Introduction

The purpose of this study was to develop a reliable methodology to assess median nerve conduction velocity (NCV) in a new animal model for longitudinally studying Carpal Tunnel Syndrome (CTS) due to volitional work tasks. The Macaca fascicularis was selected for this model due to anatomical similarities with humans and ability to perform pinching tasks similar to those associated with CTS onset in humans. The larger purpose of this work is to develop an animal model to study dose-response relationships for development of CTS that are applicable to humans. The primary quantitative dependent measure used in this type of animal model is longitudinal change in NCV, therefore making it imperative to have reliable baseline measures for each animal used in a CTS-inducing protocol.

Previous work has shown that CTS is dependent upon hand temperature. Given the intent to use these data longitudinally, it is necessary to describe this temperature-velocity relationship in these subjects, in order to provide temperature-corrected NCV assessments.

Methods

Three female and one male Macaca of varying size (3.6 – 6.5 kg) and age (4.5 to 22.5 years) were tested according to an IACUC approved protocol. Setup for testing median and ulnar nerve function is shown in Fig. 1. For testing, the subject is sedated with Ketamine hydrochloride (13 mg/kg i.m) and then anesthetized with Isoflurane anesthesia (1 – 2%) inhaled through a mask. Stimulation is applied through a Grass Model F-BSE1 bipolar stimulating electrode, driven by a battery-powered, optically isolated, current controlled stimulus isolation unit.

The stimulation site on the forearm is located 6.0 cm proximal from the positive (proximal) ring electrode on Digit 2. Pairs of 5-mm Ag-AgCl EMG disc electrodes are positioned over the thenar and hypothenar eminences, both 1 cm apart; filled with gel, they are attached via adhesive collars. EMG leads are shielded, and connected to a preamplifier close to the subject. EMG is amplified with a gain of 0.5 K, and a bandpass of 20 Hz – 3 KHz. Silver ring electrodes were custom built from shielded cable with a pair of pure silver wires emerging from the end. Once the ring electrodes are wrapped around the fingers, electrode gel is placed on the lateral aspects of the fingers where the wires touch the skin near the digital nerves. Nerve potentials from the ring electrodes are amplified at 10K, with a 20 Hz – 3 KHz bandpass. A ground electrode (10-mm Ag-AgCl disc) is placed over the dorsal aspect of the wrist. A thermal transducer taped to the palmar side of the wrist monitors hand temperature. Warmed wax pads are used to maintain hand temperature at approximately 35.5°C.

Each subject’s testing protocol begins with determination of the minimum current required to evoke a sensory nerve action potential (SNAP). Current is adjusted upwards until there is motor and sensory saturation of the action potentials. The computer is then programmed to deliver stimulus pulses at a variety of amplitudes between sub-threshold and supra-maximal intensities (10 stimuli/amplitude), with the order of stimulus amplitude randomized. A graph of current versus peak-to-peak amplitude of sensory and motor action potentials is examined to select the test current used for analysis (figure 2). The current at which the SNAP is fully saturated and the compound motor action potential (CMAP) is at 80 percent saturation is defined as the test current. Velocity is based on latency from time of stimulation to onset of depolarization (figure 3).

Temperature sensitivity of the SNAP was assessed by systematically cooling and warming each animal’s forearm and hand between 33.0 – 37.0 °C.

Results and Discussion

Table 1. Median sensory velocity (m/s)

|     | n  | Mean | St.Dev | Mean | St.Dev
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>M1</td>
<td>10</td>
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<td>41.6</td>
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</tr>
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<td>41.5</td>
<td>1.8</td>
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<td>1.9</td>
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</tr>
<tr>
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<td>9</td>
<td>44.6</td>
<td>1.6</td>
<td>45.5</td>
<td>1.8</td>
</tr>
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Temp. Corr. Vel. (m/s) = [(35.5 – Skin Temp.) x TCF] + Raw Vel. (1)

Conclusions

The developed protocol allows for reliable assessment of the median nerve conduction velocity in the Macaca fascicularis. A 15% decrement, usually used to diagnose CTS, would correspond to 3 s.d. below these baseline values. Data provided by these methods can, therefore, be used to assess the development of CTS longitudinarily in this new animal model where the onset of CTS induced through volitional exertions can be investigated.

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