Jitter Values on Voluntary Active Periocular Muscles of Healthy Subjects with Conventional (37 mm) Concentric Needle Electrode

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ABSTRACT

Introduction: The aim of this study was to re-evaluate jitter values of healthy subjects in whom pairs of single-fiber-like potentials were recorded from voluntary activated periocular muscles using a disposable 37-mm concentric needle electrode (CNE) with 2-kHz low-cut filtering.

Methods: We reviewed the recordings of 129 subjects (85 women; 44 men; mean age, 43.8 ± 15.3 years). The m. frontalis group included 116 subjects, and the m. orbicularis oculi group included 18 subjects. Jitter values were expressed as the mean consecutive difference (MCD) of 20 different pairs.

Results: The mean MCD ($n=2680$) was 22.5 ± 9.7 μ s (range, 5–121 μ s), and the upper 95% confidence limit (CL) was 39 μ s. The mean of 134 MCD values for each subject was 22.5 ± 3.7 μ s (range, 15–33 μ s),

and the upper 95% CL was 30 μ s. The outer limit of the 18th highest MCD values out of 20 recordings for each subject was 31.3 ± 6.5 μ s (range, 18–53 μ s), with an upper 95% CL of 43.3 μ s.

Conclusion: Using a conventional 37-mm CNE with 2-kHz low-cut filtering may be a cost effective alternative to a single-fiber electrode in periocular muscles if strict criteria are used for acceptable signals. Jitter values of >44 μ s that were calculated from single-fiber-like action potential pairs should alert the physician regarding the possibility of neuromuscular junction disorders and constitute an indication for a further diagnostic investigation.

Keywords: Single-fiber EMG, neuromuscular jitter, neuromuscular junction, myasthenia gravis, concentric needle electrode

INTRODUCTION

Neuromuscular jitter is the most sensitive measure of neuromuscular junction function and is a very valuable technique in the diagnosis of patients with suspected myasthenia gravis (MG) (1). Although the single-fiber electrode (SFE) is the standard electrode for SF electromyography (SFEMG), several studies have demonstrated comparable jitter measurements using a concentric needle electrode (CNE) in normal subjects and in myasthenic patients (2,3,4,5). It is important to pool normative data using CNE from various centers to obtain better age-related reference values (4).

In this study, we retrospectively evaluated the recordings of patients who were examined using a 37-mm CNE in voluntary activated periocular muscles and showed normal jitter values according to the described values for the SFEMG electrode. We aimed to obtain normal jitter values using the most conventional 37-mm CNE in a Turkish population.

METHODS

Subjects

The study population comprised subjects who were referred to our EMG laboratory to exclude ocular myasthenia between January 2010 and June 2013. Normal jitter values for voluntary activated periocular muscles have been established in the literature for the SFEMG electrode (6). In this study, we included subjects who had normal jitter values according to the described values for the SFEMG electrode; the upper 95% confidence limit (CL) for individual pairs and the mean consecutive difference (MCD) per study was accepted to be 55 and 34 μ s, respectively.

We retrospectively reviewed the recordings of 129 subjects (85 women; 44 men; mean age, 43.8 ± 15.3 years (19–82 years) who were studied using a 37-mm CNE for quantitative jitter analysis in voluntary activated periocular muscles by trained electromyographers. Two groups were defined: the m. frontalis group, which comprised 116 subjects, and the m. orbicularis oculi (Ooc) group, which comprised 18

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subjects. Neurological examination was normal at the time of electrodiagnostic examination. None of the patients had any coexistent disorder or was taking any medications that could have interfered with the study. Screening nerve conduction studies and EMG findings were normal.

Recordings

For all the studies, a two-channel EMG machine (Keypoint, v3.03, Medtronic, Skovlunde, Denmark) was used for the recordings and analysis was performed using a peak detection algorithm for time measurements. A disposable CNE (37 mm×0.46 mm×26 G, DCN 37, Technomed) with a recording area of 0.070 mm² was preferred for acquisition with a band-pass filter setting of 2–10 kHz. All of the recorded traces were saved on the hard disk of the EMG machine. All jitter analyses were done off-line from these traces. The concentric needle was inserted into the muscle near the end-plate zone. The high-pass filter was set to 2 kHz rather than 500 Hz to avoid recording composite potentials because the 37-mm CNE had a larger recording area than the SFE (2). Single-fiber-like action potentials having amplitudes higher than 200 µV and rise times shorter than 0.3 ms with a stable shape were accepted for analysis (Figure 1) (7). At least 60 consecutive traces harboring the triggering and jittering potentials were recorded after the motor unit reached an optimum stable firing rate (screen sensitivity was 0.2 mV/div, sweep speed was 0.5 ms/div) (8). Jitter values of 20 different pairs were calculated for each subject. The MCD was accepted as the measure of jitter. The mean value of MCDs and the mean sorted data differences (MSD) were calculated. If the MCD/ MSD ratio was >1.25, the MSD value was used as the jitter value instead of the MCD. The Keypoint software also calculated the mean interpotential interval (MIPI) between the triggering and the measured spike.

Analysis of data

The mean jitter values were analyzed as the calculation of the mean MCD of at least 20 consecutive discharges (9). The recommended criteria for an abnormal study is: 1) a value for the mean MCD of 20 fiber pairs greater than the 95% upper confidence limit for that muscle; or 2) jitter values in more than 10% of pairs greater than the 95% upper CL for action potential pairs in a muscle (7). The mean and standard deviation of all individual and mean MCD values were calculated. Two of the 20 recordings were allowed to be outside of the calculated limits. Jitter values were sorted from the minimum to maximum value for each subject, and the 18th highest jitter value of each case was pooled. The mean value and standard deviation of these pooled data containing the 18th highest jitter value were calculated. The 95% upper CL of the 18th value was calculated to define the outlier limit.

RESULTS

Overall, 2680 jitters were calculated from 134 muscles. The mean MCD of all the potential pairs (n=2680) was 22.5±9.7 µs (range, 5–121 µs). The upper 95% CL was 39 µs (Figure 2). The mean of 134 MCD values for each subject was 22.5±3.7 µs (range, 15–33 µs) and the upper 95% CL was 30 µs. In all cases, MCD was used. The outer limit of the 18th highest MCD values out of 20 recordings for each subject was 31.3±6.5 µs (range, 18–53 µs), with an upper 95% CL of 43.3 µs. The mean value of MIPI value was 893.8±632.6 (range, 196–3864 µs). All the above-mentioned results are presented in Table 1. None of the potential pairs had MIPI values longer than 4 ms. There was no correlation with age (p>0.5). The two sample t-test between gender and MCD revealed p values of >0.5.

Figure 1. Examples of motor unit potentials recorded with a 37-mm CNE. Three of the spikes are acceptable as being single-fiber-like action potentials (sensitivity, 2 mV/D; sweep speed, 0.5 ms/D; 2-kHz low-cut filtering)

Figure 2. Jitter in individual recordings with a 37-mm CNE in voluntary activated periocular muscles (mean MCD for 2760 individual pairs (138 muscles) MCD: mean consecutive differences; ULN: upper limit of normal)

DISCUSSION

In this study, we established reference values for jitter in voluntary activated periocular muscles with a disposable 37-mm CNE, which is the most conventional and most common used in routine electrodiagnosis. Jitter measurement using a SFE is the gold standard for evaluating neuromuscular junction dysfunction. However, disposable concentric needles are increasingly used in jitter analysis because of concern about the possible transmission of prion diseases with SFE, which are manufactured for repeated use, and due to their higher cost.

We used a high-pass filter setting of 2 kHz for acquisition of the potentials with a CNE instead of 0.5 or 1 kHz as described previously (2). As stated in the blanket principle of Payan, increasing the high-pass 127

Table 1. Using 37-mm concentric needle electrode jitter values in voluntary periocular muscles

	MCD per study	Individual pairs	18th MCD value	MIPI
n	134	2680	134	134
Jitter (μ s)	22.5	22.5	31.3	893.8
SD (μ s)	3.7	9.7	6.5	632.6
Range (μ s)	15–33	5–121	18–53	196–3864
95% CL (μ s)	30	39	43.3	
Practical limit	30		44	

MCD: mean consecutive differences; MIPI: mean interpotential interval; SD: standard deviation; CL: confidence limit

filter setting may eliminate low-frequency components (10). Setting the high-pass filter at 2 kHz, reduces the contribution of the low frequency components of the action potentials of more distant muscles and proximate muscle fibers and narrows the pick-up area of the CNE (2). Because the pick-up area of the 37-mm CNE is larger, setting the high-pass filter to 2 kHz, rather than 0.5 or 1 kHz, might be appropriate for signal acquisition. Often, the spikes obtained with CNE are not obtained from single muscle fibers, but represent a summation of more than one SFAP (11). To overcome this summation effect, the spike signal used for measurement should have a fast rise-time and a constant shape without notches or irregularities on consecutive discharges, at least in the peak area (12). Individual single-fiber-like action potentials are shorter and give less summation in the periocular muscles. Peak detection rather than the amplitude level for the time markers seems better for single-fiber-like action potentials because the influence from summation is lesser in the former (13).

Since the definition of an acceptable signal is unclear with a CNE in studies of neuromuscular jitter, normal values will differ and new reference values must be obtained (14). A few laboratories have reported reference values for jitter using a 25-mm CNE and a monopolar needle electrode in different muscles (1,2,3,4,11,14,15,16,17,18). The variation among normative data from different laboratories may result from the differences in the methods to calculate the cut-off values or the actual differences of the raw data populations (17). Kouyoumdjian et al. (14) found similar jitter values with a smaller CNE (with a recording surface of 0.019 m²) in a sample of 50 healthy subjects from voluntary activated Ooc muscles, which revealed a limit of 31 μ s for MCD and 39 μ s for individual pairs. However, the cut-off jitter values obtained with the 37-mm CNE are lower than jitter values reported with SFEMG electrodes for the voluntary activated periocular muscles (14). Jitter measurement with a CNE have risks, such as the triggering and/or jittering potentials being compound signals due to summation, and showing extra phases rather than a clear single-fiber action potential (18). When many SFAPs arrive at the electrode close together in time, the trigger will detect the earliest, which is produced by different muscle fibers in consecutive discharges. This must be the reason for the lower jitter values obtained with the CNE (13).

In practice, we prefer to use the smallest CNE (25 mm) with filter settings of 1 or 2 kHz for neuromuscular jitter analysis. However, it seems that using a conventional 37-mm CNE with filter settings of 2 kHz may also be a cost effective alternative to SFE in periocular muscles, if strict criteria are used for acceptable signals. Only relatively clear cases of increased jitter should be considered as a diagnostic of disturbed neuromuscular transmission and borderline findings should be interpreted with caution (13). In this study, the suggested practical limit with 37-mm CNE in the periocular muscles for mean MCD was 30 μ s, and for the outliers was 44 μ s.

The retrospective design and obtaining the normative data from the subjects who had been referred to exclude ocular myasthenia are the main limitations of this study. Nevertheless, jitter values higher than 44 μ s calculated from the single-fiber-like action potential pairs, which were recorded by using a 37-mm CNE with 2-kHz high-pass filtering, should alert the physician to the possibility of neuromuscular junction disorder and constitute an indication for a further diagnostic investigation.

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REFERENCES

- Sanders DB. Clinical impact of single-fiber electromyography. *Muscle Nerve* 2002; 25:15-20. [CrossRef]
- Ertas M, Baslo MB, Yildiz N, Yazici J, Oge AE. Concentric needle electrode for neuromuscular jitter analysis. *Muscle Nerve* 2000; 23:715-719.
- Sarrigiannis PG, Kennett RP, Read S, Farrugia ME. Single-fiber EMG with a concentric needle electrode: Validation in myasthenia gravis. *Muscle Nerve* 2006; 33:61-65. [CrossRef]
- Farrugia ME, Weir AI, Cleary M, Cooper S, Metcalfe R, Mallik A. Concentric and single fiber needle electrodes yield comparable jitter results in myasthenia gravis. *Muscle Nerve* 2009; 39:579-585. [CrossRef]
- Orhan EK, Deymeer F, Oflazer P, Parman Y, Baslo MB. Jitter analysis with concentric needle electrode in the masseter muscle for the diagnosis of generalised myasthenia gravis. *Clin Neurophysiol* 2013; 124:2277-2282. [CrossRef]
- Bromberg MB, Scott DM. Single fiber EMG reference values: reformatted in tabular form. Ad Hoc Committee of the AAEM. Single Fiber Special Interest Group. *Muscle Nerve* 1994; 17:820-821. [CrossRef]
- Gilchrist JM. Single fiber EMG reference values: a collaborative effort. Report from the Ad Hoc Committee of the AAEM Special Interest Group on Single Fiber EMG. *Muscle Nerve* 1992; 15:151-161. [CrossRef]
- Baslo MB, Yildiz N, Yalinay P, Ertas M. Effect of triggering potential on calculations of jitter in single-fiber EMG. *Muscle Nerve* 2002; 25:906-908. [CrossRef]
- Stålberg EV, Trontelj JV. Single fibre electromyography. Studies in healthy and diseased muscle. 2nd ed. New York: Raven Press; 1994.
- Payan J. The blanket principle: a technical note. *Muscle Nerve* 1978; 1:423-426. [CrossRef]
- Kouyoumdjian JA, Stålberg EV. Concentric needle jitter in stimulated frontalis in 20 healthy subjects. *Muscle Nerve* 2012; 45:276-278. [CrossRef]
- Stalberg E. Jitter analysis with concentric needle electrodes. *Ann N Y Acad Sci* 2012; 1274:77-85. [CrossRef]
- Stålberg EV, Sanders DB. Jitter recordings with concentric needle electrodes. *Muscle Nerve* 2009; 40:331-339. [CrossRef]
- Kouyoumdjian JA, Stålberg EV. Reference jitter values for concentric needle electrodes in voluntary activated extensor digitorum communis and orbicularis oculi muscles. *Muscle Nerve* 2008; 37:694-699. [CrossRef]

15. Benatar M, Hammad M, Doss-Riney H. Concentric needle single fiber electromyography for the diagnosis of myasthenia gravis. *Muscle Nerve* 2006; 34:163-168. [\[CrossRef\]](#)
16. Kouyoumdjian JA, Stalberg EV. Concentric needle single fiber electromyography: normative jitter values on voluntary activated Extensor Digitorum Communis. *Arq Neuropsiquiatr* 2007; 65:446-449. [\[CrossRef\]](#)
17. Kokubun N, Sonoo M, Imai T, Arimura Y, Kuwabara S, Komori T, Kobayashi M, Nagashima T, Hatanaka Y, Tsuda E, Misawa S, Abe T, Arimura K. Reference values for voluntary and stimulated single-fibre EMG using concentric needle electrodes: A multicentre prospective study. *Clin Neurophysiol* 2012; 123:613-620. [\[CrossRef\]](#)
18. Tutkavul K, Baslo MB. Reference voluntary jitter values using disposable monopolar needle electrodes in the extensor digitorum communis muscle. *Clin Neurophysiol* 2010; 21:887-889. [\[CrossRef\]](#)