Determination of Applicable Multiple Thresholds of EMG Biofeedback Training for Daytime Clenching Behavior

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Abstract

Purpose: Although a daytime clenching is thought to be one of the oral parafuncions that leads to dental problems, a treatment strategy has not yet been devised. Electromyogram (EMG) biofeedback training thresholds were determined to ascertain effective regulation of daytime clenching behavior.

Materials and Methods: Twenty subjects (10 males and 10 females; mean age, 30.9 ± 5.6 years) who had mild to moderate masseter muscle pain with daytime clenching behavior were recruited. Subjects were fitted with a hearing-aid-shaped EMG recording and biofeedback apparatus, which was used to continuously record EMG data from the temporal muscle on the side of habitual mastication under natural conditions for five hours. Recorded EMG data were analyzed to pick up clenching events by EMG thresholds that combined activity (10, 20, and 30% of maximum voluntary contraction; MVC) and duration (1−9 seconds).

Results: Eighteen of the 20 subjects exhibited two effective thresholds, while two subjects had only a single effective threshold. None of the subjects demonstrated more than two effective thresholds. Clenching events that could not be detected by the primary threshold but were detected by the secondary threshold comprised 25.8%.

Conclusion: Within the limitations of this study design, multiple thresholds of EMG biofeedback for daytime clenching were effective in reducing parafunctional oral habit. Further research is needed to confirm an enduring effect.

Key words: bruxism, oral parafuncions, temporomandibular disorders

日中のクレンチング習癖者に対する咀嚼筋筋電図
バイオフィードバック訓練の複数閾値の適用に関する検討

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要旨

目的：日中のクレンチングの抑制を目的とした咀嚼筋筋電図バイオフィードバック（EMG-BF）訓練を、より効果的なものとするため、訓練閾値を複数設定することの妥当性について検討した。

方法：日中のクレンチングを自覚し、咀嚼筋痛を有するクレンチング習癖者20名（女性10名、男性10名、30.9±5.6歳）を被験者とした。EMGは側頭筋前部筋より導出した。昼食を含む5時間のEMG記録を行った。解析ソフト上で筋活動量（10%，20%，30% MVC)と筋活動持続時間（1～9 sec）を組み合わせた閾値を設定し、クレンチングなどの非機能運動時にのみ検出する訓練閾値およびイベント数について検討した。
Introduction

Bruxism as one of the undesirable oral parafunc-
tions is considered to lead to dental problems such as
temporomandibular disorders (TMD), tooth attrition,
abfraction, broken and cracked teeth, gingival rece-
sion, sensitive teeth, occlusal trauma, and limitations
for dental implants\(^1\)\(^-\)\(^4\). While nocturnal bruxism has
been focused on, daytime clenching, even weak con-
traction, is also recognized as a contributing factor to
TMD. Electromyogram (EMG) biofeedback during
both diurnal and nocturnal bruxism would be useful to
regulate excessive muscle activity\(^5\),\(^6\). To regulate un-
conscious bruxism, some devices have been used dur-
ing sleep\(^7\)-\(^9\), with favorable results. From a practical
perspective, it is easier for patients to recognize the
EMG biofeedback signal when they are awake rather
than asleep. We have developed a portable EMG re-
cording and biofeedback system\(^10\) which is much
smaller (width : 21 mm, height : 64 mm, thickness :
12.5 mm) than the devices reported previously\(^11\),\(^12\) and,
therefore, is less noticeable during ambulatory recording
under natural daily-life circumstances. Further-
more, EMG biofeedback training as a reminder of
daytime clenching reduced parafunctional behavior,
even through no feedback signal was provided after
two consecutive training days\(^10\).

In a previous study\(^10\), a fixed single threshold was
applied for training sessions only to remind of clench-
ing events without interruption of functional mandibu-
lar movement such as eating, speaking, and laughing.
To provide more effective ways of providing feedback
signals, multiple thresholds were determined for day-
time clenching regulation.

Materials and Methods

Subjects

Twenty subjects (10 males, 10 females; mean age :
30.9 ± 6.8 years) with masticatory muscle pain were
recruited. Inclusion criteria were : age between 20 and
35 years, awareness of pain or stiffness in the mastica-
tory muscles, and subjective awareness of daytime
teeth clenching. Furthermore, two or more items de-
scribed below were required : tooth indentation inside
the cheek and/or on the tongue, masticatory muscle
hypertrophy, bone torus, jaw opening range less than
40 mm between upper and lower incisal edges, or ten-
derness of the masticatory muscles on palpation, mild-
moderate pain intensity (2–4 out of 10 in Numerical
Rating Scale). Exclusion criteria were : wearing a re-
movable partial denture, lack of any occlusal support-
ing zone due to teeth loss in the molar region, current
use of muscle relaxants or anti-inflammatory medi-
cine, or advanced periodontal disease and psychiatric
or neurologic disorders.

This research was approved by the Human Research
Ethics Committee of Iwate Medical University Dental
School, and a signed informed consent form was ob-
tained from each subject after they had received a de-
tailed explanation of the research protocol.

EMG recording

A hearing-aid-shaped EMG recording apparatus with
auditory biofeedback system was placed behind the
ear of each subject (Fig 1). This portable device was
composed of three components – an electromyography
unit, a data-logger, and an auditory feedback unit.
EMGs were recorded from the anterior part of the temporal muscle on the habitual side of mastication under natural conditions, continuously for five hours, including lunchtime. Subjects were instructed to behave normally, with the exception of washing their faces, avoid touching the electrode unit or cable intensively, and avoid any actions that might create undesirable noise interference of the EMG signals. To calibrate the EMG signal levels, a maximum voluntary contraction (100% MVC) lasting 3 seconds was repeated three times with a 30-second interval between the tasks both at the beginning and end of the daily recording period.

**Data analysis procedure**

The fully rectified EMG data were transformed into root mean square values with a sampling rate of 4 Hz. Voice recording (Memory Recorder DMR-1800 S, Toshiba, Tokyo, Japan) and a self-administered chart were used to identify the parafunctional activities corresponding to the EMG signals. The voice recording device and self-administered chart did not aim to check all the parafunctional activities, merely help discriminate functional (talking, eating lunch) from parafunctional activities. The threshold which discriminated parafunctional mandibular movements such as clenching or grinding from the functional ones (Fig 2) such as eating, speaking, and laughing was calculated. The proper threshold for each subject was assigned using a combination of the intensity and duration of each EMG activity (Fig 3). Those thresholds would alert to parafunctional mandibular movements without disturbing functional mandibular movements, where by 27 recording points including combinations of durations (1~9 seconds) and intensities (10, 20, and 30% MVC) are set (Fig 4). The threshold which does
not detect an event at the time of functional activities, but detects an event only at the time of parafunctional activities, was determined. In the threshold value which fulfills this condition, that with the highest detection rate of events was set up as the primary threshold. Moreover, in addition to the primary threshold, the thresholds which fulfill the conditions described above were then set as the secondary and subordinate (Fig 5).

Finally, the possible rate of eligible subordinate thresholds were determined.

Results

The effective primary thresholds were assigned for all of the 20 subjects. Eighteen of the 20 subjects exhibited the secondary eligible threshold, while the subordinate threshold was not applicable for the remaining two subjects. The third threshold, however, was not applicable to any subjects (Fig 6).

Although 18 subjects had two different combinations of thresholds, all the events were completely identical in 13 subjects (Fig 7).

Total numbers of clenching events determined by primary and secondary thresholds were 23 and 13, respectively, in the remaining five subjects who exhibited two different effective thresholds to pick up distinct events. However, five events were found to be identical. Taking these five events into account, the secondary threshold comprised 25.8% clenching events in those five subjects (Fig 8).

Discussion

In recent dental practice, new strategies have been developed to expand the dental treatment options, such as dental implants and all-ceramic restorations. On the other hand, bruxism inhibits such promising dental practice. Moreover, oral parafunction plays an important role as a contributing factor to TMD. Since TMD patients with masticatory muscle pain habitually
keep their teeth in contact to some extent\textsuperscript{13−15}, cognitive biobehavioral therapy could be expected to be a suitable strategy for pain management.

EMG biofeedback training is expected to help reduce overload to stomatognathic components including the tooth structure, which could lead to the idea not only to treat TMD, but also to enhance the indications of dental implants and all-ceramic restorations.

Our previous report\textsuperscript{10} showed EMG biofeedback training with an effective single threshold on two consecutive days decreased daytime clenching. Furthermore, a long-lasting learned effect was also found in some cases\textsuperscript{10}.

In this study, multiple effective thresholds were determined in the same subjects as in the previous report. Five subjects exhibited two different thresholds to pick up distinctive clenching events, leading to a detection rate of 25.8%. On the other hand, using the secondary threshold made it difficult to detect extra parafunctional events in 75% of them. In this study, multiple thresholds would work better in some subjects; however, it is difficult to confirm what is an intrinsic factor for those who showed effective results. Since this study was designed to determine the rationale of using multiple thresholds of EMG biofeedback for clenching patients, a practical study is needed in the following step. The stress level and other physiological parameters also need to be recorded simultaneously in the future.

**Conclusion**

Within the limitations of this study design, multiple thresholds of EMG biofeedback for daytime clenching could be effective in reducing parafunctional oral habit. Further research is needed to confirm an enduring effect.

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**References**

12) Ogawa Y and Fujisawa M: Electromyogram biofeedback threshold determination for clenching behavior. Dent in Japan 41, 54−56, 2005

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