



Case report

Sustained atypical myokymia of the abductor pollicis brevis with a focal slowing of the median nerve motor axons at the wrist

Nagako Murase^{a,*}, Masahiro Goto^a, Nobuo Kohara^b, Jun Kimura^c^a Department of Neurology, National Hospital Organization, Kyoto Medical Center, 1-1 Mukoubata-cho, Fukakusa, Fushimi-ku, Kyoto City, Kyoto 612-8555, Japan^b Department of Neurology, Kobe City Medical Center General Hospital, 1-1, 2 cho-me, Minamimachi, Minatojima, Chuou-ku, Kobe City, Kobe 650-0047, Japan^c Department of Neurology, Division of Clinical Neurophysiology, University of Iowa Health Center, 200 Hawkins Drive, Iowa City, IA 52242, USA

ARTICLE INFO

Article history:

Received 17 May 2020

Received in revised form 15 November 2020

Accepted 26 November 2020

Available online 17 December 2020

Keywords:

Myokymia
Neuromyotonic discharge
Inching study
Single fiber EMG
Filter
Botulinum toxin
Carpal tunnel syndrome

ABSTRACT

Objective: We report a case of sustained atypical myokymia associated with short bursts of neuromyotonic discharges involving the abductor pollicis brevis (APB) muscle and describe a useful way of detecting a focal slowing involving a small number of median nerve motor fibers with a concentric needle using the filter setting for single fiber electromyography (EMG).

Methods and Results: A 62-year-old woman developed right thumb twitches at regular interval of 1.7–3.3 s (0.6–0.3 Hz), which continued for more than four months. Muscle twitches remained the same during altered hand position, psychological stress, or sleep. A concentric needle inserted in the active zone of the APB muscle revealed myokymic bursts with a characteristic of neuromyotonic discharges. Inching study, stimulating at 5 mm increment along the median nerve and recording with a concentric needle using a filter setting for single fiber EMG, revealed a focal slowing of the motor fibers at a point 5–10 mm distal from the distal crease of the wrist, an entrapment site occasionally seen in the carpal tunnel syndrome. One injection of botulinum toxin type A eliminated the myokymia, which then recurred two and a half years later, showing less prominent muscle twitches.

Conclusions: Sustained atypical myokymia seen in our case represented bursts of neuromyotonic discharges originated from a focal demyelinating lesion involving a few median nerve motor fibers.

© 2020 Published by Elsevier B.V. on behalf of International Federation of Clinical Neurophysiology. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

Myokymia, a disorder of the motor unit, refers to the clinical phenomenon of undulating rippling muscles. Its electrophysiological basis, myokymic discharge, usually consists of three to six bursts of spontaneous firing of single motor unit potentials at a uniform rate (2–60 Hz) occurring repetitively at 0.1–10 s intervals (AANEM Glossary of Terms, 2015; Kimura, 2013; Gutmann and Gutmann, 2004). Myokymia, less often, accompanies neuromyotonic discharges with higher frequencies up to 300 Hz (Kimura, 2013; Gutmann and Gutmann, 2004), sometimes with a waning pattern (Gutmann and Gutmann, 2004; Gutmann et al., 2001). Myokymia, focal or generalized, usually results from demyelination, associated with autoimmune diseases such as Guillain-Barre syndrome and multiple sclerosis, or radiation plexopathy (Gutmann and Gutmann, 2004). Focal myokymia tends to favor

the facial nerve (Gutmann and Gutmann, 2004) and less commonly the limb nerves, usually in association with focal neuropathies, particularly CTS (carpal tunnel syndrome) (Chee et al., 2019; Gutmann, 1991; Spaans, 1982; Albers et al., 1981).

We report an unusual case of myokymia associated with short bursts of neuromyotonic discharges causing regular abductor pollicis brevis (APB) muscle twitches, which sustained for four months. Although the routine nerve conduction studies revealed no abnormalities, an inching technique, using concentric needle recording with a filter setting for single fiber EMG (Stålberg et al., 2010; Padua et al., 2007; Sanders et al., 2019), isolated a focal site of conduction abnormalities at the wrist affecting only a small number of median nerve motor axons (Padua et al., 2011, 2007, 2001).

2. Case reports

A 62-year-old woman developed right thumb twitches at regular interval of 1.7–3.3 s (0.6–0.3 Hz), which continued for more than four months. This abnormal movement remained unaltered

* Corresponding author.

E-mail addresses: murase.nagako.bq@mail.hosp.go.jp (N. Murase), jun-kimura@uiowa.edu (J. Kimura).

during sleep, under psychological stress or by voluntary movement (see [Video](#)). Her past medical history included hypertension with primary aldosteronism, hypokalemia and hyperlipidemia, all treated optimally by medication. She had no family history of involuntary movement.

Neurological examination revealed no abnormalities other than the twitches of the thenar eminence, which we localized to the APB muscle by needle EMG. The thenar eminence showed no atrophy or hypertrophy.

Laboratory studies included a decreased K^+ (3.5 mEq/l: reference range 3.6–4.9), increased aldosterone (502 pg/ml: reference range 30–159), normal X-rays of the right hand and normal MRIs of the right forearm, cervical spine and brain. Somatosensory-evoked potentials after median nerve stimulation at the wrist showed no evidence of giant potentials suggestive of cortical reflex myoclonus. Electroencephalography, including jerk-locked back averaging, disclosed no epileptic discharges.

Surface electromyogram (EMG) in one recording session ([Fig. 1A](#)) showed rhythmic bursts time-locked to the twitches of the APB muscle at regular interval of 1.73 \pm 0.06 sec (mean

\pm SD, n = 30), each epoch lasting for 122 \pm 9 ms. The peak-to-peak amplitude of spontaneous twitch potentials, 609 \pm 6 μ V, corresponded to approximately 5% of the 12.0 mV compound muscle action potential (CMAP) evoked by a supramaximal stimulation of the median nerve at the wrist.

Routine concentric needle EMG, recorded with the band pass filter ranging from 10 Hz to 10 kHz, ([Fig. 1B](#)), revealed high frequency myokymic discharges in the active zone of APB muscle, synchronous to the surface recorded bursts. Each burst consisted of the initial 750 μ V potential and approximately 60 much smaller spikes with an inter-spike interval (ISI) ranging from 4 to 6 ms as typically seen in neuromyotonic discharges. The first 5–7 spikes appeared nearly identical in amplitude in any burst, although the subsequent gradually-decrementing and incrementing smaller discharges, lasting for about 270 ms, varied from one burst to the next ([Fig. 1B](#)).

Routine nerve conduction studies (NCSs) of the right median ([Fig. 2A](#)) and ulnar nerves were normal. Using a concentric needle as a pick up, surface stimulation of the median nerve revealed a delay across the wrist to palm segment if recorded with the tip

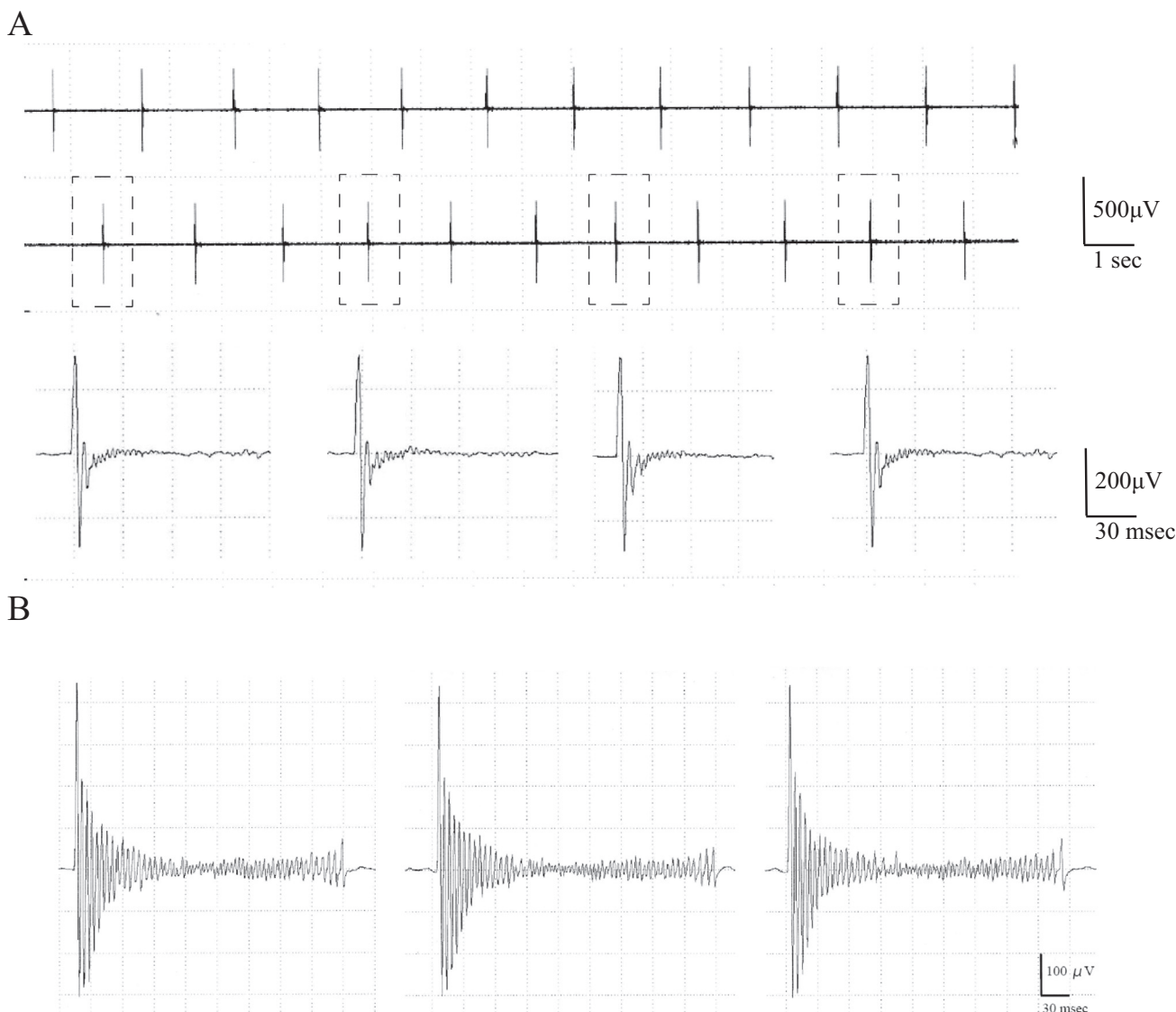


Fig. 1. Waveforms of muscle twitches recorded with a pair of surface electrodes placed on the abductor pollicis brevis (APB) muscle (A) and with a concentric needle inserted in the active zone of the APB muscle (B).

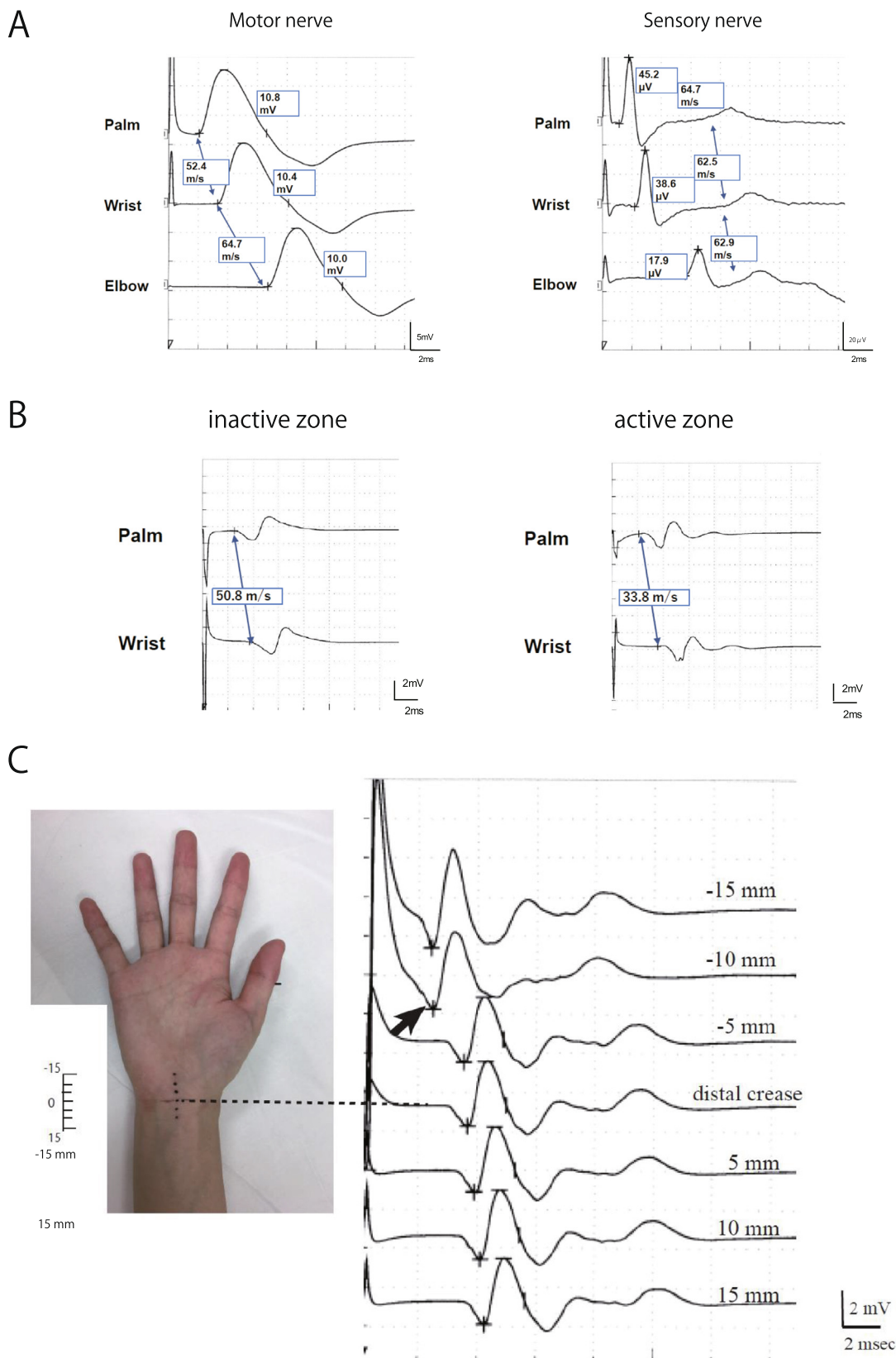


Fig. 2. Nerve conduction study of the right median nerve. Routine nerve conduction study with a pair of surface electrodes of the motor (A right) and sensory (B left) nerves. Recording with a concentric needle as a pick up and surface stimulation of the median nerve, with the tip of the electrode placed at the active zone (B right) and elsewhere in the APB (B left). Inching study stimulating the right median nerve in 0.5 cm increment and recording with a concentric needle placed in the active zone of the APB muscle, using a filter setting of 500 Hz to 10 kHz (C).

of the electrode placed at the active zone (Fig. 2B right) but not elsewhere in the APB (Fig. 2B left). In this recording, we were unable to determine the onset latency with precision, especially with palm stimulation. To further localize the lesion affecting only a small number of axons (Padua et al., 2011, 2007, 2001; Stålberg et al., 2010; Sanders et al., 2019), we elevated the low cut filter from 10 Hz to 500 Hz for an inching study (Fig. 2C) stimulating the median nerve with surface electrode in 5 mm increment. When recorded with a concentric needle placed in the active zone of APB, the study disclosed a reproducible focal slowing of motor nerve fibers at a point between 5 and 10 mm from the distal crease of the right wrist (Fig. 2C).

Clonazepam had no effect on the muscle twitching. After approval of the Kyoto Medical Center Ethics Committee, we obtained an informed consent from the patient and injected botulinum toxin type A (15 units of Botox®) into the active zone of APB. Abnormal twitches completely abolished within a few days, with no evidence of recurrence for the duration of follow up period extending to two years. Botulinum toxin injection caused no side effects except for a transient, mild paresis of the thumb. The patient had a good relief three days after injection when the movement subsided. She experienced a slight difficulty in abducting the thumb for one week but no problem thereafter. Abnormal twitches then partially recurred two and a half years later. Recording with a needle electrode revealed spontaneous bursts like the original discharge in amplitude (mean: 750 μ V) and duration (126 ms) but longer in twitch intervals (3.06 s).

3. Discussion

We report a 62-year-old woman who developed a repetitive twitch in a small part of the right thenar muscle. This sustained movement corresponded to myokymia clinically, although electrophysiological study showed repetitive short runs of high frequency spikes most consistent with neuromyotonic discharges. Inching studies revealed a focal slowing consistent with a demyelinating lesion of the median nerve motor fibers at a point 5 to 10 mm distal from the distal crease of the wrist.

Focal demyelinating lesions known to cause myokymia include peripheral facial palsy, hemifacial spasm, post radiation brachial plexopathy, multiple sclerosis and demyelinating neuropathies (Gutmann and Gutmann, 2004). Less commonly focal myokymia occurs in association with focal neuropathies, particularly CTS (Chee et al., 2019; Gutmann, 1991; Spaans, 1982; Albers et al., 1981). In these disorders, the hyperexcitable segment of demyelination induces ectopic discharge (Valls-Solé and Montero, 2003), or ephaptic transmission (Kameyama et al., 2016) as the cause of myokymia. Our patient had a unique pattern of spontaneous burst, each block showing a brief neuromyotonic discharges with interspike intervals of 3–5 ms which corresponds to the relatively refractory period of the motor axons (Burke et al., 2009). Myokymic discharge, usually consists of three to six bursts of spontaneous firing of single motor unit potentials at a uniform rate (2–60 Hz) occurring repetitively at 0.1–10 s intervals (AANEM Glossary of Terms, 2015; Kimura, 2013; Gutmann and Gutmann, 2004). Myokymia, less often, accompanies neuromyotonic discharges with higher frequencies up to 300 Hz (Kimura, 2013; Gutmann and Gutmann, 2004), sometimes with a waning pattern (Gutmann and Gutmann, 2004; Gutmann et al., 2001). Based on this description, we believe our waveforms constitute a variant of neuromyotonic discharges underlining the clinical phenomenon of myokymia. Similar waveforms were previously reported in two cases of radiation plexopathy (Albers et al., 1981). This finding reinforces the notion that myokymia represents a form of neuromyotonia.

An inching study, recording with a concentric needle electrode using a filter setting for single fiber EMG, served well in our case to detect a focal lesion affecting only a small number of motor fibers by a non-linear shift in latency just distal to the wrist. This filter setting, used commonly for the study of neuromuscular junction (Noto et al., 2011), also works well for assessing a lesion affecting only a limited number of motor fibers, minimizing the activities from the remaining normal axons, which would mask the abnormality (Padua et al., 2011, 2007, 2001). The utility of this method was reported in diabetic polyneuropathy using single fiber EMG electrode (Sunter et al., 2014) and in immune-mediated ulnar nerve neuropathy using a bipolar needle electrode (Coraci et al., 2017). This method has some technical limitations in detecting a localized lesion, which critically depends on placing a needle very close to the active zone showing recordable abnormality. In the current case, we were able to position the needle correctly, guided by sustained single muscle fiber discharges associated with muscle twitches. Using this technique, we were able to record myokymic discharge only if the needle was placed in the active zone supplied by the motor axons showing a focal delay (see Fig. 2B and C). This finding justifies the conclusion that the causal relationship exists between the abnormal muscle discharge and focal conduction delay of a few motor axons, which induced the spontaneous bursts.

A slight distortion of the waveform at -10 mm resulted from a relatively large (positive) stimulus artifact which we were unable to eliminate. The recorded response represents a composite of affected and still relatively normal motor unit potentials within a small recording radius of the concentric needle. Desynchronization of these unit discharges also slightly alters the waveform recorded at -10 mm. The latency of the major negative peaks, however, verifies a nonlinear shift of the elicited response. The major negative peaks recorded at -15 mm and -10 mm are slightly larger in amplitude and area under the waveform compared to all the subsequent responses. This finding, probably indicating a mild conduction block, gives a distinct impression that the raster mode (Fig. 2 bottom) displays two separate groups of recording, top two traces and bottom 5 traces. This characteristic appearance signals a non-linear jump, indicating a focal lesion at this point with a calculated conduction velocity of 5 m/s between -10 mm to -15 mm as compared to 40–80 m/s for all the remaining 5 mm segments.

The patient had no complaint suggestive of CTS and standard motor and sensory nerve conduction studies were normal. In addition, we found a delay of the motor conduction more proximally than expected for a typical entrapment (Kimura, 1979). Our clinical and electrophysiological findings, however, suggest the diagnosis of a median nerve mononeuropathy with a focal abnormality of some motor axons innervating the APB muscle, causing atypical myokymic discharges. This extends previous observations in CTS, showing selective involvement of median motor axons with normal sensory conduction (Kimura, 1978; Mondelli et al., 2010; Repaci et al., 1999) and an entrapment near the distal wrist crease (Kimura, 1979; Nathan et al., 1990) rather than the usual lesion site near the distal edge of carpal ligament located 20–40 mm further distally. Although we consider the CTS as the most likely cause of atypical myokymia, other possibilities would include immune-mediated or traumatic neuropathies, which seem unlikely in the absence of abnormalities outside the median nerve and history of trauma at the wrist.

Botulinum toxin injection had sustained effect until two and a half years later, when abnormal twitches partially recurred. A repeat laboratory tests remained the same as before with normal potassium concentration of 3.7–4.3 mEq/L (reference range: 3.6–4.9) and aldosterone elevated to 421–514 pg/ml (30–159). Thus, we consider it unlikely that the spontaneous discharges were associated with either hypokalemia or hyperaldosteronism. In addition,

this unspecific treatment, not directed against the presumed neural lesion per se, only suppressed the excitation of the muscle fibres by blocking neuromuscular transmission.

4. Conclusions

Our patient had a unique variant of sustained myokymia with firing frequency in the range of neuromyotonic discharge, not previously seen in an entrapment neuropathy. Inching studies using single fiber recording with a concentric needle electrode allowed us to localize the abnormality near the distal wrist crease. A focal lesion, probably demyelinating in nature affected a few median nerve motor axons causing myokymia, a finding consistent with the diagnosis of a median nerve mononeuropathy.

Acknowledgements

We thank Michikazu Nakamura for giving a general advice to this work.

Author roles

Nagako Murase mainly contributed to the conception and design of this work, drafted and modified the manuscript following to the suggestions by Jun Kimura and Nobuo Kohara. Masahiro Goto is the first doctor who found our patient and consulted to Nagako Murase. He substantially contributed to the acquisition and interpretation of the data. Jun Kimura mainly contributed to the design of this work and interpretation of the data. Nobuo Kohara contributed to the interpretation of data for the work, and revised the manuscript critically for important intellectual content. All four authors revised for the context and finally approved the latest version after questions related to the accuracy or integrity of any part of the work were appropriately investigated and resolved.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.cnp.2020.11.003>.

References

AANEM Glossary of Terms in Neuromuscular & Electrodiagnostic Medicine. 2015. *Muscle Nerve* 52(S3):145–203.

Albers, J.W., Allen 2nd, A.A., Bastron, J.A., Daube, J.R., 1981. Limb myokymia. *Muscle Nerve* 4, 494–504. <https://doi.org/10.1002/mus.880040606>. PMID: 7311989.

Burke D, Howells J, Trevillion L, McNulty PA, Jankelowitz SK, Kiernan MC., 2009. Threshold behaviour of human axons explored using subthreshold perturbations to membrane potential. *J. Physiol.* 587, 491–504. doi: 10.1113/

jphysiol.2008.163170. Epub 2008 Dec 1. PMID: 19047204; PMCID: PMC2670058.

Chee, Y.C., Ong, B.H., Mohd Saleh, N.B., 2019. Focal myokymia in carpal tunnel syndrome. *Neurol. Clin. Pract.* 9, e11–e12. <https://doi.org/10.1002/mus.880141102>. PMID: 1745276.

Coraci, D., Erra, C., Santilli, V., Padua, L., 2017. Immune-mediated neuropathies: Role of single-fiber conduction velocity. *Clin. Neurophysiol.* 128, 1411–1412. <https://doi.org/10.1016/j.clinph.2017.05.011>. Epub 2017 May 23 PMID: 28618291.

Gutmann, L., Gutmann, L., 2004. Myokymia and neuromyotonia. *J. Neurol.* 251, 138–142. <https://doi.org/10.1007/s00415-004-0331-5>. PMID: 14991346.

Gutmann L, Libell D, Gutmann L., 2001. When is myokymia neuromyotonia? *Muscle Nerve.* 24:151–153. doi: 10.1002/1097-4598(200102)24:2<151::aid-mus10>3.0.co;2-7. PMID: 11180199.

Gutmann L., 1991. AAEM minimonograph #37: facial and limb myokymia. *Muscle Nerve.* 14:1043–1049. doi: 10.1002/mus.880141102. PMID: 1745276.

Kameyama, S., Masuda, H., Shirozu, H., Ito, Y., Sonoda, M., Kimura, J., 2016. Ephaptic transmission is the origin of the abnormal muscle response seen in hemifacial spasm. *Clin. Neurophysiol.* 127, 2240–2245. <https://doi.org/10.1016/j.clinph.2016.02.004>. Epub 2016 Feb 11 PMID: 27072096.

Kimura, J., 2013. *Electrodiagnosis in Diseases of Nerve and Muscle: Principles and Practice.* Oxford University Press, Oxford, pp. 375–376.

Kimura, J., 1979. The carpal tunnel syndrome: localization of conduction abnormalities within the distal segment of the median nerve. *Brain* 102, 619–635.

Kimura, J., 1978. A method for determining median nerve conduction velocity across the carpal tunnel. *J. Neurol. Sci.* 38, 1–10.

Mondelli, M., Aretini, A., Ginanneschi, F., Padua, L., 2010. Thenar motor neuropathy electrophysiological study of 28 cases. *J. Clin. Neurophysiol.* 27, 344–349.

Nathan, P.A., Srinivasan, H., Doyle, L., Meado, K.D., 1990. Location of impaired sensory conduction of the median nerve in carpal tunnel syndrome. *J. Hand Surg. Br.* 15, 89–92. [https://doi.org/10.1016/0266-7681\(90\)90056-a](https://doi.org/10.1016/0266-7681(90)90056-a). PMID: 2307889.

Noto, Y., Misawa, S., Kanai, K., Sato, Y., Shibuya, K., Ise, S., et al., 2011. Activity-dependent changes in impulse conduction of single human motor axons: a stimulated single fiber electromyography study. *Clin. Neurophysiol.* 122, 2512–2517. <https://doi.org/10.1016/j.clinph.2011.05.005>. Epub 2011 Jun 12 PMID: 21664178.

Padua, L., Stålberg, E., Caliandro, P., Muscogiuri, G., Pazzaglia, C., Sorice, G.P., et al., 2011. Single-fiber conduction velocity test allows earlier detection of abnormalities in diabetes. *Muscle Nerve* 43, 652–656. <https://doi.org/10.1002/mus.21935>. PMID: 21484824.

Padua L, Caliandro P, Stålberg E., 2007. A novel approach to the measurement of motor conduction velocity using a single fiber EMG electrode. *Clin. Neurophysiol.* 118, 1985–1990. doi: 10.1016/j.clinph.2007.05.010. Epub 2007 Jun 27. PMID: 17588808.

Padua L, Aprile I, D'Amico P, Pauri F, Sabatelli M, Caliandro P, et al., 2001. A useful electrophysiological test for diagnosis of minimal conduction block. *Clin. Neurophysiol.* 112:1041–1048. doi: 10.1016/s1388-2457(01)00525-9. PMID: 11377263.

Repaci, M., Torrieri, F., Di Blasio, F., Uncini, A., 1999. Exclusive electrophysiological motor involvement in carpal tunnel syndrome. *Clin. Neurophysiol.* 110, 1471–1474.

Sanders DB, Arimura K, Cui L, Ertaş M, Farrugia ME, Gilchrist J, et al., 2019. Guidelines for single fiber EMG. *Clin. Neurophysiol.* 130, 1417–1439. doi: 10.1016/j.clinph.2019.04.005. Epub 2019 Apr 27. PMID: 31080019.

Spaans, F., 1982. Spontaneous rhythmic motor unit potentials in the carpal tunnel syndrome. *J. Neurol. Neurosurg. Psychiatry* 45, 19–28.

Stålberg EV, Trontelji JV, Standers DB. Single fiber EMG. 3rd ed. Fiskeb ckskil: Edshagen; 2010.

Sunter G, Uluc K, Salcini C, Temucin CM, Yilmaz O, Tanridag T, et al., 2014. Motor nerve impairment in diabetic patients with symmetrical distal sensory polyneuropathy: a single nerve fiber conduction velocity study. *Muscle Nerve.* 49, 84–89. doi: 10.1002/mus.23876. Epub 2013 Oct 8. PMID: 23588824.

Valls-Solé J, Montero J., 2003. Movement disorders in patients with peripheral facial palsy. *Mov. Disord.* 18, 1424–1435. doi: 10.1002/mds.10605. PMID: 14673878.