原 著

Spectral Analysis of Surface EMG to Evaluation of Extraocular Muscles

(This paper is a tribute to the memory of Professor Jun Tsutsui)

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Abstract

A new designed surface electrode for electromyogram (EMG) of extraocular muscle and spectral analysis is described. Electrode was made of a pair of silver-silver cloride wires which were embedded in both end of sclero-corneal shell which was made by silicone rubber to bring them closer to the medial and lateral rectus muscles. Power spectrum was computed of interference EMG during static and acting conditions. EMG of extraocular muscles demonstrated higher power spectrum than those of facial muscles. These enable us to pick up electrical activity of extraocular muscles and distinguish them from that of facial muscles.

Introduction

Surface interference EMG of skeletal muscle is widely studied because of its easiness and application to the neuromuscular disorders[1~3)]. However, extraocular muscle have not been an object of surface EMG because of some knotty problems in recording. Small size, orthogonal running direction and that surrounded by facial muscles are reasons of small EMG amplitude and contamination respectively. The purposes of this study are to record the EMG of extraocular muscle and identify it from that of other muscles by use of new designed electrode and computerized spectral analyzer.

Materials and Methods

Subjects and recording condition

Five healthy men aged 20-37 were the subjects of the experiment. Informed consent was obtained from the subjects prior to the study. The EMG of medial rectus muscle (MR) and lateral rectus muscle (LR) of left eye were recorded simultaneously by a surface electrode which is mentioned below. The data were sampled at the conditions of straight eye position, extreme right and left gaze.

Electrode

Screlo-corneal shell was casted on an artificial eye with elastic silicone rubber. A pair of silver-silver cloride wires with 15mm length, 0.5mm diameter and rounded tip of each were embedded in both end of the shell (Fig. 1). Total weight was 4.5g. The shell cover the eye from inner to outer fornix of conjunctiva but the subject could move his eyes smoothly. To prevent pain and making erosion on the cornea, topical anesthesia and visco-elastic material were dropped on the eye before attach the shell. The band pass of the amplifier was 40-1,000Hz. The recorded EMG was played back from an FM data recorder, which had frequency responses of DC-5000Hz, to signal processor.

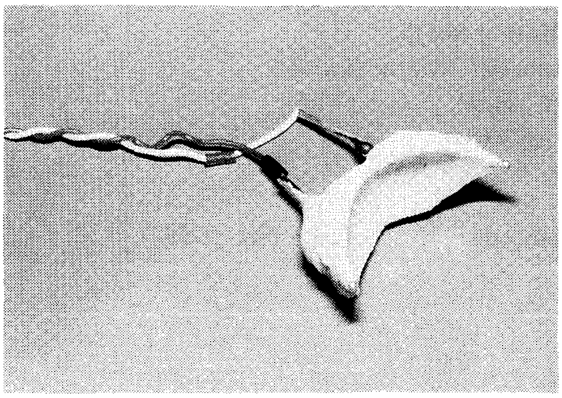

Fig. 1 A new designed surface electrode for extraocular muscle. A pair of silver-silver cloride wires embedded in silicone rubber.

Spectral analysis

EMG spectral analysis was performed with a signal processor 7T18-SP (NEC San-ei, Japan) with the help of a Fast Fourier transformation program. Details were mentioned in previous paper[4].

Results

In all five subjects, interference EMG was successfully recorded without corneal erosion except for one. During the subject keep the eye at straight position, amplitude of LLR was almost 20μV (Fig. 2). That varied from 15-40μV in subjects. When the eye turn to

Fig. 2 EMG fragments of left lateral rectus (LLR) recorded by the surface electrode.

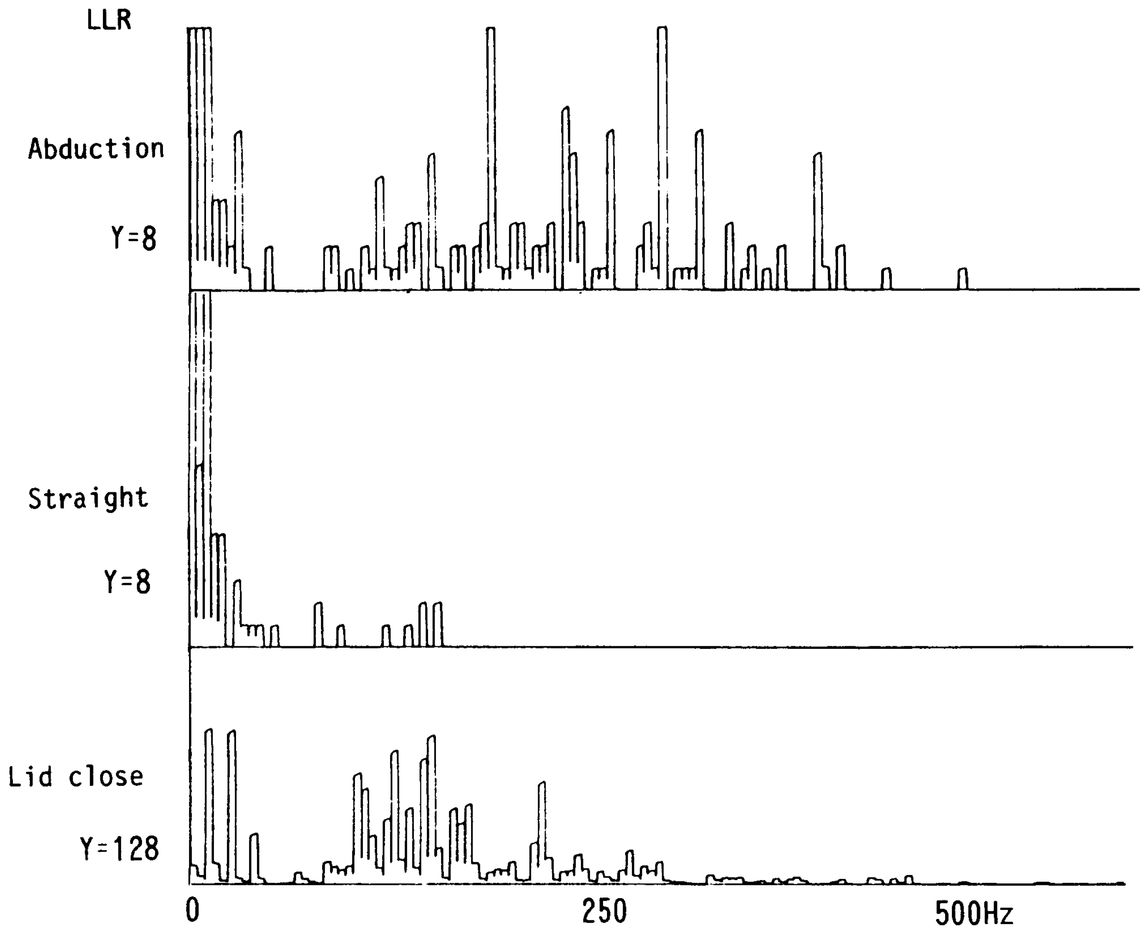

Fig. 3 Power spectrum corresponds to EMG in Fig. 2.

abducting position, LLR showed increased activity to about 30μV. When the subject close his eyes tightly, electrode picked up greater amplitude of EMG of facial muscles. At straight eye position, EMG demonstrated a spectral distribution completery lower than 250Hz (Fig. 3). At abducting position, pronounced spectral shift towards higher frequencies up to 500Hz was observed. At closing eye situation, main component of spectrum was distributed under 250Hz.

Figures 4A and B show power spectrums of EMG which were recorded from LLR and LMR simultaneously. Generally, LMR demonstrated a higher power spectrum in the higher frequency domain than that of LLR. At straight eye position, spectral distribution of LLR was under 125Hz. However, the main component of LMR was distributed around 250Hz, and even a small spike was observed at 700Hz. At abducting position (Fig. 4A), on direction of LLR, shift of the spectrum towards higher frequency was observed. However, at adducting position (Fig. 4B), on direction of LMR, reinforcement of power of 125Hz was appeared, but on spectral shift was observed.

Discussion

In the present study, application of surface

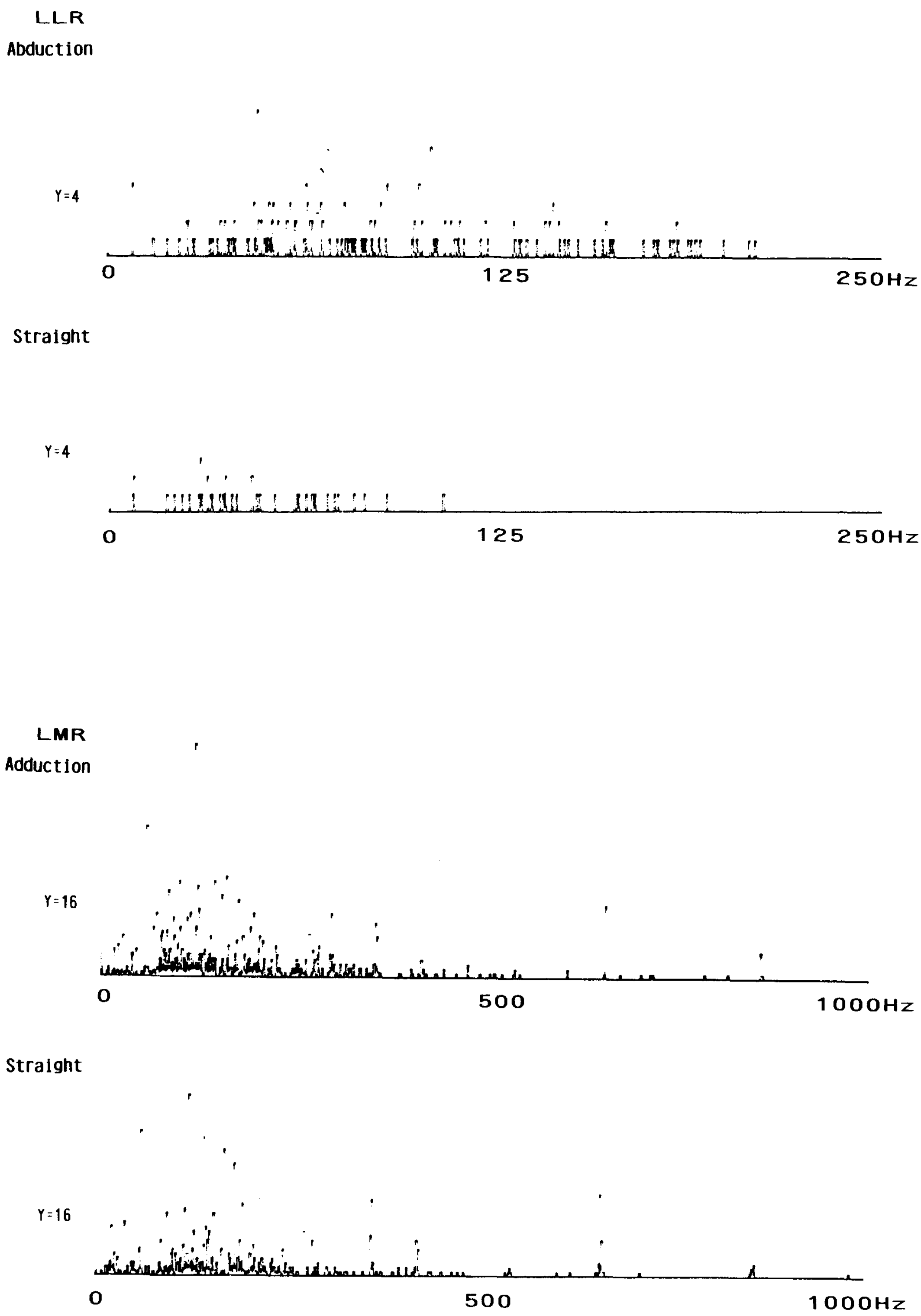

Fig. 4 Power spectrum of left lateral rectus (LLR) : A. and left medial rectus (LMR) : B. Both muscles were sampled simultaneously.

electrode and spectral analysis to distinguish EMG of extraocular muscle from that of other facial muscle were attempted. Therefore, extraocular muscle is located at deep position from skin surface, we used a sclero-corneal shell so that the electrode closes to the muscle. Although, amplitude of EMG recorded by this electrode was smaller than that by needle electrode, EMG was recorded from all subjects successfully.

LLR and LMR demonstrated relatively higher power spectrum in the higher frequency domain than facial muscles[4]. These results suggest that we are able to distinguish EMG of extraocular muscle from that of facial muscles by using surface electrode. Previous basic experiment mentioned that the existence of slow fiber in the extraocular muscle is the cause of this phenomenon[5].

LLR showed different amplitude and spectral distribution from LMR at simultaneous recording in all subjects. This phenomenon was considered to be due to the difference of distance from electrode to muscle and difference of contact area of electrode and tissue. The distance alter by slip of electrode at eye movement. Crip type electrode may produce good result in this problem.

One subject developed a severe corneal erosion after the experiment, and it took five days to recover. The sclero-corneal shell should be reformed to fit the curve of cornea.

This experiment produced an advancement for practical application of surface EMG of extraocular muscle.

Acknowledgment

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外眼筋の表面筋電図と周波数分析

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