface electrodes and a preamplifier were placed over the masseter muscle area. These were connected to a portable data recorder (HDX-82, Oxford, Abingdon, England), which is small and convenient enough to be used at home (Figure 1). EMG data were stored on a portable data recorder (HR-30J, TEAC, Tokyo, Japan). The recorded EMG data were then reproduced (MR-30, TEAC, Tokyo, Japan), converted to digital format, and finally analyzed on a personal computer (PC-9821AP, NEC, Tokyo, Japan).

A bite splint, made of modeling compound at the intercuspal position, was used to eliminate the influences of occlusal interference on masseter muscle activity during recordings.[13] Discharge voltage of the masseter muscle was

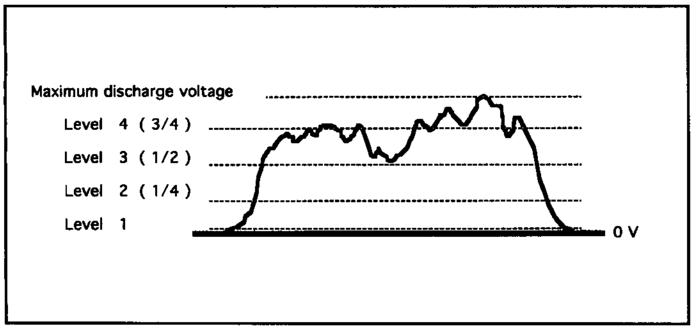


Figure 3

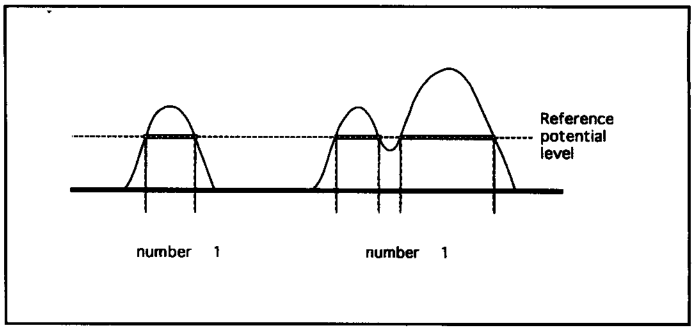


Figure 4

Figure 3
Reference potential levels. The levels are defined on the EMG wave, processed by a smoothing filter to decrease the frequency. Levels 4, 3, and 2 correspond to 3/4, 1/2, and 1/4, the maximum discharge voltage, respectively.[11] Level 1, which represents muscle activity at resting position, was not evaluated in this study.

Figure 4
Counting the bursts of muscle activity. If a burst showed a complicated wave, as at right, it was counted as a single burst.[11]

measured during maximum clenching at the beginning and end of measurement. Reference potential levels from 2 to 4 were defined on the basis of the maximum discharge voltage, as depicted in Figure 3.

EMG data were recorded for 24-hour periods approximately weekly over the course of treatment. Recordings were made on 4 different days before treatment, including the day the extractions were performed, on 41 days during active treatment, and on 8 days after treatment, for a total of 53 days of recordings. The number of bursts of masseter muscle activity that exceeded the predefined reference levels was calculated for each 24-hour recording session (Figure 4).

Results

Figures 5 and 6 show masseter muscle activity before, during, and after orthodontic treatment.

On 3 days before treatment, the number of bursts greater than level 2 ranged from 1478 to 1403 to 1602 (Figure 5). Although these numbers represent relatively stable activity, they are lower than figures obtained previously from 20 adult males.[14] (In that study, the mean number of masseter muscle activity bursts over level 2 was 1938.) There were also fewer bursts exceeding levels 3 and 4 than in the earlier study.

When the teeth were extracted, the number of bursts over level 2 dropped to 48, approximately 1/30 the pretreatment level, and bursts over levels 3 and 4 disappeared completely (Figure 5).

When the multibracket appliance and transpalatal arch were placed, bursts greater than levels 2, 3, and 4 numbered only 32, 2, and 2, respectively. One week later, the number of bursts over level 2 had climbed to 164. Two and three weeks later, the bursts over levels 2 and 3 numbered 976 and 688, respectively (Figure 5).

During the initial leveling phase, from 2 to 5 months after the start of treatment, masseter muscle activity bursts decreased significantly for a week or so following each archwire change or adjustment. Within a few weeks, activity recovered almost to the preadjustment level (Figure 5). From 6 months until the end of treatment, the archwires were adjusted but not changed and decreases in the number of bursts were not observed. The number of bursts over level 2 gradually approached the pretreatment counts, and bursts over levels 3 and 4 reappeared (Figure 6).

When the appliance was removed, 457 bursts over level 2 were recorded, or about half the number observed 1 week earlier. Two weeks later, the activity became similar to that before removal. Six months after the end of treatment, the number of bursts was almost constant, although there were still fewer than before treatment (Figure 6).

Discussion

The degree of discomfort or pain produced by orthodontic treatment differs from patient to patient. Many factors are involved, including the patient's age, sex, and periodontal status; magnitude of orthodontic force; and type of appliance.

Electrophysiologic techniques have been employed to investigate the nature of discomfort and/or pain during orthodontic treatment. Soltis and associates[5] reported that the pain threshold fell 4 days after placement of an orthodontic appliance and approached the original level 6 months to 1 year later. Yamasaki et al.[7] also found that pain thresholds were lower approximately 3 hours after the application of lingual arch springs and that the lower threshold lasted for 7 days. Fujita[6] demonstrated that the maximum occlusal force of tolerance of each tooth fell progressively for up to 26 days.

In order to evaluate the degree of discomfort in terms of muscle activity, EMG studies have been carried out for orthodontic patient groups.[8,9] These studies have shown that masseter muscle activity decreases for 48 hours after archwire adjustments[8] and for 11 hours after archwire changes.[9] However, in all the previous studies measurements were recorded for only short periods during treatment. The present study was thus designed to investigate long-term changes

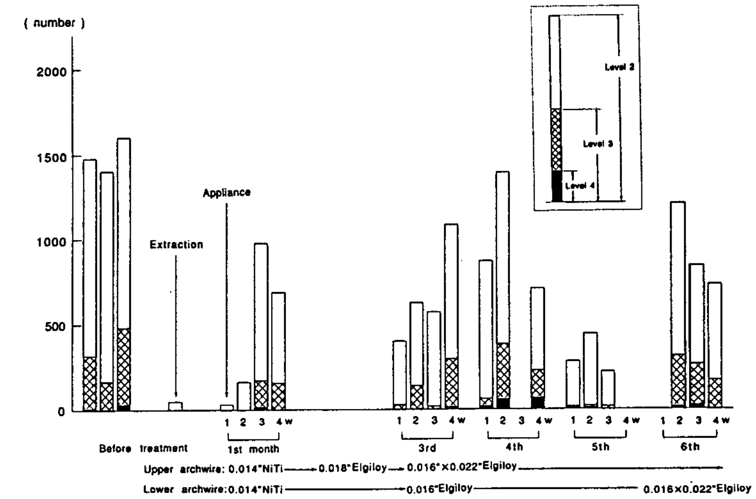


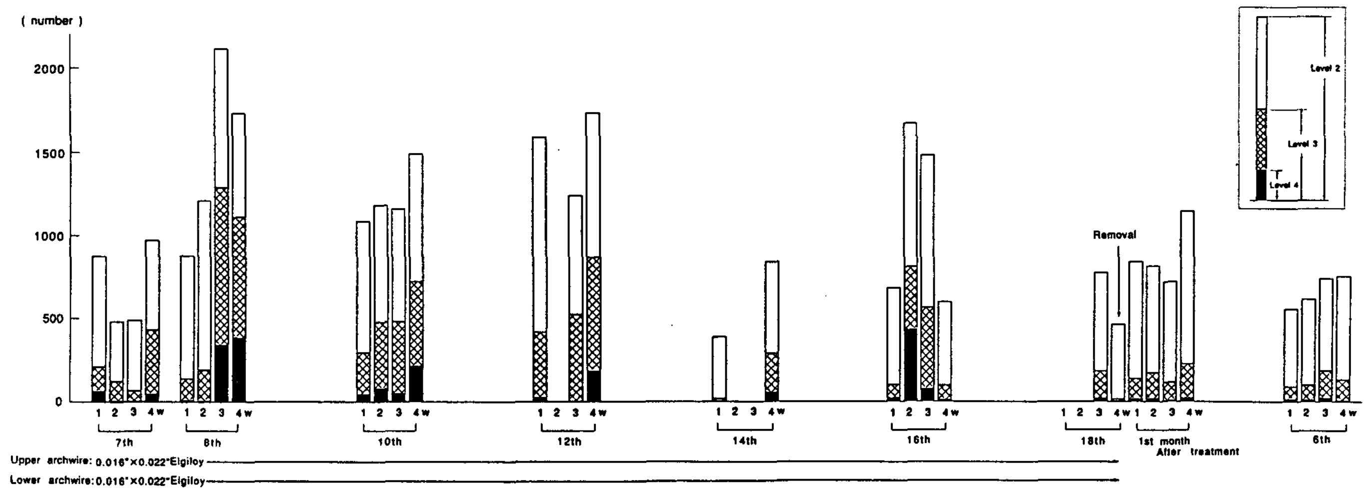
Figure 5
Changes in masseter muscle activity immediately before treatment and during initial leveling. Muscle activity is shown in terms of levels 2 to 4. On the horizontal axis, the period following the start of treatment is indicated by month and week (1-4). The archwires used are also described. In the first week, the archwires were changed or adjusted.

in masseter muscle activity, which is assumed to relate to discomfort or pain and changes in occlusal relationship during orthodontic treatment.

For this purpose, masseter muscle EMG activity was measured during 24-hour periods. The 24-hour-EMG system is portable and does not require an electrically-sealed room. Although discharge voltage of EMG with surface electrodes is not reproducible because of the differences in electrode position and electric resistance, acceptable reliability and sensitivity of quantitative EMG values may be achieved by precisely controlling and quantifying specific types of activity, especially higher levels of muscle activity during maximum clenching.[15] Reference potential levels, defined on the basis of the maximum discharge voltage of the masseter muscle during maximum clenching with a bite splint in use, were employed in this study as a target for the evaluation of muscle activity.

The present study revealed that masseter muscle activity changed during the course of orthodontic treatment with a multibracket appliance. At the beginning of treatment, the number of bursts of masseter muscle activity decreased substantially. In particular, only 32 bursts over level 2 occurred during the 24-hour period following placement of the appliance, indicating substantial discomfort and pain and subsequent difficulties in mastication. Actually, the subject reported that that day was the most painful day of the active treatment period. Since that was the day leveling was initiated, the initial remodeling of the periodontium was speculated to be a key to determining various degrees of pain during the subsequent orthodontic treatment. this was demonstrated by the finding that tooth mobility increased significantly during the initial phase of orthodontic treatment.[16]

From 6 months later until the end of treatment, in order to avoid unnecessary orthodontic forces, the archwires were adjusted but not changed. During this period, no remarkable decreases in masseter muscle activity occurred, indicating an adaptation to the treatment. However, the number of bursts greater than level 2 fell again when



the appliance was removed. Six months after the end of treatment, masseter muscle activity was stable. This finding suggests that the muscle activity can recover to original pretreatment levels, which is of great significance for orthodontic treatment.

These findings suggest that masseter muscle activity changes during orthodontic treatment due to discomfort or pain or alterations in the occlusal relationship produced by tooth movement or the orthodontic appliance. The mechanism of decreases in masseter muscle activity proposed by Lund et al.[10] may well be accommodated to the long-term changes in masseter muscle activity revealed in this study. Although the present findings were derived from an orthodontic patient, the results provide an insight into the nature of biting function as affected by orthodontic stimuli.

Conclusions

Changes in masseter muscle activity during orthodontic treatment were investigated in a 25-year-old male patient by means of a 24-hour EMG system. Masseter muscle activity changes substantially during orthodontic treatment. These changes may be due to discomfort or pain and alterations in the occlusal condition produced by tooth movement or the orthodontic appliance itself.

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Figure 6
Changes in masseter muscle activity during the latter half of treatment and retention. Muscle activity is shown in terms of levels 2 to 4. On the horizontal axis, the period following the start of treatment is indicated by month and week (1-4). The archwires used are also described. In the first week, the archwires were changed or adjusted.

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