

Short communication

LASER ETCHED BIFILAR FINE WIRE ELECTRODE FOR SKELETAL MUSCLE MOTOR UNIT RECORDING

ROGER M. NELSON * and GARY L. SODERBERG **

* National Institute for Occupational Safety and Health, U.S.P.H.S., Department HHS, Morgantown, W.Va., and ** Graduate Programs in Physical Therapy Education, University of Iowa, Iowa City, Ia. (U.S.A.)

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Bifilar, fine wire electrodes are essential for recording single motor unit action potentials (SMUAP) from skeletal muscles. Selective recording of SMUAP data is related to both the diameter and the physical configuration of the active recording apertures (Hannerz 1974; Andreassen and Rosenfalk 1978). The most common fine wire configuration consists of two wires insulated except for the portion exposed by cross-sectional cut. The active aperture is the cross-section cut and depends on the diameter of wire used. Usually the wires are bent to form a hook at the end for insertion with a hypodermic needle (Basmajian and Stecko 1962). The other form of fine wire recording is via a side hole configuration. Bifilar fine wires are braided together, and one end is insulated with lacquer. Active apertures along the length of the wires are usually produced by an induction spark (Andreassen and Rosenfalk 1978). The diameter of the spark induced apertures can vary between 10 and 25 μm . The side hole electrode is usually passed into and out of the muscle by a curved hypodermic needle (Andreassen and Rosenfalk 1978).

In an attempt to record from a limited number of single motor unit action potentials a bifilar, fine wire electrode was developed that incorporates side hole recording in an end-cut design.

Two 8 μm diameter (40 gauge, A.W.G.) wires, 25 cm in length were twisted together for 3 cm. The braided ends were insulated by lacquer. One centimeter from the insulated end the wire was bent to 160°. Approximately 2 cm distal to the formed hook, a 5 μm piece of insulation was etched from each wire by a pulse laser (Fig. 1). The laser was a Model 11 ND glass lens that produced a round beam. The beam had a pulse of 1/sec and had a voltage output of 1 kV. All etchings were performed under a microscope. The sole problem encountered during the etching procedure was moving the laser beam from one wire to another. In retrospect two different colors for the wires would be recommended. The apertures were oriented 50° from one another (Andreassen and Rosenfalk 1978). Active bipolar recordings of the SMUAP were obtained from these

two non-insulated 5 μm areas on the fine wires.

Each pair of fine wire electrodes was evaluated for resistive and capacitive components. A total of 64 fine wire electrodes were constructed and tested for impedance components. While impedance could not be controlled it was measured. Any pair of fine wires which had a large disparity of impedance measurements between the two wires were discarded. The resistive component ranged from 0.42 to 3.8 M Ω (mean 1.57 ± 0.55 M Ω) at 1000 Hz. The capacitance ranged from 67 to 319 pfarads (mean 1.57 ± 34) with an average dissipation factor of 0.480 (± 0.17). The fine wires were threaded through the hollow core of a 27-gauge disposable hypodermic needle, subsequently packaged and sterilized. After intramuscular insertion, the fine wires were connected to a high impedance probe of the pre-amplifier. This probe had an input resistance of 100,000 M Ω and an input capacitance of 10 pfarads per input. The rejection ratio at normal physiologic levels was 1000:1.

Spark etchings may produce an aperture that can vary between 10 and 25 μm . The pulsed laser used in this study accurately and consistently produced 5 μm apertures. Consistent and accurate small active apertures coupled with side hole recording allowed recording of SMUAPs from uninjured muscle fibers. The high resistance offered by the small apertures was effectively countered by the yet higher input impedance offered by the high impedance probe of the preamplifier. Success of electrode design was determined by the selectivity of

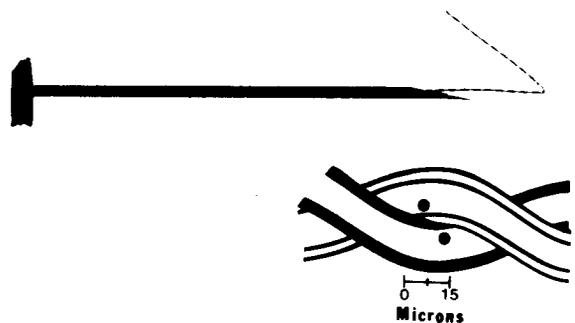


Fig. 1. Fine wire bifilar electrodes inserted in needle. Insert: exploded view of active aperture areas.

Address reprint requests to Dr. Roger Nelson, NIOSH, DSR, 944 Chestnut Ridge Road, Morgantown, W.Va. 26505, U.S.A.



Fig. 2. From top to bottom, a continuous record (610 msec) of single motor unit action potentials recorded with $5\ \mu\text{m}$ active apertures during a 5% maximum voluntary isometric contraction.

motor unit recording and the absence of any interference signals obtained when recording, in situ, skeletal muscle motor units. The electrode was used successfully in all subjects tested. Specifically, 44 subjects were tested in one study which yielded 268 SMUAPs.¹ The remaining 20 electrodes were used in a variety of other studies. In all recordings this electrode was selective in recording from 1 to 5 SMUAPs during isometric tension tasks ranging from 5 to 30% maximum voluntary contraction (Fig. 2). With proper cleaning and sterilization these fine wire electrodes are reusable at least once, perhaps twice.

Summary

To selectively record a limited number of skeletal muscle motor unit action potentials, a bifilar fine wire electrode was developed. Two $8\ \mu\text{m}$ fine wires were braided together, a hook formed, and ends insulated. A round beam, pulsed laser, etched a $5\ \mu\text{m}$ piece of insulation from each wire near the hooked end. Bipolar recordings from a select number of skeletal muscle motor units were obtained from these two uninsulated $5\ \mu\text{m}$ areas. Reactive and capacitive components for each set of electrodes were measured. These electrodes were selective in recording from 3 to 5 single motor unit action potentials at low isometric tension levels.

¹ Nelson, R.M. *Discharge Characteristics of Motor Units in Elderly People*. Ph.D. dissertation, The University of Iowa, Iowa City, Ia. 52242, 1981.

Résumé

Fine électrode bifilaire désisolée au laser pour l'enregistrement d'unité motrice dans un muscle squelettique

En vue d'enregistrer sélectivement un nombre limité de potentiels d'unité motrice de muscle squelettique, une fine électrode bifilaire a été mise au point. Deux fils de $8\ \mu\text{m}$ ont été torsadés, un crochet formé et les extrémités ont été isolées. Un laser pulsé, à rayon circulaire a permis de décaper chaque fil sur $5\ \mu\text{m}$ à proximité du crochet. Des enregistrements bipolaires d'un nombre restreint d'unités motrices squelettiques ont été obtenus à partir de ces deux régions non isolées de $5\ \mu\text{m}$. Les composantes réactive et capacitive de chaque paire d'électrodes ont été mesurées. Ces électrodes recueillaient sélectivement de 3 à 5 potentiels d'unités motrices sous faible tension isométrique.

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