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Editorial

Single fiber EMG guidelines: Moving towards a "single" methodological consensus

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Single Fiber EMG (SFEMG) has become a cornerstone tool to explore the safety factor of neuromuscular transmission and muscle physiology, enriching the armamentarium of clinical neurophysiologists during the last 40 years.

Back in 1967, Jan Ekstedt and Erik Stålberg developed an electrode to record action potentials from single muscle fibers (SFAPs), while exploring the physiology of muscle fatigue. This technical advancement allowed them to study two physiological properties of the muscle: (i) the jitter phenomenon and (ii) the muscle fiber action potential propagation velocity (Ekstedt, 1964; Ekstedt et al., 1969). After that, many investigators and clinicians, led by Prof. Erik Stålberg, Prof. Jože V. Trontelj and Prof. Donald B. Sanders, improved this technique and explored its clinical utility in many neuromuscular diseases. Their knowledge and experience were captured in the book, *Single Fibre Electromyography*, which already has three editions (Stålberg et al., 2010). Moreover, the technological developments during these years have been crucial for SFEMG translation from the basic research field into clinical neurophysiology laboratories. One important advancement leading to a wider and cheaper application of the technique is the standardization of SFEMG with concentric needle electrode (CNE) (Stålberg and Sanders, 2009). Initially this variation of the technique emerged due to the restrictions on the use of reusable materials in many countries. Today, CNE has practically replaced SFEMG electrodes (SFE) to measure jitter. In fact, with a concentric needle it is not really a "single fiber" recording but a multiple fibers recording, but normal values and a standard technique have been stablished (Stålberg et al., 2016). Nowadays, common EMG equipment includes technical features such as signal trigger and signal delay, which is fundamental for jitter recording, and most of them also include the software necessary for the application of SFEMG. This is another element that has contributed to the diffusion of the technique. The wider use of a still "new" technique in many different centers around the world has the risk of generating different application methods, as well as different normal and pathological criteria.

The measurement of neuromuscular jitter reflects the time variability of processes in the motor end-plate, and may thus be used to recognise diseases with disturbed end-plate function. This includes myasthenic conditions, nerve diseases with ongoing reinnervation, as well as some muscle conditions (Liu et al., 2013). Because SFEMG is extremely sensitive in detecting disturbed neuromuscular transmission, the method has been rapidly introduced into clinical practice to identify myasthenic disorders. Specifically, SFEMG is more sensitive than repetitive nerve stimulation because it can identify impairment of neuromuscular transmission before a complete conduction block has occurred. Thus, it may be abnormal even in the absence of clinical weakness or fatigue. SFEMG is the most sensitive diagnostic study in myasthenia gravis (MG), being positive in up to 99% of patients with either generalized or ocular MG (Sanders and Howard, 1986). However, given that neuropathic (e.g. ALS) and myopathic (e.g. mitochondrial myopathy) conditions also cause impairment of neuromuscular transmission and therefore may also result in an increased jitter, the specificity of SFEMG among MG patients depends on the population included in these studies. On the other hand, SFEMG also guides the understanding of novel principles of motor unit organization, specifically by quantifying fiber density, which can be abnormal in muscle and nerve diseases.

In the current issue of *Clinical Neurophysiology*, Sanders and colleagues (including Prof. Erik Stålberg), published a guideline endorsed by the IFCN that reviews the current status of the SFEMG technique and the measurement of jitter, including standard technical recommendation for its measure and the pitfalls of measuring jitter with CNE (Sanders et al., 2019). This guideline invites the reader to briefly explore and understand the evolution and development of SFEMG over the past 40 years. It summarizes and discusses the essential neurophysiological discoveries across the study of SFEMG in healthy controls and patients with neuromuscular diseases, including its clinical utility. The guideline also explains in detail the new standards for signal measurement and normative values with the CNE (Stålberg and Sanders, 2009).

The guideline is instructive, both for beginners who will find basic information regarding the technique, indications and pitfalls, but also to experienced clinical neurophysiologists. The practical description of a large volume of technical factors into an accessible format is remarkable. This should prove to be of significant value to those performing SFEMG or seeking to improve proficiency in the technique, together with advancing in a collective standardization of the method across different countries. However, as all clinical neurophysiologists know, the measurement of jitter (with CNE or SFE) is technically challenging, requiring substantial time and experience to develop the skills necessary to obtain recordings according to technical standards. Ultimately, there are still future challenges in the field such as the design of signal analysis software to evaluate the quality of the signals online, and the fabrica-

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tion of disposable SFE, which is the only needle able to record SFAPs without any signal contamination.

Without doubt, this "*Guidelines for Single Fiber EMG*" fills an empty niche in the clinical neurophysiology literature.

Declaration of Competing Interest

We do not have any conflict of interests related to the present work.

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