PERFORMING MOTOR AND SENSORY NEURONAL CONDUCTION STUDIES IN ADULT HUMANS

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Project Officers:

David E. Nestor, PT, MS
Research Physical Therapist

Roger M. Nelson, PT, PhD
Research Physical Therapist

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PREFACE

The National Institute for Occupational Safety and Health, Division of Safety Research is attempting to standardize the assessment methods used to define occupational safety and health hazards from physical trauma. Therefore, the standardized procedures offered in this document are suggested guidelines for the performance of routine, nerve conduction studies of selected peripheral nerves in adult humans. These guidelines should serve as a starting point for electrophysiologic assessment procedures for evaluating common motor and sensory neuronal conduction disorders encountered in the workplace. These procedures can be used to objectively assess the motor and sensory neuronal conduction status of adult workers subjected to cumulative trauma, toxic substances, etc. that may cause acute or chronic neuromuscular disorders. Unusual and unique problems require sound, creative modification of the standard procedures to assess the problem.

This manual is the result of three working group meetings conducted over a two and one-half year period. The working group consisted of neurophysiologists, therapists, physicians, and allied health professionals recognized for their expertise in electrophysiologic assessment of neuromuscular disorders. The manual represents a consensus opinion of this working group.

Industrial engineers, human factors engineers, medical practitioners, allied health professionals, and researchers conducting ergonomic assessment of the workplace can use these standardized procedures.

The purpose of this manual is to provide technical performance guidelines for assessing the peripheral neuromuscular system of workers. These technical procedures may be used in both job-site evaluations and in research protocols.

ACKNOWLEDGEMENTS

This technical manual was developed as part of the National Institute for Occupational Safety and Health (NIOSH), Division of Safety Research (DSR) project entitled ''Development of Normal Motor and Sensory Neuronal Conduction Values in Adult Humans'' (89278817).

The project officers greatfully acknowledge Herb Bohnet, Jack Echternach, John Eddy, Robert Kellogg, Rod Schlegel, Michael Skurja, Jr., Gary Soderberg, Arnold Tripp, and Regis Turocy for their work on the original document and many revisions. The review comments of Rene Cailliet, Jean Crothers, Anne Fidler, Sean Gallagher, David Labosky, Monica Milliron, Arthur Nitz, Tim Pizatella, John Russo, and Thomas Waters were very useful in revising the document.

Mr. Vincent Perez provided the first class medical illustrations in this manual. The clerical support provided by Polly Fiorini was invaluable in completing this document. Special thanks to Herb Linn, Gary Williams, and Mike Moore for their help in preparing the manuscript.

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INTRODUCTION

Nerve conduction studies are technical procedures used to objectively assess the functional status of the peripheral neuromuscular system. The reliability of the studies is increased when the technical procedures are standardized. The standardized procedures presented in this manual represent the consensus opinion of "expert" medical clinicians, neurophysiologists, and health care practitioners who routinely perform nerve conduction studies.

This manual is divided into four sections. The first section provides general information that should be considered while performing nerve conduction studies. Subsequent sections provide technical procedures for performing nerve conduction studies, solutions to problems that arise during testing sessions, and a glossary of terms.

[<u>Note</u>: Information on the electromyographic instrumentation used to collect motor and sensory nerve conduction data, neurophysiology, and peripheral neuroanatomy are not presented in this manual.]

GENERAL INFORMATION

Basic Nerve Conduction Studies

The study of nerve conduction assumes that when a nerve is stimulated electrically a reaction should occur somewhere along the nerve. The reaction of the nerve to stimulation can be monitored with appropriate recording electrodes. Direct recording can be made along sensory or mixed nerves. Indirect recording from a muscle can be used for motor conduction studies. Both orthodromic and antidromic conduction can be studied because stimulus propagation occurs proximally to and distally to the point of stimulation. The time relationship between the stimulus and the response can be displayed, measured, and recorded.

This first section of the manual provides general information that should be considered while performing nerve conduction studies.

Electrodes

Active (Recording) and Reference Electrodes: The type of metal surface electrodes used is determined by the type of nerve response being studied.

> *Motor Response:* Motor responses are recorded over the muscle being studied. The active (recording) electrode should be placed over the motor point of the muscle so that a clear negative deflection (upward) is recorded when electrostimulation is applied to the nerve supplying that muscle. The reference electrode should be placed <u>off</u> the muscle on a nearby tendon or bone. Recording and reference electrodes used for motor responses are surface disc electrodes about 0.5 - 1.0 centimeters in diameter. The surface disc electrodes may be separate discs or fixed 2.0 - 3.0 centimeters apart in a plastic bar (Figures 1 & 2).
>
> *Sensory Response:* Sensory responses are recorded over the nerve. Recording and reference electrodes used for sensory responses are surface electrodes with spring clips or rings (Figures 3 & 4).

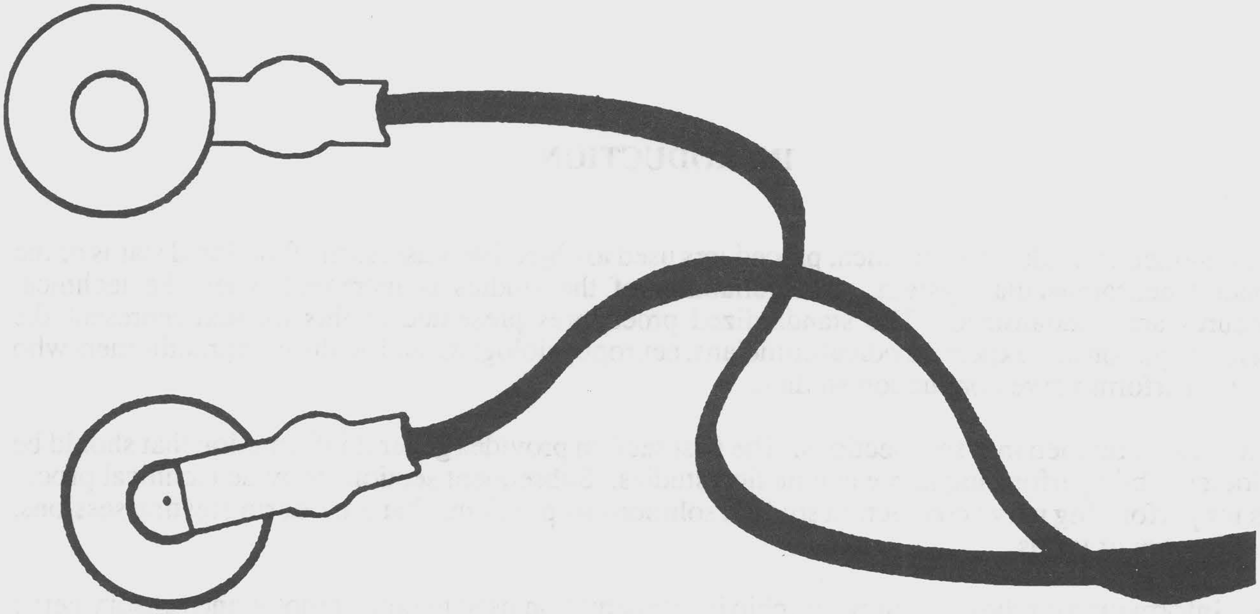


Figure 1. Surface recording (disc) electrodes.

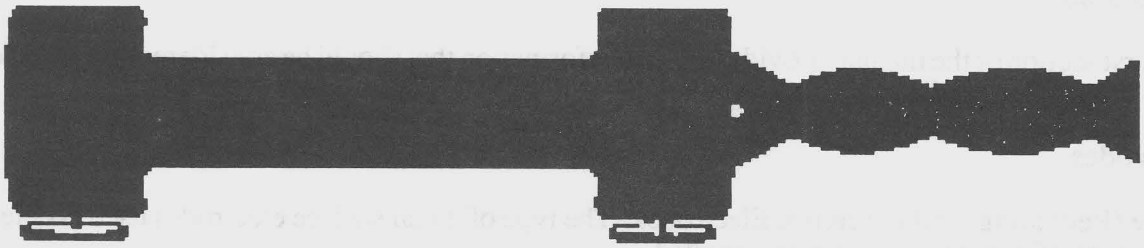


Figure 2. Surface recording (bar) electrode.

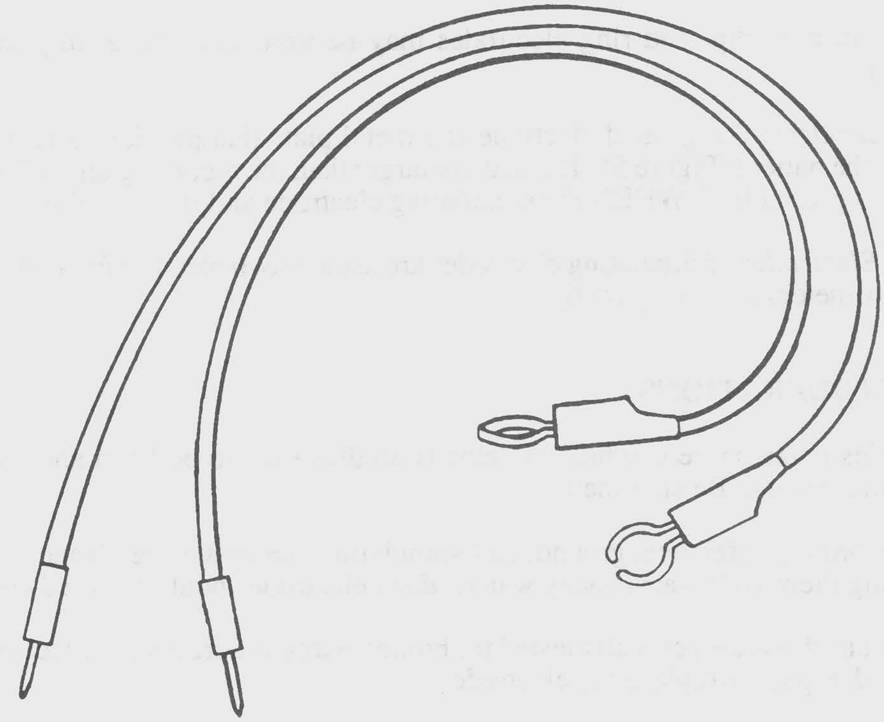


Figure 3. Sensory digital clip electrodes.

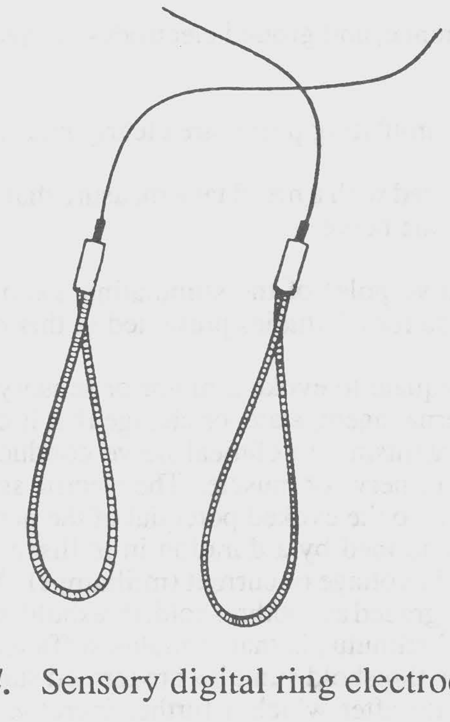


Figure 4. Sensory digital ring electrodes.

[<u>NOTE</u>: Disc, bar, clip, and ring electrodes may be used interchangeably for recording and stimulating.]

Ground Electrodes: The ground electrode is a metal plate that provides a large surface area of contact with the patient (Figure 5). It is usually larger than the recording and reference electrodes. The ground is placed **BETWEEN** the stimulating electrode and the recording electrode.

Stimulating Electrodes: Stimulating electrodes are usually two metal or felt pad electrodes placed 1.5 - 3.0 centimeters apart (Figure 6).

GENERAL CONSIDERATIONS

A few general rules make nerve conduction velocity studies easy to perform and greatly reduce the number of examiner errors. Be sure that:

1. All recording, reference, ground, and stimulating electrodes are cleaned after each use by washing them with warm soapy water. Each electrode should be dried completely.

2. All electrodes are electrically tested for broken wires or defective contact points. If a defect is noted, repair or replace the electrode.

3. A <u>thin</u> film of electrode gel is used on each electrode to maximize conductivity.

4. The electrode site on the subject's skin is clean and free of oil, grease, and soil. The site should be cleaned and abraded, as necessary, to reduce impedance at the electrode/skin inferface.

5. All recording, reference, and ground electrodes are securely fastened to the patient/subject with tape or straps.

6. All recording and stimulating points are clearly marked with visible ink.

7. Distances are measured with a metal tape measure that is closely apposed to the skin and the anatomic course of the nerve.

8. The cathode (negative pole) of the stimulating electrode is positioned toward the active (recording) electrode for all studies presented in this manual.

9. The stimulus is adequate to evoke a motor or sensory response. In general, a stimulus is defined as any external agent, state, or change that is capable of influencing the activity of a cell, tissue, or organism. In clinical nerve conduction studies, an electric stimulus is generally applied to a nerve or muscle. The electric stimulus may be described in absolute terms or with respect to the evoked potential of the nerve or muscle. In absolute terms, the electric stimulus is defined by a duration in milliseconds, a waveform, and a strength or intensity measured in voltage or current (milliamps). With respect to the evoked potential, the stimulus may be graded as subthreshold, threshold, submaximal, maximal, or supramaximal. The threshold stimulus is that stimulus sufficient to produce a detectable response. Stimuli less than the threshold stimulus are termed subthreshold. The maximal stimulus is the stimulus intensity after which a further increase in the stimulus intensity causes no increase in the amplitude of the evoked potential. Stimuli of intensity below this level but

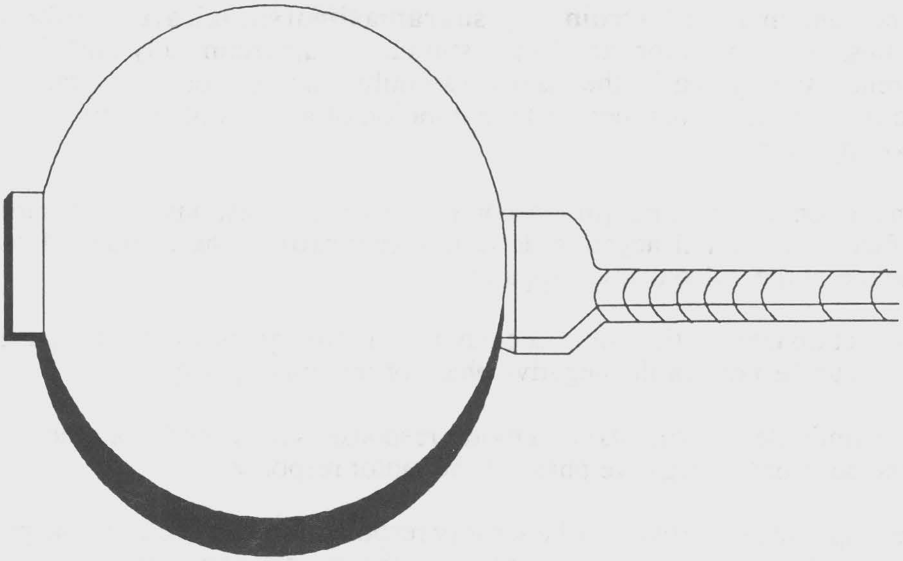


Figure 5. Ground Electrode.

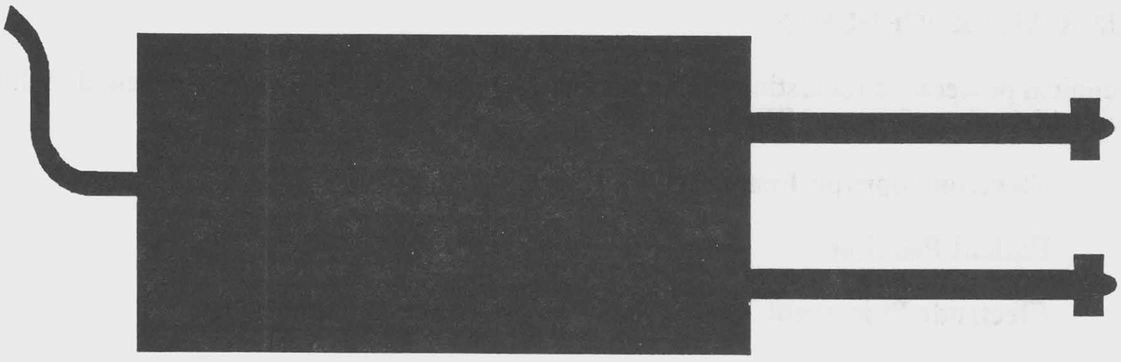


Figure 6. Stimulator.

above threshold are submaximal. Stimuli of intensity greater than the maximal stimulus are termed supramaximal. **Ordinarily, supramaximal stimuli are used for nerve conduction studies.** By convention, an electric stimulus of approximately 20% **GREATER** voltage/ current than required for the maximal stimulus may be used for supramaximal stimulation. The frequency, the number, and the duration of a series of stimuli should be specified on reporting forms.

10. Conduction latency time (milliseconds) for a motor response is measured from the shock artifact to the initial negative deflection (upward) of the response from the iso-electric baseline of the video display apparatus.

11. Conduction latency time (milliseconds) for a sensory response is measured from the shock artifact to the peak of the negative phase of the sensory response.

12. The amplitude (microvolts) of a motor response is measured from the iso-electric baseline to the peak of the negative phase of the motor response.

13. The amplitude (microvolts) of a sensory response is measured from the peak of the negative phase to the peak of the positive phase of the sensory response.

14. The duration (milliseconds) of a motor or a sensory response is measured from the initial deflection of the negative phase of the response from the iso-electric baseline to the return of the positive phase of the response to the iso-electric baseline.

15. Conduction velocity (meters/second) of a nerve is calculated by measuring the distance (millimeters) between two stimulation sites and dividing by the difference in latency (milliseconds) from the more proximal stimulus and the latency (milliseconds) of the distal stimulus. The equation is as follows:

$$\text{Conduction Velocity (meters/second)} = \frac{\text{Distance (millimeters)}}{\text{Proximal Latency - Distal Latency (milliseconds)}}$$

TECHNICAL PROCEDURES

The technical procedures for testing each motor and sensory peripheral nerve presented in this manual are divided into five (5) parts. They are:

Electromyograph Instrument Settings

Patient Position

Electrode Placement

Electrostimulation

Technical Comments

The upper extremity nerves are presented first. The motor component of the nerve is described and is followed by a description of the sensory component of that same nerve. The lower extremity nerves comprise the second half of the technical section and they are presented in the same format as those nerves in the upper extremity. Illustrations showing appropriate electrode placement, anatomic landmarks, and stimulation sites accompany each test description.

Electromyograph Instrument Settings

Filters: The filter settings for each technical procedure allow adequate instrument response to record the motor and sensory potentials being studied. The filter settings are 10 Hz - 10,000 Hz for the motor potentials and 20 Hz - 2,000 Hz for the sensory potentials.

Sweep Speeds: The sweep speeds for each technical procedure allow for display of the motor and sensory potential waveforms. The sweep speed settings are 2 - 5 milliseconds for the motor potentials and 1 - 2 milliseconds for the sensory potentials per horizontal division on the video display apparatus.

Sensitivity/Gain: Sensitivity or gain settings for each technical procedure are general guidelines for recording the motor and sensory potentials. **Increasing or decreasing the sensitivity or gain settings may be necessary to accommodate very low or very high amplitude motor or sensory responses.** Motor sensitivity is 1,000 to 5,000 microvolts per vertical division on the video display apparatus while sensory sensitivity begins at 5 - 10 microvolts.

These are general guidelines and should serve as starting points for basic evaluation procedures. These settings should be modified to meet unusual situations or difficult evaluation problems.

Patient Position

The recommended patient position provides a comfortable, resting position for the patient. It also allows the examiner easy access to the extremity and nerve segment being studied.

Electrode Placement

The active (recording) electrode is placed over the muscle or nerve segment being studied. The reference electrode for motor responses is positioned off of and distal to the muscle being studied on a nearby bone or tendon. The reference electrode for sensory responses is placed on the nerve segment being studied.

The ground electrode for both the motor and sensory responses is placed on a bony prominence **BETWEEN** the stimulating and active (recording) electrodes.

Electrostimulation

Percutaneous electrostimulation is performed with surface electrodes at appropriate anatomic locations along the course of the nerve segment being studied. For all techniques presented in this manual, the cathode (negative pole) of the stimulating electrode is positioned toward the active (recording) electrode. Stimulation sites are designated as S1, S2, etc. to identify the location and sequence of stimulation.

Technical Comments

Information that is considered useful for conducting an adequate and efficient evaluation is provided for each nerve. Cautions, special concerns, and recommendations for using the technical procedures are also included.

Illustrations

Medical illustrations showing electrode placement, stimulation sites, pertinent anatomic structures, and surface anatomy accompany each technical description.

Median Motor

Electromyograph Instrument Parameters:

Filter Settings/Frequency Response: 10 Hz - 10,000 Hz
Sweep Speed: 2 - 5 milliseconds/Division
Sensitivity/Gain: 1,000 - 5,000 microvolts/Division

Patient Position: (Illustration 1) The patient is positioned supine with arm abducted approximately 45 degrees. The forearm is fully supinated and the wrist is in a neutral position.

Electrode Placement: (Illustration 1)

Active (Recording) Electrode: The active recording electrode is positioned directly over the anatomic center of the abductor pollicis brevis muscle. The electrode is placed one-half the distance between the metacarpophalangeal joint of the thumb and the midpoint of the distal wrist crease.

Reference Electrode: The reference electrode is positioned off the abductor pollicis brevis muscle on the distal phalanx of the thumb over bone or tendon.

Ground Electrode: The ground electrode should be firmly positioned on the dorsum of the hand between the active and stimulating electrodes.

Electrostimulation: (Illustration 2)

Percutaneous electrostimulation is performed at the appropriate anatomic sites in the following order:

S1: Distal stimulation is performed at the wrist between the flexor digitorum sublimis and flexor carpi radialis tendons. The cathode (negative pole) of the stimulator should be placed proximal to the center of the active recording electrode on the abductor pollicis brevis muscle. (See Illustration 20, Distal Upper Extremity Stimulation Sites)

S2: Stimulation above the elbow is performed proximal and medial to the antecubital space and proximal to the elbow crease between the belly of the biceps muscle and the medial head of the triceps muscle. The stimulator should be positioned just lateral to the brachial artery to minimize the possibility of inadvertent electrostimulation of the ulnar nerve.

S3: Proximal stimulation is performed in the axilla at least 10 centimeters proximal to the above elbow site and immediately lateral and anterior to the brachial artery.

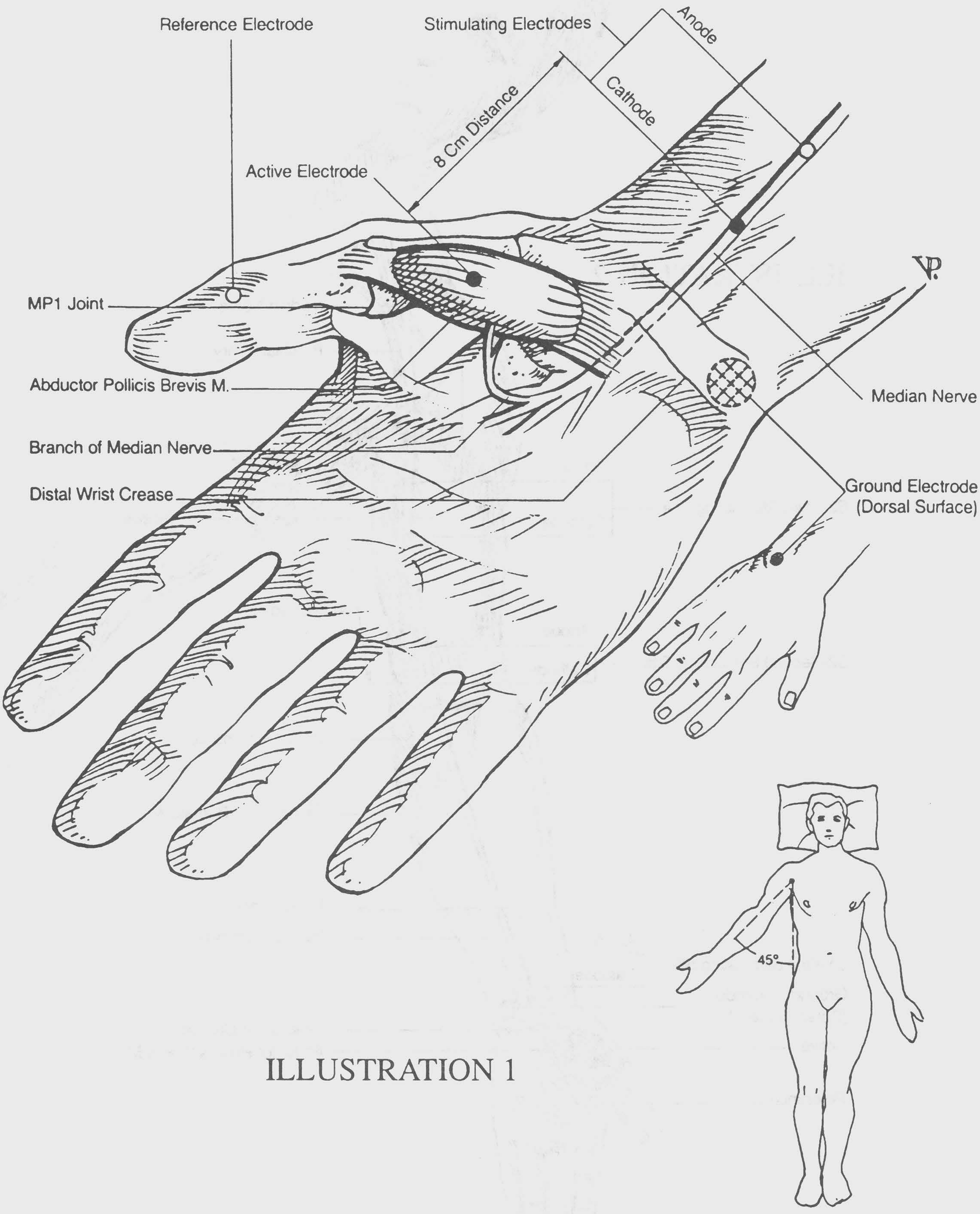
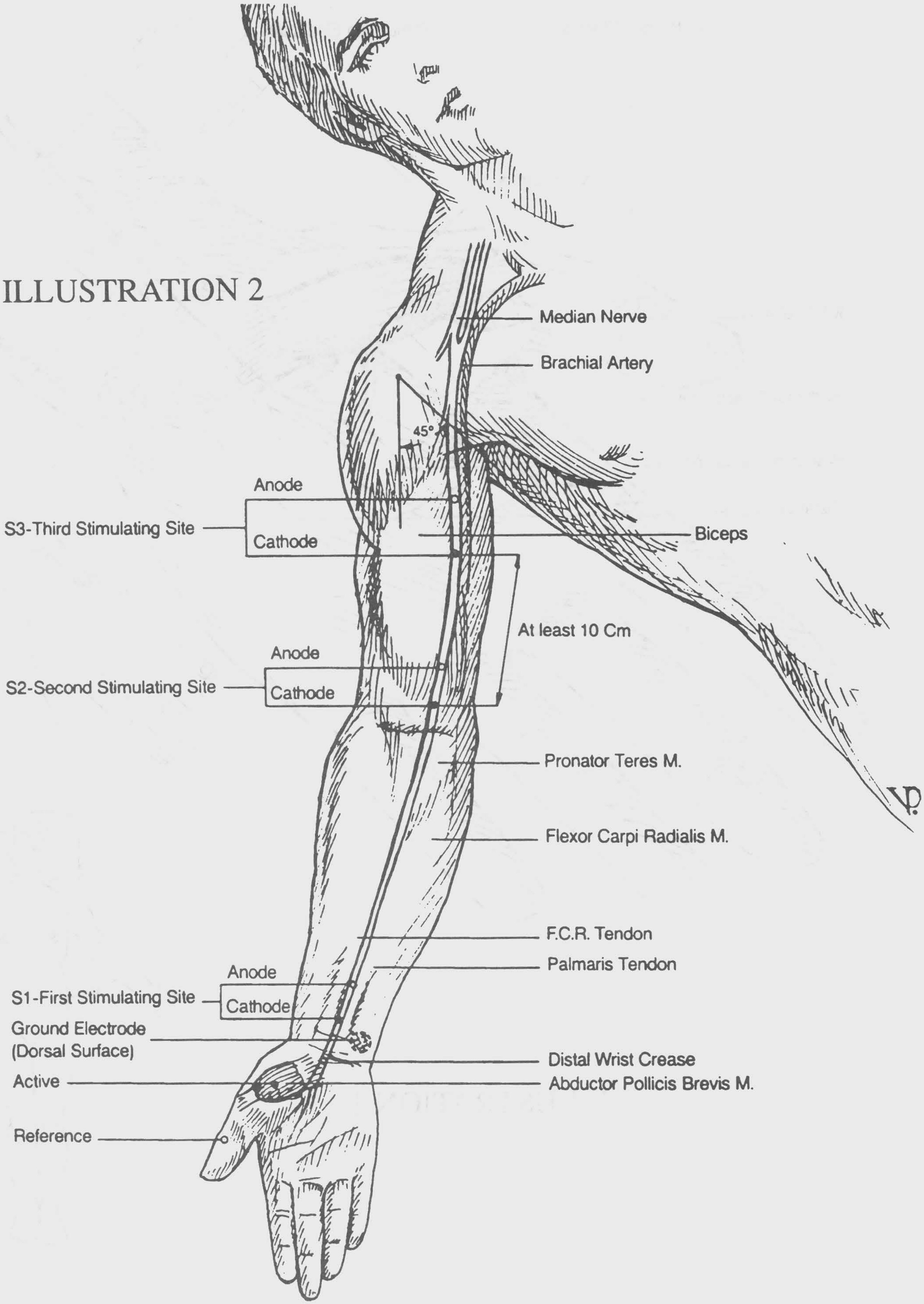


ILLUSTRATION 1

ILLUSTRATION 2



TECHNICAL COMMENTS:

Evoked muscle action potential responses from all three sites **should** be similar in waveform, amplitude, and duration of response.

Wrist site stimulation voltage and/or stimulus pulse duration should be increased gradually and monitored carefully as a high voltage/long pulse width stimulation at the wrist may volume conduct to the adjacent ulnar nerve at the wrist, eliciting a short latency volume conducted ulnar response causing a change in the shape of the evoked potential.

The clinical response should be carefully observed to avoid mistaking an ulnar for median response. At the wrist, median stimulation elicits thumb palmar ABDuction and opposition, while ulnar stimulation elicits thumb ADDuction and metacarpal phalangeal flexion. At the above elbow and axilla stimulation sites, median stimulation elicits wrist flexion in radial deviation involving the flexor carpi radialis muscle, while ulnar stimulation involves wrist flexion in ulnar deviation by contraction of the flexor carpi ulnaris muscle. Palpation of the tendons may help to distinguish the two contractions.

The wrist should be maintained in a standard position while measuring forearm distance. Wrist flexion decreases while wrist extension increases the distance. All distance measurements should be taken with a metal tape measure. The measurement of distance should approximate the anatomic course of the nerve being tested.

Median Sensory (Orthodromic)

Electromyograph Instrument Parameters:

Filter Settings/Frequency Response: 20 Hz - 2,000 Hz
Sweep Speed: 1 - 2 milliseconds/Division
Sensitivity/Gain: 5 - 10 microvolts/Division

Patient Position: (Illustration 3) The patient is positioned supine with arm abducted approximately 45 degrees. The forearm is fully supinated, the wrist is in a neutral position. The fingers may flex slightly when in a relaxed, ''resting'' position.

Electrode Placement: (Illustration 3)

Active (Recording) Electrode: The active recording electrode will be positioned directly over the cathode (distal) stimulating site used for evoking the median motor response at the wrist. (Refer to Illustration 1)

Reference Electrode: The reference electrode will be positioned 2-3 centimeters proximal to the active electrode. This electrode will be positioned so that it is directly over the anode (proximal) stimulating site used for evoking the median motor response at the wrist. (Refer to Illustration 1)

Ground Electrode: The ground should be positioned on the dorsum of the hand between the active and stimulating electrodes.

Electrostimulation: (Illustration 3)

Percutaneous electrostimulation is performed as follows:

Stimulation is applied over the digital nerve via electrodes attached to the index finger. The cathode is positioned at the midpoint of the proximal phalanx of the index finger and the anode is positioned at or about the distal phalangeal joint line. A distance of not less than 10 cm, but not more than 14 cm is maintained between the stimulating cathode on the index finger and the active electrode at the wrist.

TECHNICAL COMMENTS:

A low stimulation intensity is usually adequate to elicit an orthodromic sensory response.

The possibility of obtaining a spurious motor response is decreased using the orthodromic technique.

Motor response and volume conduction effects may be lessened by decreasing electrostimulation intensity and/or decreasing pulse width duration of the applied electrostimulation.

Special Concern: Care must be taken to maintain a separation between the stimulating cathode and anode on the index finger. Do not allow conducting gel to bridge this interelectrode space.

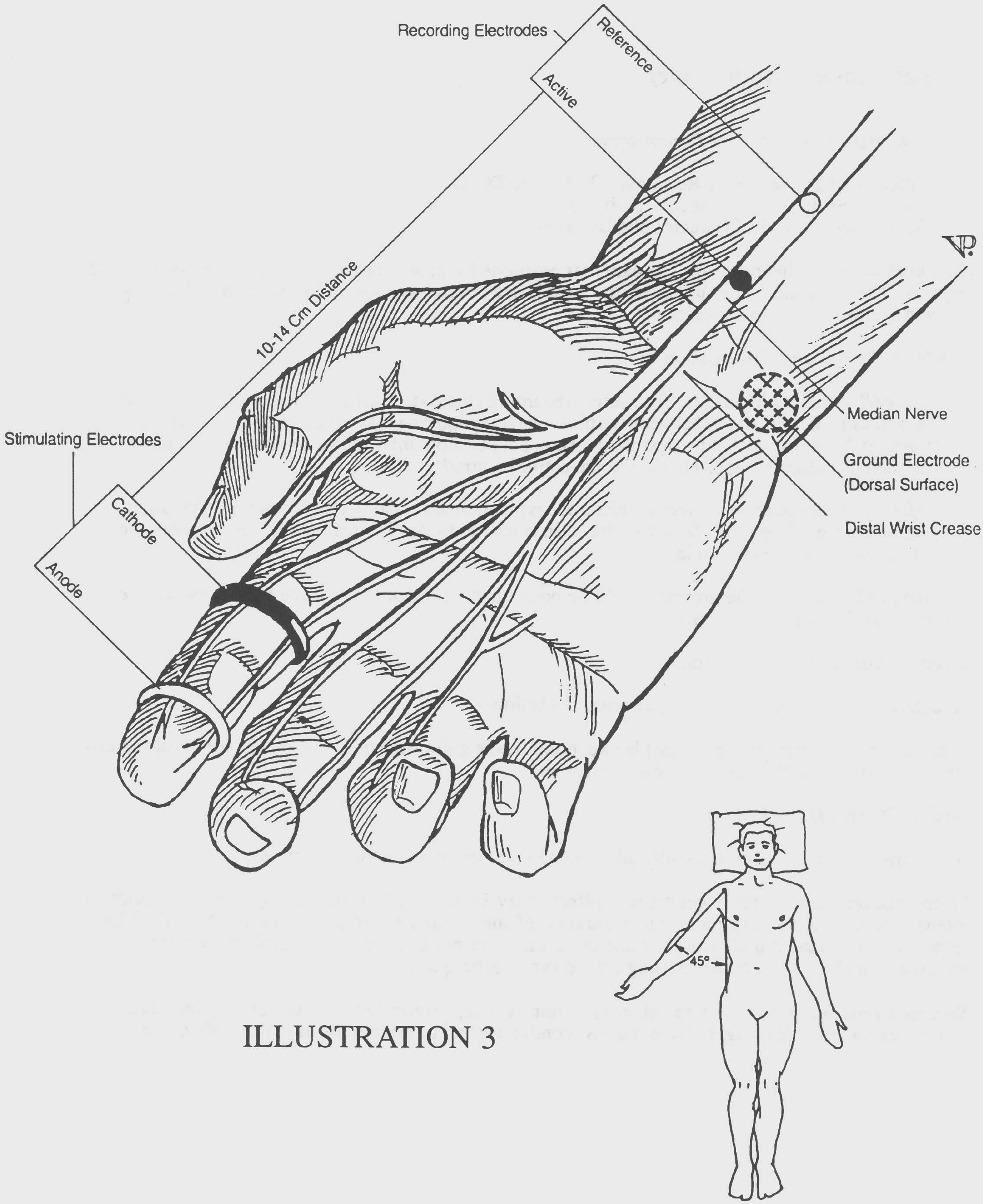


ILLUSTRATION 3

Median Sensory (Antidromic)

Electromyograph Instrument Parameters:

Filter Settings/Frequency Response: 20 Hz - 2,000 Hz
Sweep Speed: 1 - 2 milliseconds/Division
Sensitivity/Gain: 5 - 20 microvolts/Division

Patient Position: (Illustration 4) The patient is positioned supine with arm abducted approximately 45 degrees. The forearm is fully supinated, the wrist is in a neutral position. The fingers may flex slightly when in a relaxed, "resting" position.

Electrode Placement: (Illustration 4)

Active (Recording) Electrode: The active recording electrode is attached to the index finger at the midpoint of the distance between the phalangeal flexion crease and the web space of the index finger so that a distance of not less than 10 cm, but not more than 14 cm distance is maintained between the stimulating electrode and the active electrode.

Reference Electrode: The reference electrode is positioned at or about the distal interphalangeal flexion crease of the index finger so that a distance of at least 3 cm is maintained between the active and reference electrode.

Ground Electrode: The ground should be positioned on the dorsum of the hand between the active and stimulating electrodes.

Electrostimulation: (Illustration 4)

Percutaneous electrostimulation is performed as follows:

Stimulation is performed at the wrist between the flexor digitorum sublimis and flexor carpi radialis tendons proximal to the transverse carpal ligament.

TECHNICAL COMMENTS:

A low stimulation intensity is usually adequate to elicit the antidromic sensory response.

Motor response and volume conduction effects may be lessened by decreasing electrostimulation intensity and/or decreasing pulse width duration of the applied electrostimulation. (NOTE: Motor responses from hand muscles and volume conduction are more of a technical problem when utilizing antidromic techniques than when using orthodromic techniques.)

Special Concern: Care must be taken to maintain a separation between the active and reference electrodes on the index finger. Do not allow conducting gel to bridge this interelectrode space.

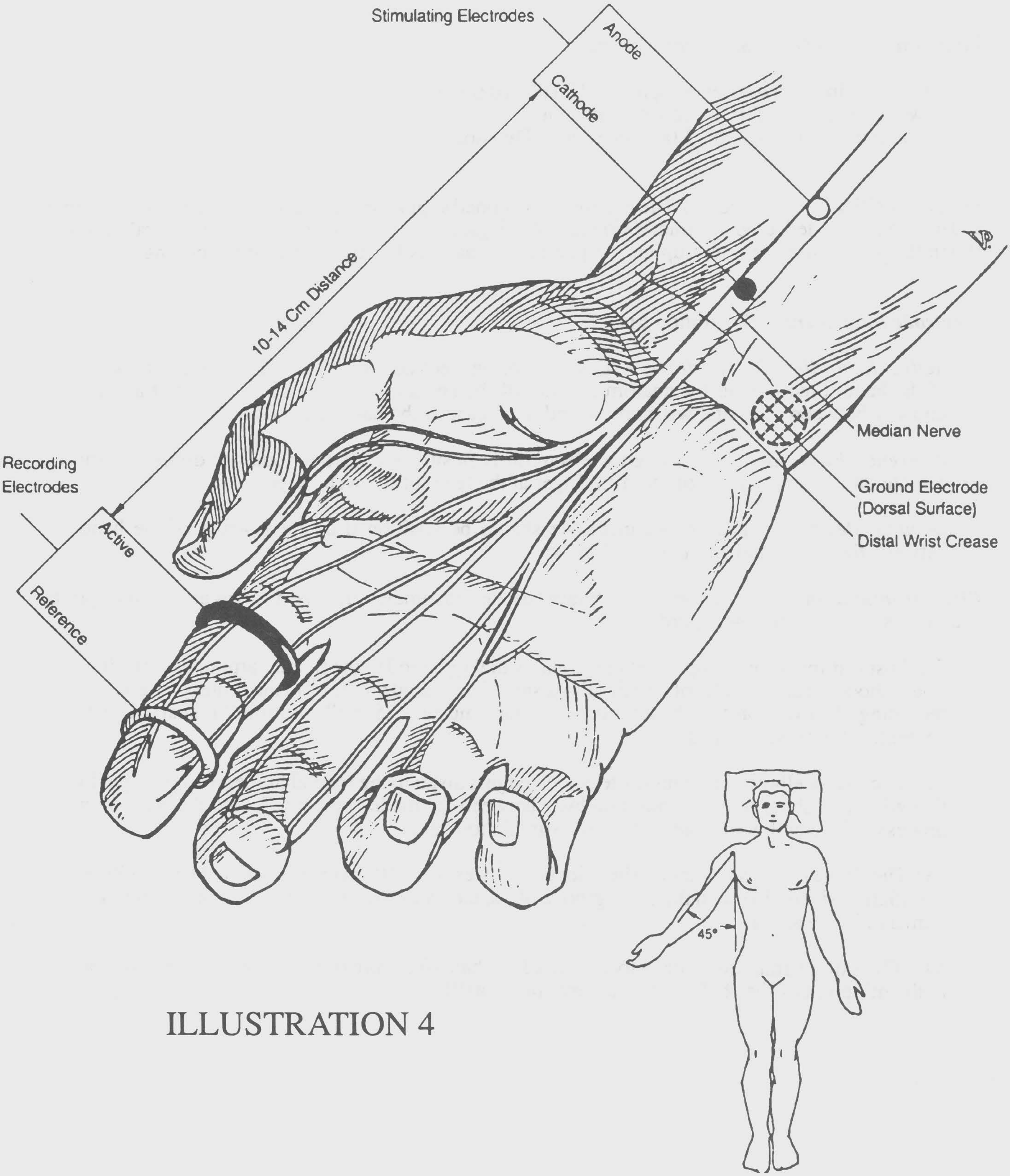


ILLUSTRATION 4

Ulnar Motor

Electromyograph Instrument Parameters:

Filter Settings/Frequency Response: 10 Hz - 10,000 Hz
Sweep Speed: 2 - 5 milliseconds/Division
Sensitivity/Gain: 1,000 - 5,000 microvolts/Division

Patient Position: (Illustration 5) The patient is positioned supine with the arm ABDucted to 90 degrees and externally rotated, elbow in midflexion at 60-90 degrees, palm up, and the wrist in a neutral position. When the patient is positioned supine, the palm of the hand is facing up toward the ceiling.

Electrode Placement: (Illustration 5)

Active (Recording) Electrode: The active recording electrode is positioned on the ulnar border of the hand directly over the anatomic center of the abductor digiti minimi muscle at a point midway between the distal wrist crease and the crease at the base of the fifth digit.

Reference Electrode: The reference electrode is positioned off the abductor digiti minimi muscle on the ulnar aspect of the fifth finger at the level of the web space.

Ground Electrode: The ground electrode should be positioned on the dorsum of the hand between the active and stimulating electrodes.

Electrostimulation: (Illustration 6) Percutaneous electrostimulation is performed at the appropriate anatomic sites in the following order:

S1: Distal stimulation is applied at the wrist, medial or lateral to the flexor carpi ulnaris tendon. The cathode (negative pole) of the stimulator should be placed proximal to the center of the active recording electrode on the abductor digiti minimi muscle. (See Illustration 20, Distal Upper Extremity Stimulation Sites)

S2: The below elbow stimulation site is located just distal to the medial humeral epicondyle in line with the cubital tunnel (a point midway between the medial epicondyle and the olecranon process) of the elbow and the distal wrist stimulation site.

S3: The above elbow stimulation site is located not less than 10 cm proximal to the below elbow stimulation site in line with the ulnar groove of the elbow and the midportion of the shaft of the humerus in the axilla.

S4: The axilla stimulation site is located not less than 10 cm proximal to the above elbow site at the midpoint of the shaft of the humerus in the axilla.

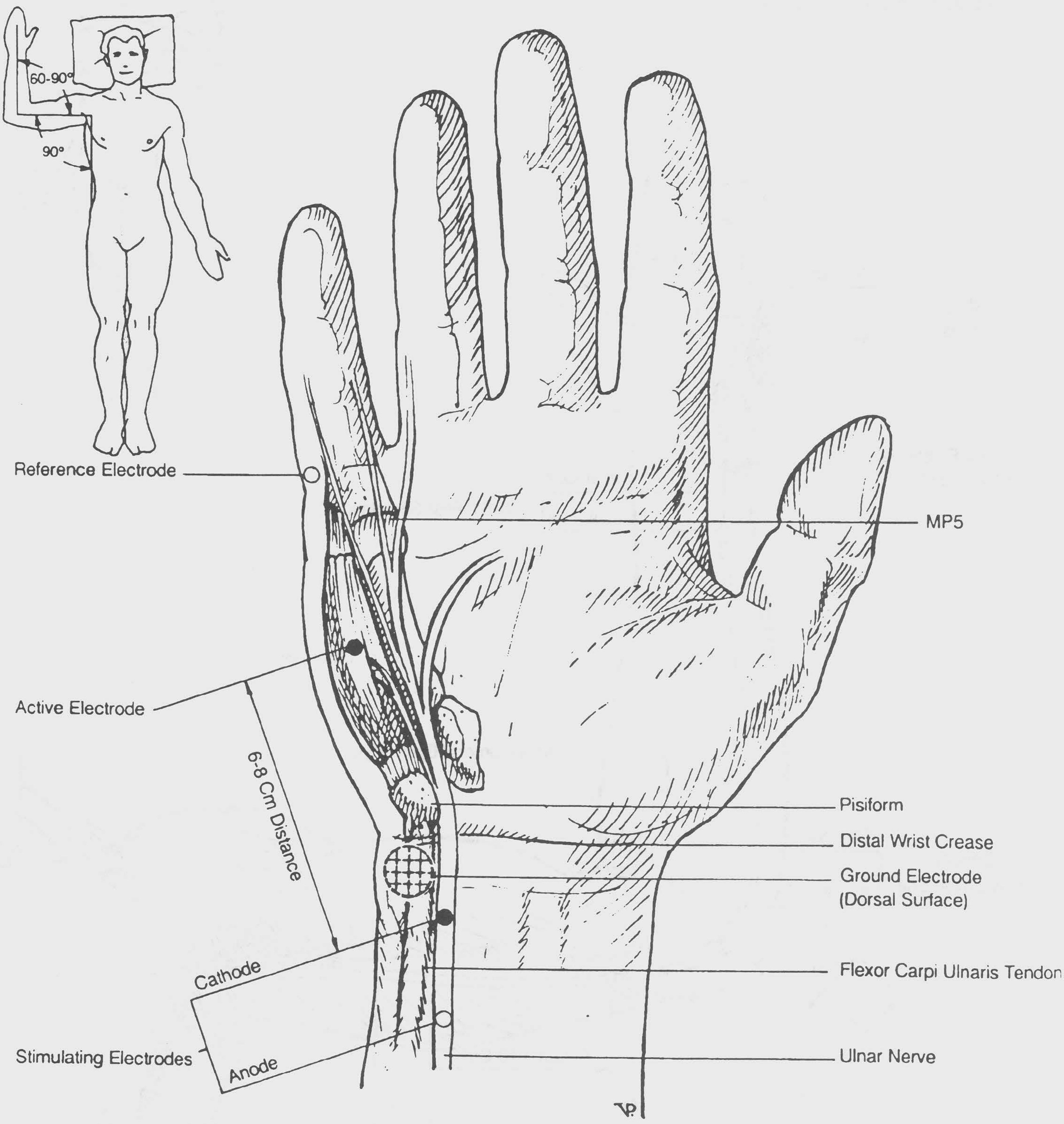
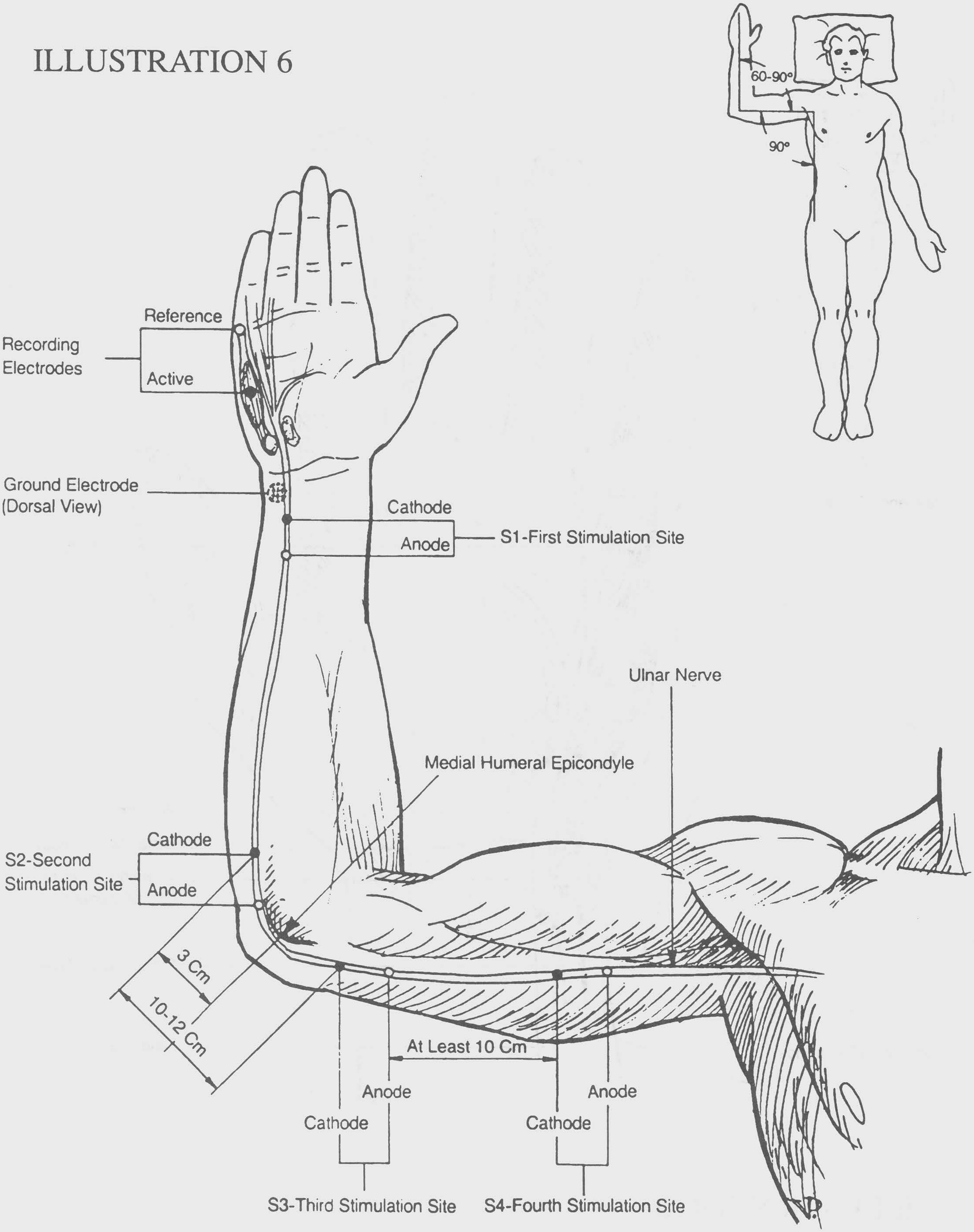


ILLUSTRATION 5

ILLUSTRATION 6



TECHNICAL COMMENTS:

Evoked muscle action potential responses from all four sites **should** be similar in waveform, amplitude, and duration of response.

Wrist stimulation voltage and/or stimulus pulse duration should be increased gradually and monitored carefully as high voltage/long pulse width stimulation at the wrist may volume conduct to the adjacent median nerve at the wrist, eliciting a volume conducted median nerve response.

The upper extremity should be maintained in the same standard position while performing the test and measuring segmental distances.

A major source of error in performing segmental studies is stimulation below the elbow and across the elbow. The below elbow stimulation site must allow access to the ulnar nerve **BEFORE** it enters the flexor carpi ulnaris muscle in the forearm. It is important to select an above elbow stimulation site not less than 10 cm proximal to the below elbow stimulation site.

The above elbow stimulation may best be accomplished by positioning the stimulating electrodes at the midhumeral area just posterior to the medial intermuscular septum. Care should be taken not to stimulate too anteriorly (causing contraction of the biceps muscle via direct stimulation and/or stimulation of the median nerve) or posteriorly (causing contraction of the triceps or failure to stimulate the ulnar nerve).

Ulnar Sensory (Orthodromic)

Electromyograph Instrument Parameters:

Filter Settings/Frequency Response: 20 Hz - 2,000 Hz
Sweep Speed: 1 - 2 milliseconds/Division
Sensitivity/Gain: 5 - 10 microvolts/Division

Patient Position: (Illustration 7) The patient is positioned supine with the arm abducted to 45 degrees, the forearm is fully supinated, palm up, and the wrist is in a neutral position with the fingers slightly flexed in a relaxed, ''resting'' position.

Electrode Placement: (Illustration 7)

Active (Recording) Electrode: The active recording electrode will be positioned directly over the cathode (distal) stimulating site used for evoking the ulnar motor response at the wrist. (Refer to Illustration 5)

Reference Electrode: The reference electrode will be positioned 3 cm proximal to the active electrode. This electrode will be positioned directly over the anode (proximal) stimulating site used for evoking the ulnar motor response at the wrist. (Refer to Illustration 5)

Ground Electrode: The ground electrode should be positioned on the dorsum of the hand between the active and stimulating electrodes.

Electrostimulation: (Illustration 7)

Percutaneous electrostimulation is performed as follows:

Stimulation is applied over the digital nerve via electrodes attached to the little (5th) finger. The cathode is positioned at or about the midpoint of the proximal phalanx of the little finger. The anode is positioned at or about the distal interphalangeal joint line of the little finger so that a distance of not less than 10 cm, but not more than 14 cm is maintained between the stimulating cathode on the digit and the active electrode at the wrist.

TECHNICAL COMMENTS:

A low stimulation intensity is usually adequate to elicit an orthodromic sensory response.

The possibility of obtaining a spurious motor response is decreased using the orthodromic technique.

Motor response and volume conduction effects may be lessened by decreasing electrostimulation intensity and/or decreasing pulse width duration of the applied electrostimulation.

Special Concern: Care must be taken to maintain a separation between the stimulating cathode and anode on the little finger. Do not allow conducting gel to bridge this interelectrode space.

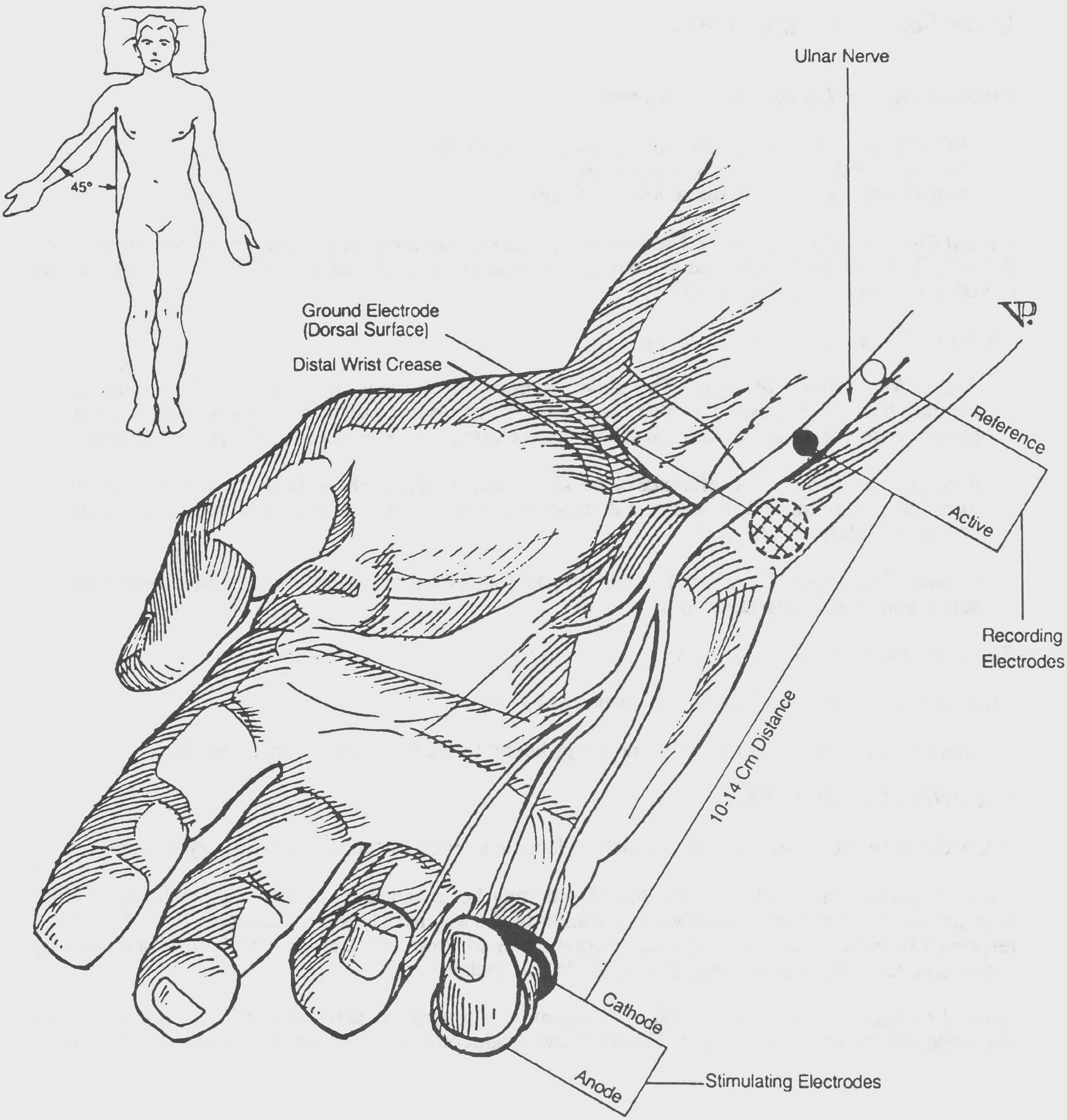


ILLUSTRATION 7

Ulnar Sensory (Antidromic)

Electromyograph Instrument Parameters:

Filter Settings/Frequency Response: 20 Hz - 2,000 Hz
Sweep Speed: 1 - 2 milliseconds/Division
Sensitivity/Gain: 5 - 20 microvolts/Division

Patient Position: (Illustration 8) The patient is positioned supine with arm abducted approximately 45 degrees. The forearm is supinated, palm up, the wrist is in a neutral position and the fingers are slightly flexed in a relaxed, ''resting'' position.

Electrode Placement: (Illustration 8)

Active (Recording) Electrode: The active recording electrode is attached to the little finger at the midpoint of the proximal phalanx of the little finger so that a distance of not less than 10 cm, but not more than 14 cm is maintained between the stimulating electrode and the active electrode.

Reference Electrode: The reference electrode is positioned at or about the distal interphalangeal joint line of the little finger so that a distance of not less than 3 cm is maintained between the active and reference electrode.

Ground Electrode: The ground should be positioned on the dorsum of the hand between the active and stimulating electrodes.

Electrostimulation: (Illustration 8)

Percutaneous electrostimulation is performed as follows:

Stimulation is performed at the wrist, medial or lateral to the flexor carpi ulnaris tendon.

TECHNICAL COMMENTS:

A low electrostimulation intensity is usually adequate to elicit the antidromic sensory response.

Motor response and volume conduction effects may be lessened by decreasing electrostimulation intensity and/or decreasing pulse width duration of the applied electrostimulation. (NOTE: Motor responses from hand muscles and volume conduction are more of a technical problem when utilizing antidromic techniques than when using orthodromic techniques.)

Special Concern: Care must be taken to maintain a separation between the active and reference electrodes on the little (5th) finger. Do not allow conducting gel to bridge this interelectrode space.

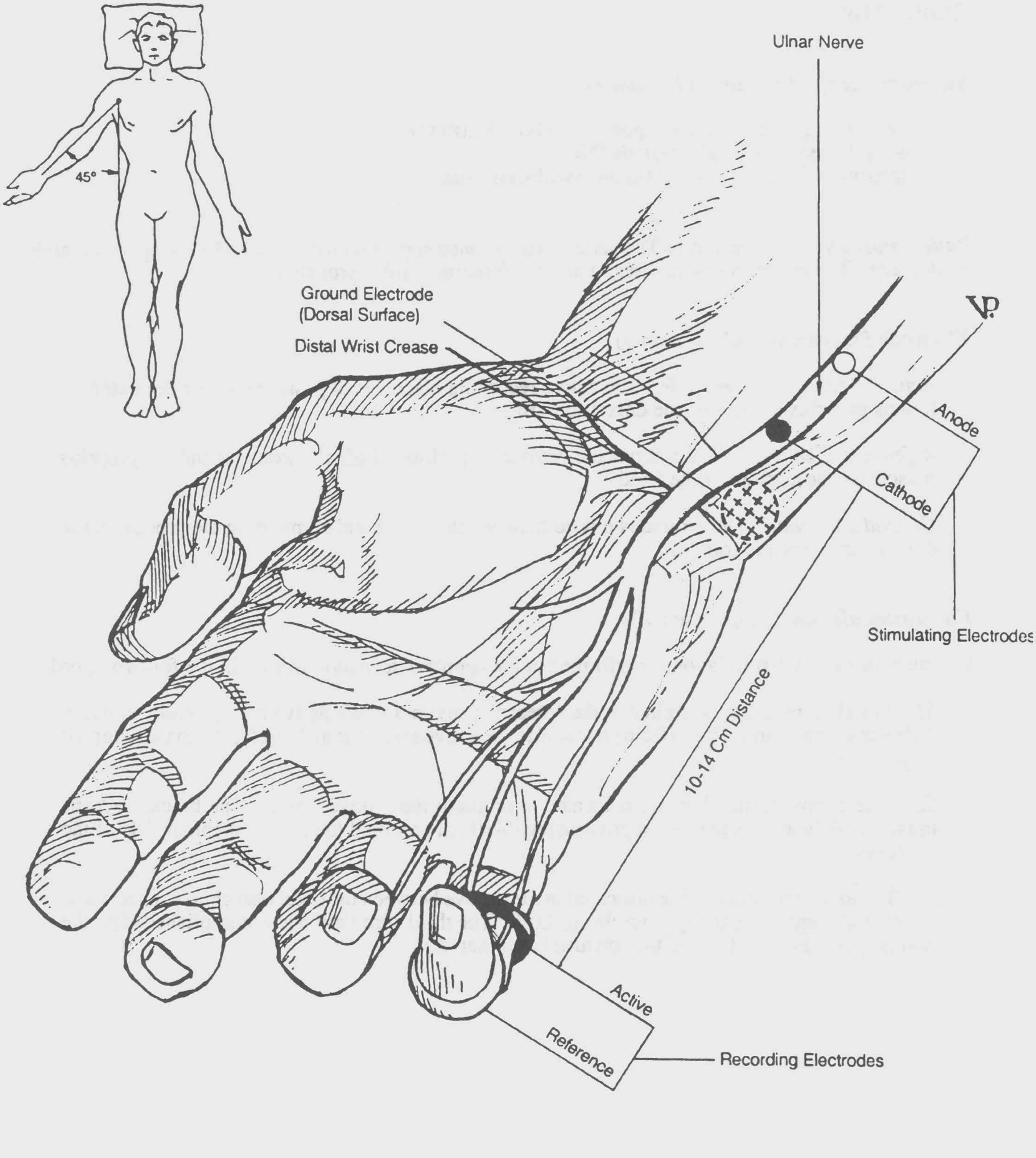


ILLUSTRATION 8

Radial Motor

Electromyograph Instrument Parameters:

Filter Settings/Frequency Response: 10 Hz - 10,000 Hz
Sweep Speed: 2 - 5 milliseconds/Division
Sensitivity/Gain: 1,000 - 5,000 microvolts/Division

Patient Position: (Illustration 9) The patient is positioned supine with the arm abducted approximately 45 degrees. The elbow is slightly flexed and the forearm is fully pronated.

Electrode Placement: (Illustration 9)

Active (Recording) Electrode: The active recording electrode is positioned over the extensor indicis proprius muscle on the dorsal forearm.

Reference Electrode: The reference electrode is positioned off the extensor indicis proprius muscle on the dorsum of the hand.

Ground Electrode: The ground is placed between the active and stimulating electrodes on the dorsal surface of the forearm.

Electrostimulation: (Illustration 10)

Percutaneous electrostimulation is performed at the appropriate anatomic sites in the following order:

S1: Distal stimulation is applied at the forearm, proximal to the active and ground electrode. This site is approximately 8-10 cm proximal to the active electrode and just lateral to the extensor carpi ulnaris muscle.

S2: The elbow stimulation site is located at or about the groove between the brachioradialis muscle and the biceps tendon, approximately 6-10 cm proximal to the lateral epicondyle of the humerus.

S3: The axilla stimulation site is located in the groove between the coracobrachialis muscle and the medial edge of the triceps muscle. (NOTE: The third stimulation is accomplished after the arm is externally rotated and the forearm is supinated.)

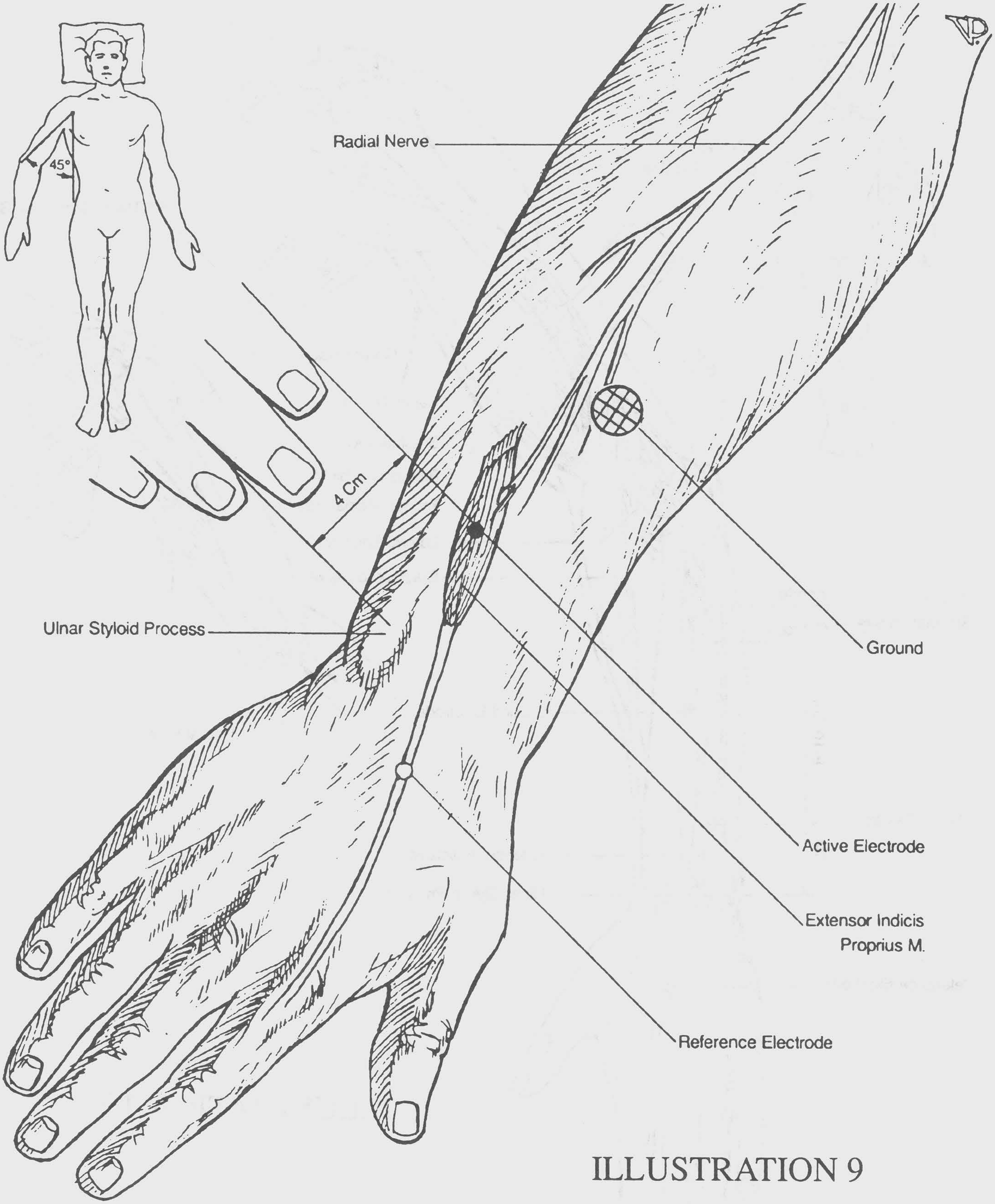


ILLUSTRATION 9

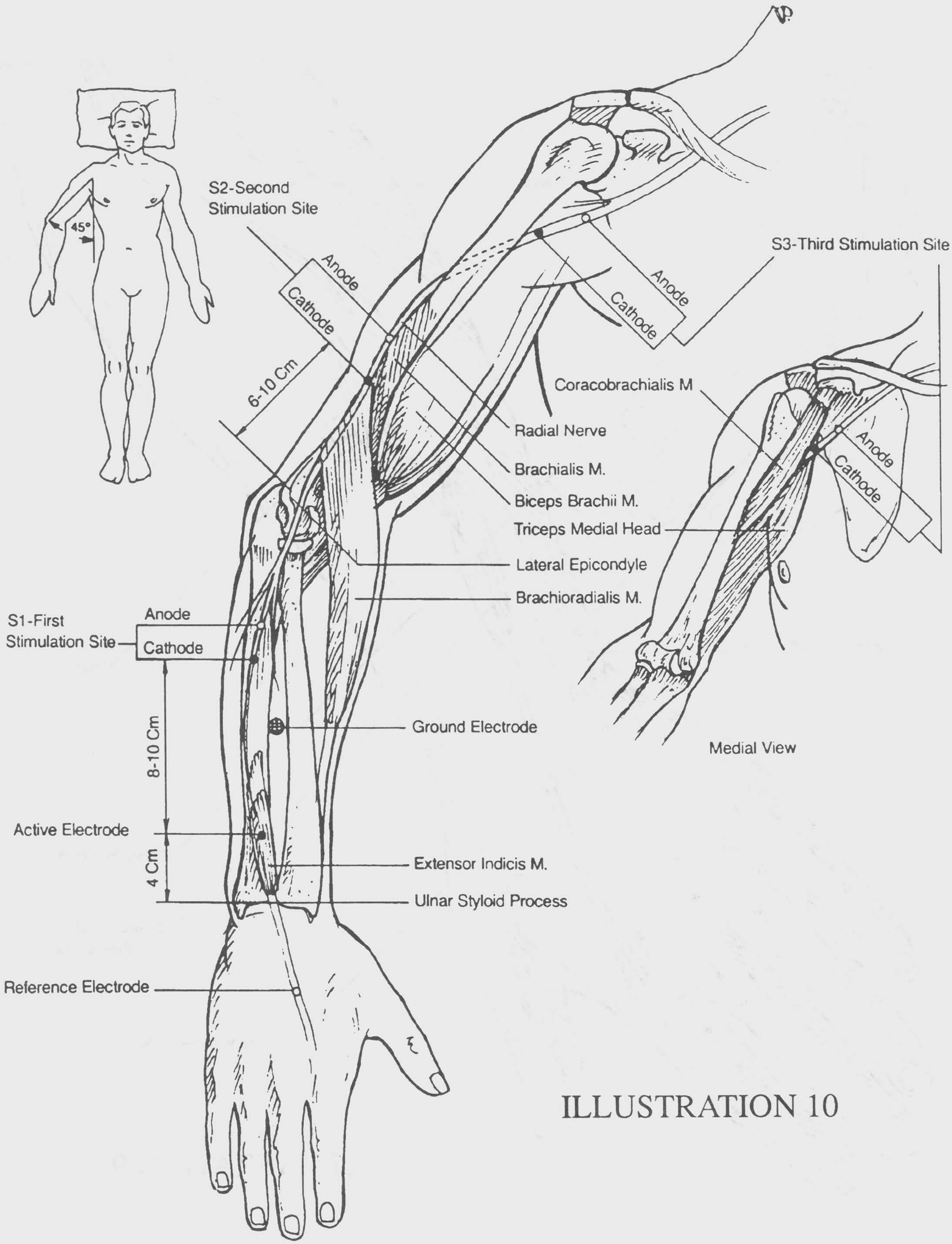


ILLUSTRATION 10

TECHNICAL COMMENTS:

This is a technically difficult test to perform. Surface or needle active (recording) electrodes may be used, but in either case it is crucial to obtain similar evoked responses from all stimulation sites. When using surface electrodes it is common for the response to have an initial positive deflection. If so, this should be obtained at all sites for valid calculations. Then the latency is measured at the same place for all three waveforms.

Any radial nerve innervated distal extensor muscle of the upper extremity may be used as a recording site. The extensor indicis proprius is the most distal. To localize this muscle it should be palpated and the function during extension of the index finger should be evaluated.

Superficial Radial Sensory (Antidromic)

Electromyograph Instrument Parameters:

Filter Settings/Frequency Response: 20 Hz - 2,000 Hz
Sweep Speed: 1 - 2 milliseconds/Division
Sensitivity/Gain: 5 - 20 microvolts/Division

Patient Position: (Illustration 11) The patient is positioned supine with the arm abducted to approximately 45 degrees. The elbow is extended and the forearm is in a resting, neutral (mid-range supination and pronation). The thumb is pointed toward the ceiling.

Electrode Placement: (Illustration 11)

Active (Recording) Electrode: The active recording electrode is positioned over the portion of the nerve which can be palpated over an extended extensor pollicis longus tendon at or about the dorsal-radial aspect of the wrist.

Reference Electrode: The reference electrode is positioned distal to the active electrode on the dorsum of the hand.

Ground Electrode: The ground electrode is placed between the active and stimulating electrodes on the dorsal surface of the forearm.

Electrostimulation: (Illustration 11)

Percutaneous electrostimulation is performed as follows:

Distal stimulation is applied along the dorsolateral border of the radius, lateral to the cephalic vein, not less than 10 cm proximal to the active (recording) electrode.

TECHNICAL COMMENTS:

The extensor pollicis longus tendon forms the medial border of the anatomic ''snuff box''. By running the examiner's index fingernail along this tendon distal to the wrist, the superficial radial sensory nerve can be palpated. The active (recording) electrode should be placed at the intersection of the tendon and nerve.

Stimulation of the superficial radial nerve is usually accomplished using a low voltage, short duration stimulus. Stronger stimulation may spread to the anterior interosseous branch of the median nerve and produce an unwanted motor response or a volume conducted artifact. When this occurs, slight flexion of the distal phalanx of the thumb will be seen.

The subject may be able to help locate the nerve by reporting a ''tingling'' sensation along the dorsum of the thumb, index and/or second finger when a stimulus is delivered.

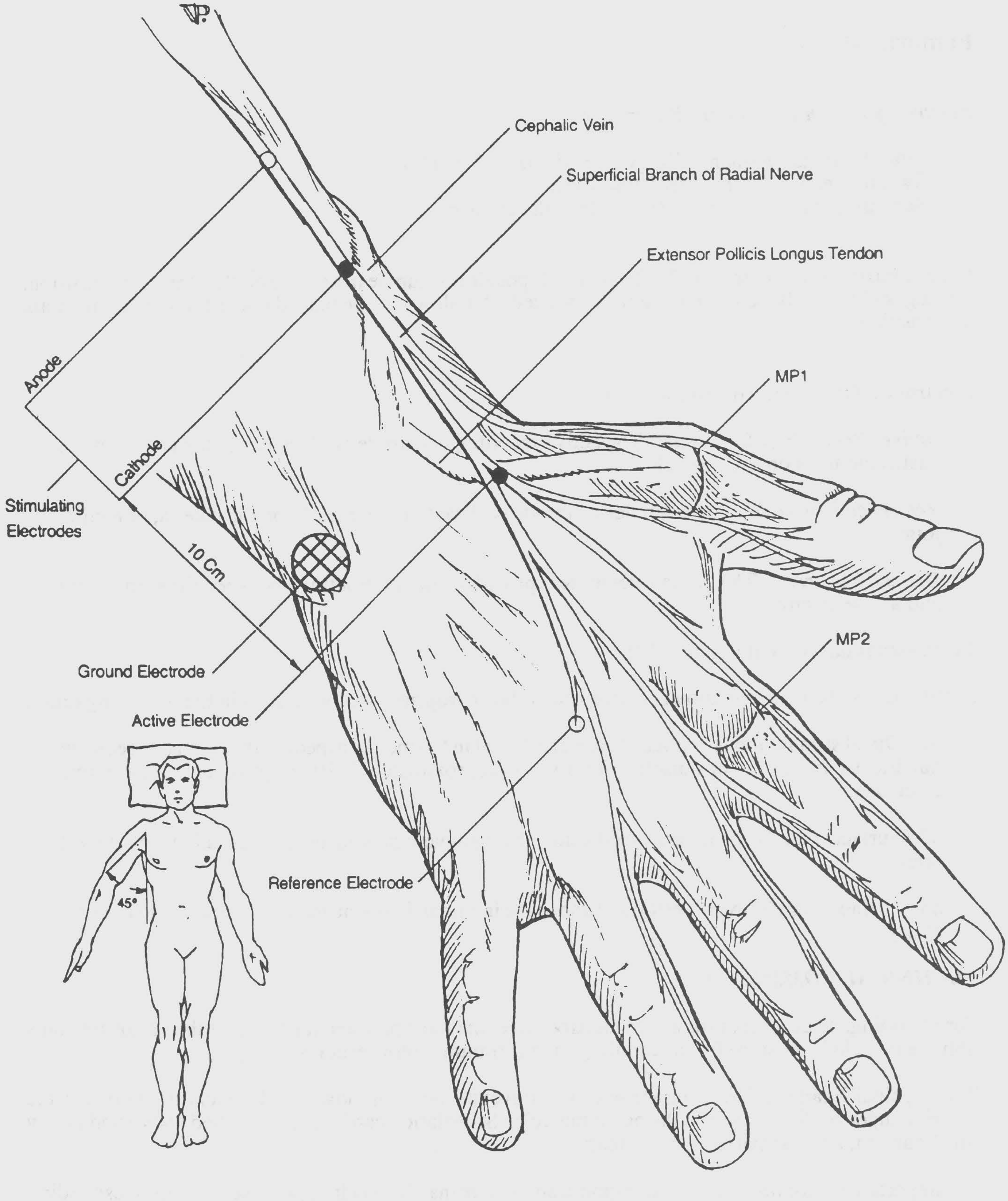


ILLUSTRATION 11

Femoral Motor

Electromyograph Instrument Parameters:

Filter Settings/Frequency Response: 10 Hz - 10,000 Hz
Sweep Speed: 2 - 5 milliseconds/Division
Sensitivity/Gain: 1,000 - 5,000 microvolts/Division

Patient Position: (Illustration 12) The patient is positioned supine in a comfortable, ''resting'' position. The leg is slightly abducted and externally rotated. A pillow may be placed under the knee to maintain this position.

Electrode Placement: (Illustration 12)

Active (Recording) Electrode: The active recording electrode is placed over the center of the vastus medialis oblique muscle.

Reference Electrode: The reference electrode is placed <u>off</u> the muscle on the patella, or medial joint line.

Ground Electrode: The ground electrode is placed on the anterior thigh between the stimulating and active electrodes.

Electrostimulation: (Illustration 12)

Percutaneous electrostimulation is performed at the appropriate anatomic sites in the following order:

S1: Distal stimulation is applied at Hunter's Canal in the medial aspect of the thigh between the quadriceps and adductor muscles. This site is approximately 8-10 cm proximal to the active electrode.

S2: Surface stimulation is performed below the inguinal ligament and just lateral to the femoral artery.

S3: Surface stimulation is performed above the inguinal ligament and just lateral to the femoral artery.

TECHNICAL COMMENTS:

For recording, placement of the active electrode over the most prominent portion of the vastus medialis oblique muscle is most useful in recording the maximum motor response.

The inguinal ligament forms an arc with its convexity pointing downward, extending between the anterior superior iliac spine and the pubic tubercle. Stimulation can be accomplished above and below this ligament, approximately 4-8 cm apart.

It is important to monitor the clinical response and ensure that the quadriceps muscle group is responding to the stimulus and that patellar movement is evident.

Conduction velocities should be calculated across the long segments; i.e., below inguinal ligament to Hunter's Canal and above inguinal ligament to Hunter's Canal.

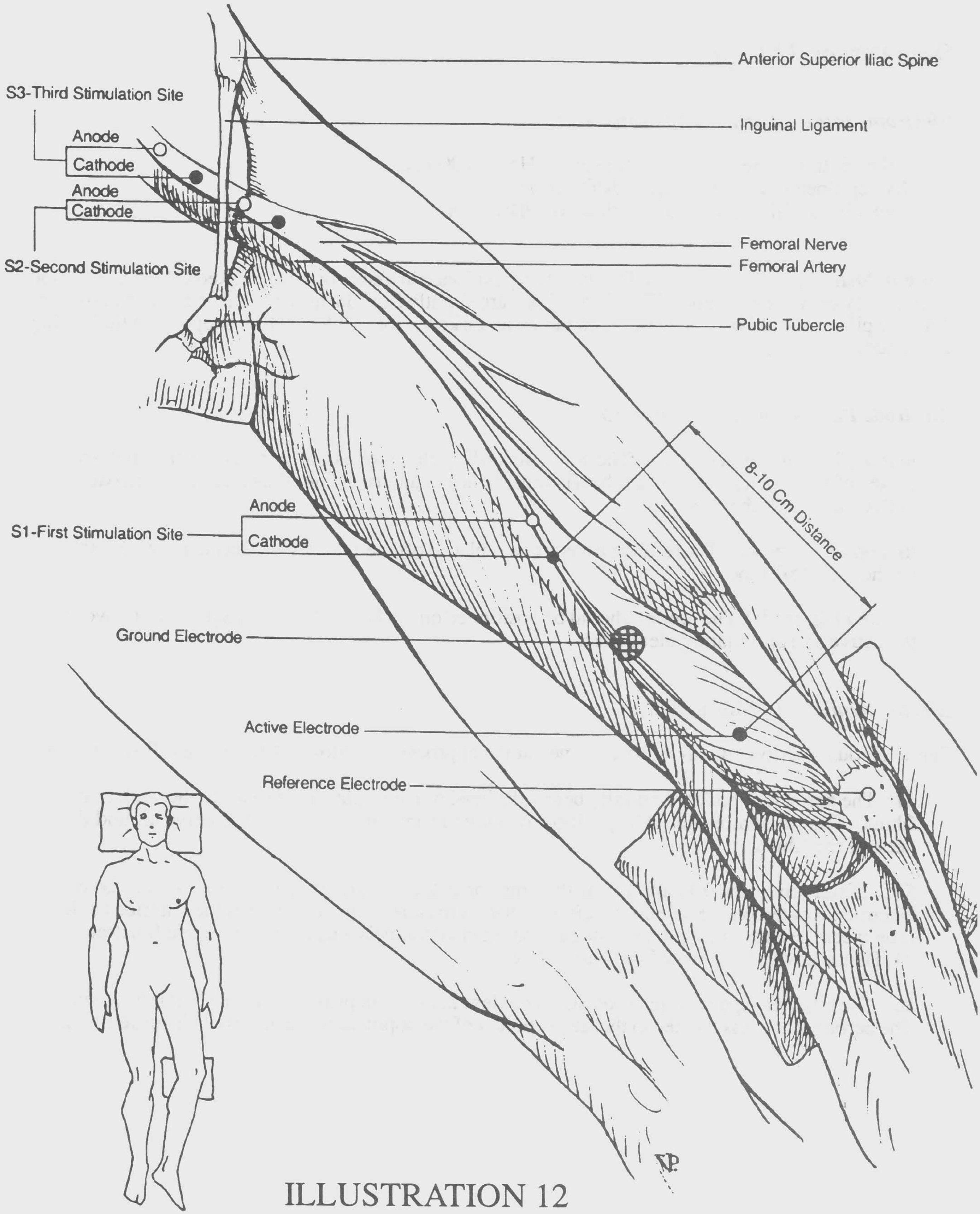


ILLUSTRATION 12

Deep Peroneal Motor

Electromyograph Instrument Parameters:

Filter Settings/Frequency Response: 10 Hz - 10,000 Hz
Sweep Speed: 2 - 5 milliseconds/Division
Sensitivity/Gain: 500 - 2,000 microvolts/Division

Patient Position: (Illustration 13) The patient is positioned in a comfortable, relaxed sidelying position facing away from the examiner. The hip and knee are slightly flexed with the ankle in a neutral position. A single pillow should be placed between the patient's knees for comfort and to support the limb being examined.

Electrode Placement: (Illustration 13)

Active (Recording) Electrode: The active recording electrode is positioned over the anatomic center of the extensor digitorum brevis muscle in the anterior, lateral aspect of the proximal midtarsal area of the foot.

Reference Electrode: The reference electrode is placed off the extensor digitorum brevis muscle on the little (5th) toe.

Ground Electrode: The ground should be positioned on the lateral or medial malleolus between the active and stimulating electrodes.

Electrostimulation: (Illustration 14)

Percutaneous electrostimulation is performed at the appropriate anatomic sites in the following order:

S1: The nerve is stimulated initially below the head of the fibula and anterior to the neck of the fibula. The stimulator should be positioned along the anatomic course of the nerve around the neck of the fibula.

S2: Distal stimulation is applied at the anterior ankle, proximal to the center of the active electrode located on the extensor digitorum brevis muscle. The distal site at the anterior ankle is between the extensor digitorum longus and extensor hallucis longus tendons. (See Illustration 21, Distal Lower Extremity Stimulation Sites)

S3: The popliteal space stimulation site is not less than 10 cm proximal to the fibular neck site. The peroneal nerve is located in the lateral border of the popliteal space, near the biceps femoris.

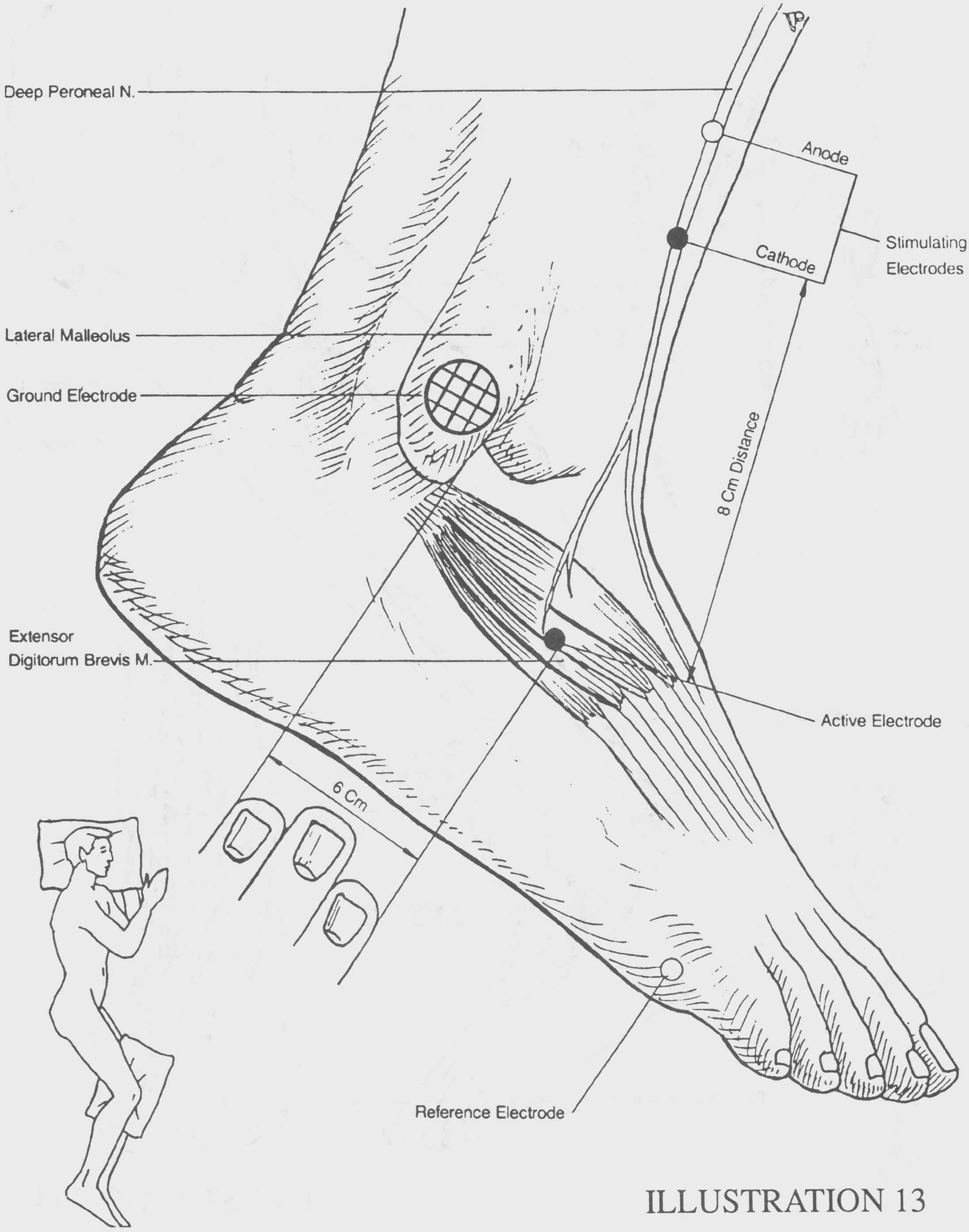


ILLUSTRATION 13

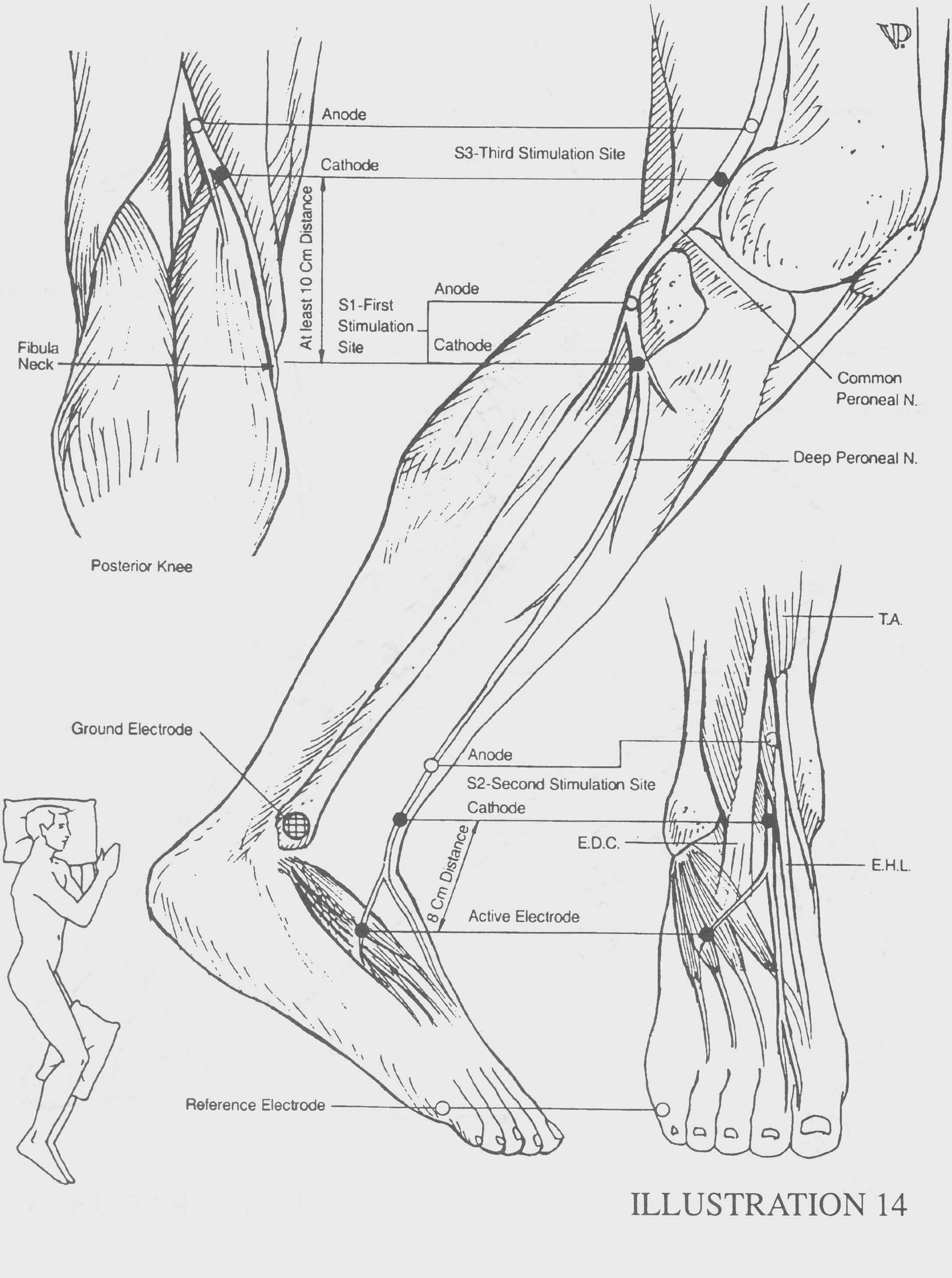


ILLUSTRATION 14

TECHNICAL COMMENTS:

Evoked muscle action potential responses from all three sites **should** be similar in waveform, amplitude, and duration of response.

When applying proximal stimulation in the popliteal fossa the clinical response in the leg/calf should be monitored to avoid volume conducted stimulation of the posterior tibial nerve. Ankle **eversion** ensures that the peroneal nerve is being stimulated while plantar flexion of the ankle indicates stimulation of the tibial nerve.

Distal stimulation is performed approximately halfway between the malleoli, lateral to the extensor hallucis longus tendon, just proximal to the level of the anterior tarsal tunnel. Occasionally the response may be improved by stimulating more laterally to the extensor digitorum longus tendon. In obese patients, or in patients with edema or induration, the ankle response may be difficult to elicit. Increasing the stimulus intensity and/or pulse width duration may overcome this difficulty.

Superficial Peroneal Sensory (Antidromic)

Electromyograph Instrument Parameters:

Filter Settings/Frequency Response: 20 Hz - 2,000 Hz
Sweep Speed: 1 - 2 milliseconds/Division
Sensitivity/Gain: 5 - 10 microvolts/Division

Patient Position: (Illustration 15) The patient is positioned in a comfortable, relaxed supine position.

Electrode Placement: (Illustration 15)

Active (Recording) Electrode: The active recording electrode is placed just above the junction of the lateral third of a line connecting the malleoli. This site may also be located at the ankle one fingerbreadth medial to the lateral malleolus.

Reference Electrode: The reference electrode is positioned 3 cm or more distal to and in line with the active electrode.

Ground Electrode: The ground electrode is placed on the crest of the anterior tibia between the active and stimulating electrodes.

Electrostimulation: (Illustration 16)

Percutaneous electrostimulation is performed as follows:

Antidromic surface stimulation is performed not less than 10 cm but not more than 14 cm proximal to the active (recording) electrode, along the anterolateral aspect of the leg, just anterior to the peroneus longus tendon.

TECHNICAL COMMENTS:

The electrostimulation point is proximal to the recording site. The stimulation site is anterior to the peroneus longus muscle and adjacent to the belly of the tibialis anterior muscle between the peroneus longus and extensor digitorum longus tendons. The superficial peroneal sensory nerve may be palpated in this area if a fingernail is rolled over the tendon of the peroneus longus muscle from a posterior to anterior direction. Several trials may be necessary to find the optimal stimulation site. The anterior border of the fibula may be used as an alternative landmark for stimulation.

The patient may be able to detect the response and report it as a ''tingling'' sensation radiating to the dorsum of the foot.

It may be necessary to use a stimulus of low voltage and short duration to avoid a motor response from adjacent muscles which can obscure the sensory response.

Signal averaging may be necessary to record low amplitude responses.

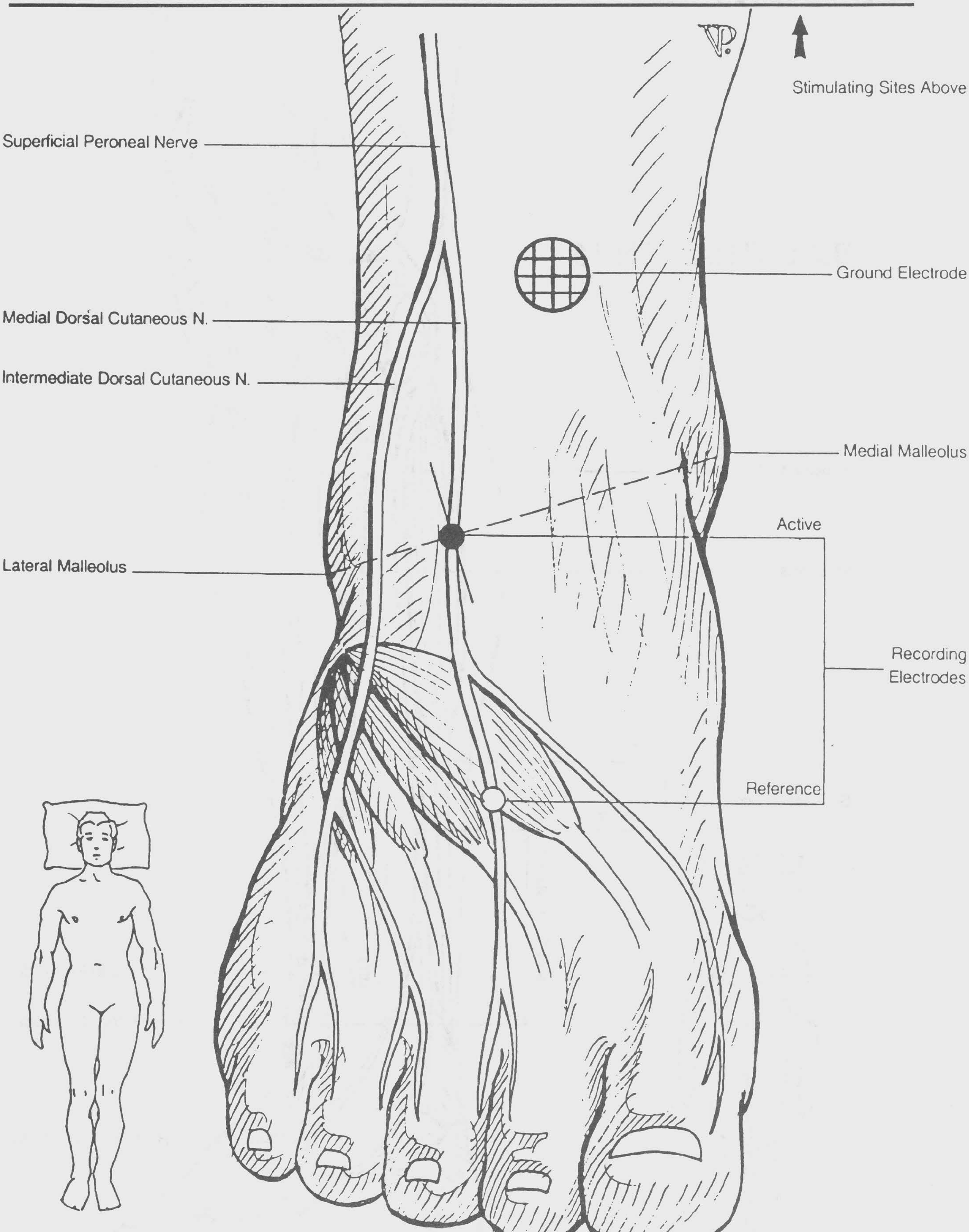
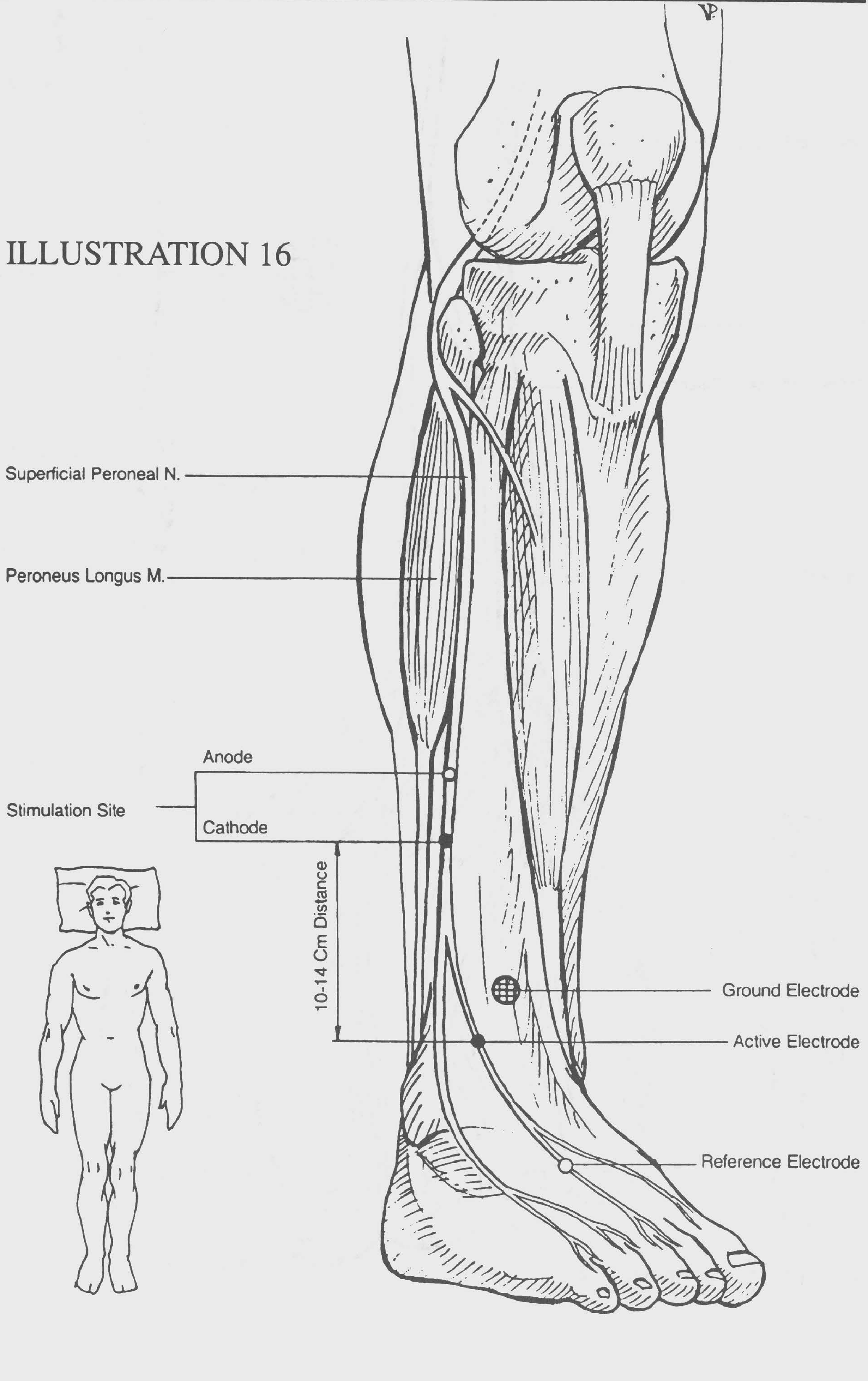


ILLUSTRATION 15

ILLUSTRATION 16



Posterior Tibial Motor

Electromyograph Instrument Parameters:

Filter Settings/Frequency Response: 10 Hz - 10,000 Hz
Sweep Speed: 2 - 5 milliseconds/Division
Sensitivity/Gain: 1,000 - 5,000 microvolts/Division

Patient Position: (Illustration 17) The patient is positioned prone with a single pillow placed under the ankles to allow slight flexion of the knees.

Electrode Placement: (Illustration 17)

Active (Recording) Electrode: The active recording electrode is positioned over the abductor hallucis muscle, 1 cm inferior (toward the plantar surface) and 1 cm distal (toward the great toe) to the navicular.

Reference Electrode: The reference electrode is positioned off the abductor hallucis muscle on the medial border of the great toe.

Ground Electrode: The ground electrode should be positioned on the medial or lateral malleolus between the active and stimulating electrodes.

Electrostimulation: (Illustration 18)

Percutaneous electrostimulation is performed at the appropriate anatomic sites in the following order:

S1: Stimulation at the ankle is performed at a point halfway between the medial malleolus and Achilles tendon, proximal to the center of the active recording electrode and proximal to the flexor retinaculum. (See Illustration 21, Distal Lower Extremity Stimulation Sites)

S2: Proximal stimulation is performed at the popliteal fossa, slightly lateral to the midline, along the flexor crease of the knee.

TECHNICAL COMMENTS:

The electrical and clinical responses should be closely monitored, especially during proximal stimulation. Care must be taken to ensure that all evoked muscle action potential responses to ankle and popliteal stimulation have similar waveforms, amplitudes, and durations of response. Ankle **plantar flexion** ensures that the tibial nerve is being stimulated while ankle eversion indicates peroneal nerve stimulation.

The waveform often exhibits an initial positive deflection. Repositioning of the active electrode on the abductor hallucis muscle will minimize but may not eliminate this problem. If the active electrode is repositioned, the distance to the stimulator must be adjusted to ensure that stimulation is proximal to the flexor retinaculum. In the event the positive deflection remains after repositioning, then accept the waveform and ensure that each subsequent stimulation site waveform has the same configuration and all latencies are marked in a consistent manner.

The prone position makes this test more convenient for the examiner.

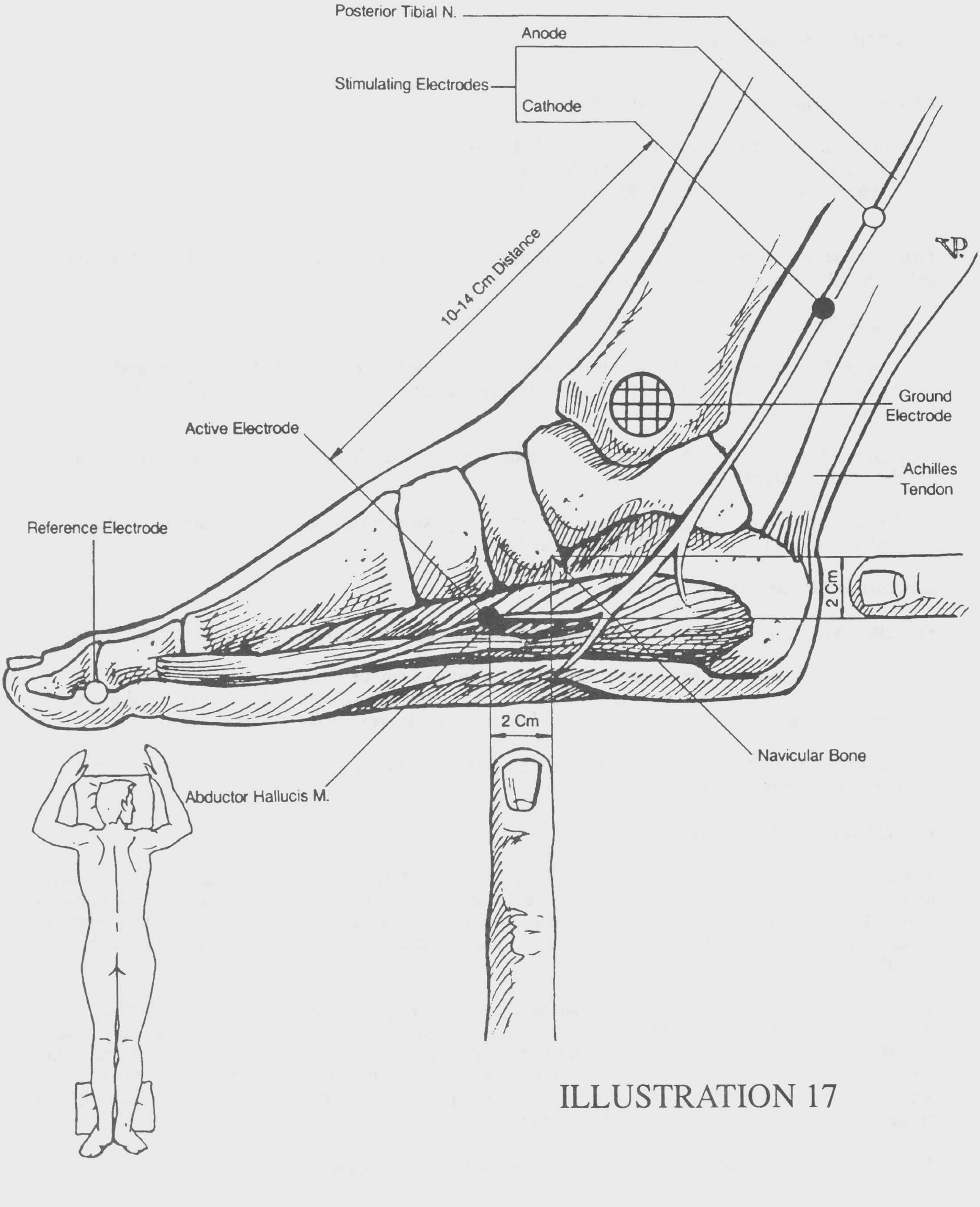


ILLUSTRATION 17

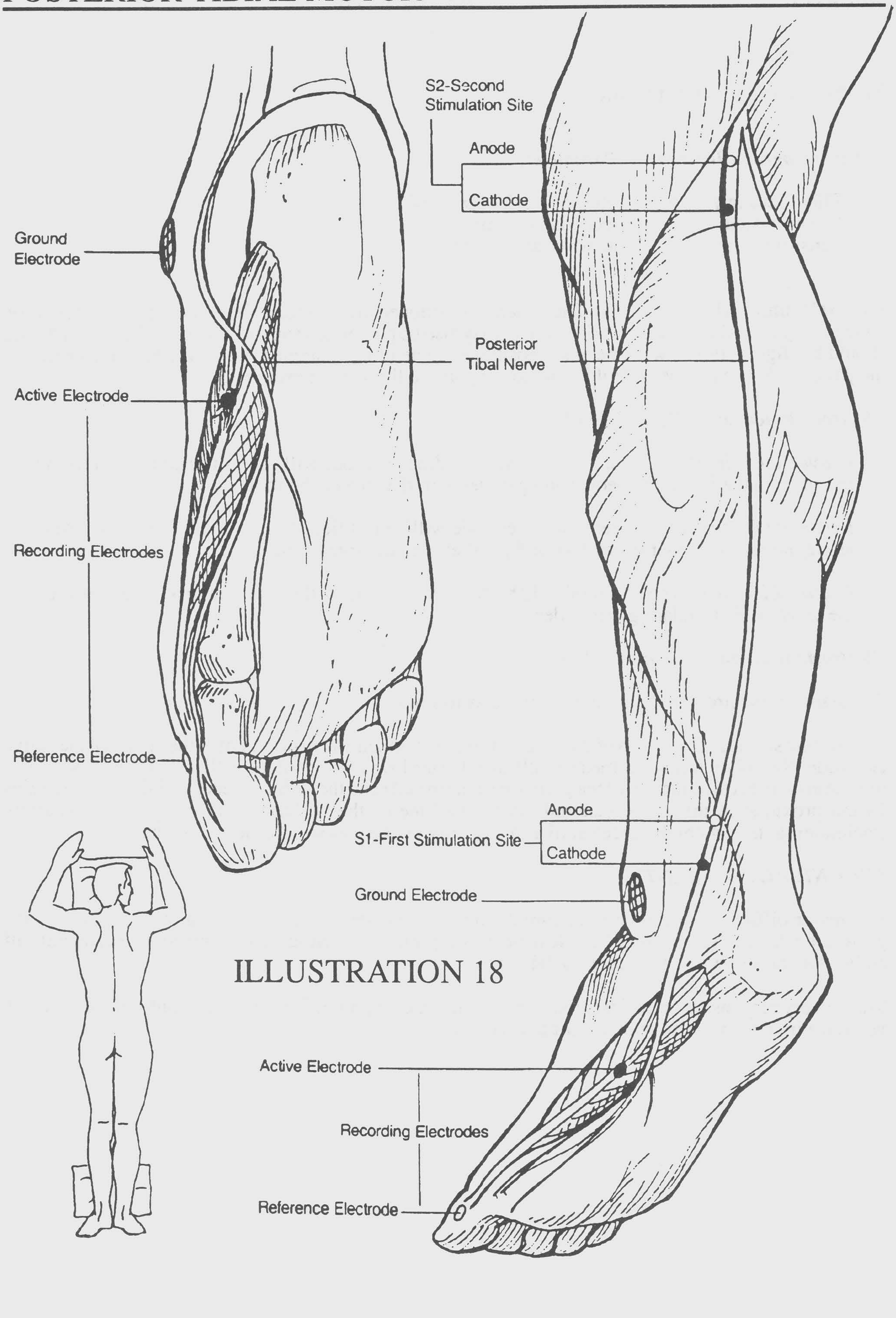


ILLUSTRATION 18

Sural Sensory (Antidromic)

Electromyograph Instrument Parameters:

Filter Settings/Frequency Response: 20 Hz - 2,000 Hz
Sweep Speed: 1 - 2 milliseconds/Division
Sensitivity/Gain: 5 - 10 microvolts/Division

Patient Position: (Illustration 19) The patient is positioned in a comfortable, relaxed sidelying position facing away from the examiner. (The patient may also be positioned supine or prone.) The hip and knee should be slightly flexed with the ankle positioned in neutral. A single pillow may be placed between the patient's knees for their comfort and to support the limb being examined.

Electrode Placement: (Illustration 19)

Active (Recording) Electrode: The active recording electrode will be positioned inferior to and in line with the lateral malleolus and parallel with the sole of the foot.

Reference Electrode: The reference electrode will be positioned distal to the active electrode along the lateral border of the foot and parallel with the sole of the foot.

Ground Electrode: The ground should be positioned on the medial or lateral malleolus between the active and stimulating electrodes.

Electrostimulation: (Illustration 19)

Percutaneous electrostimulation is performed as follows:

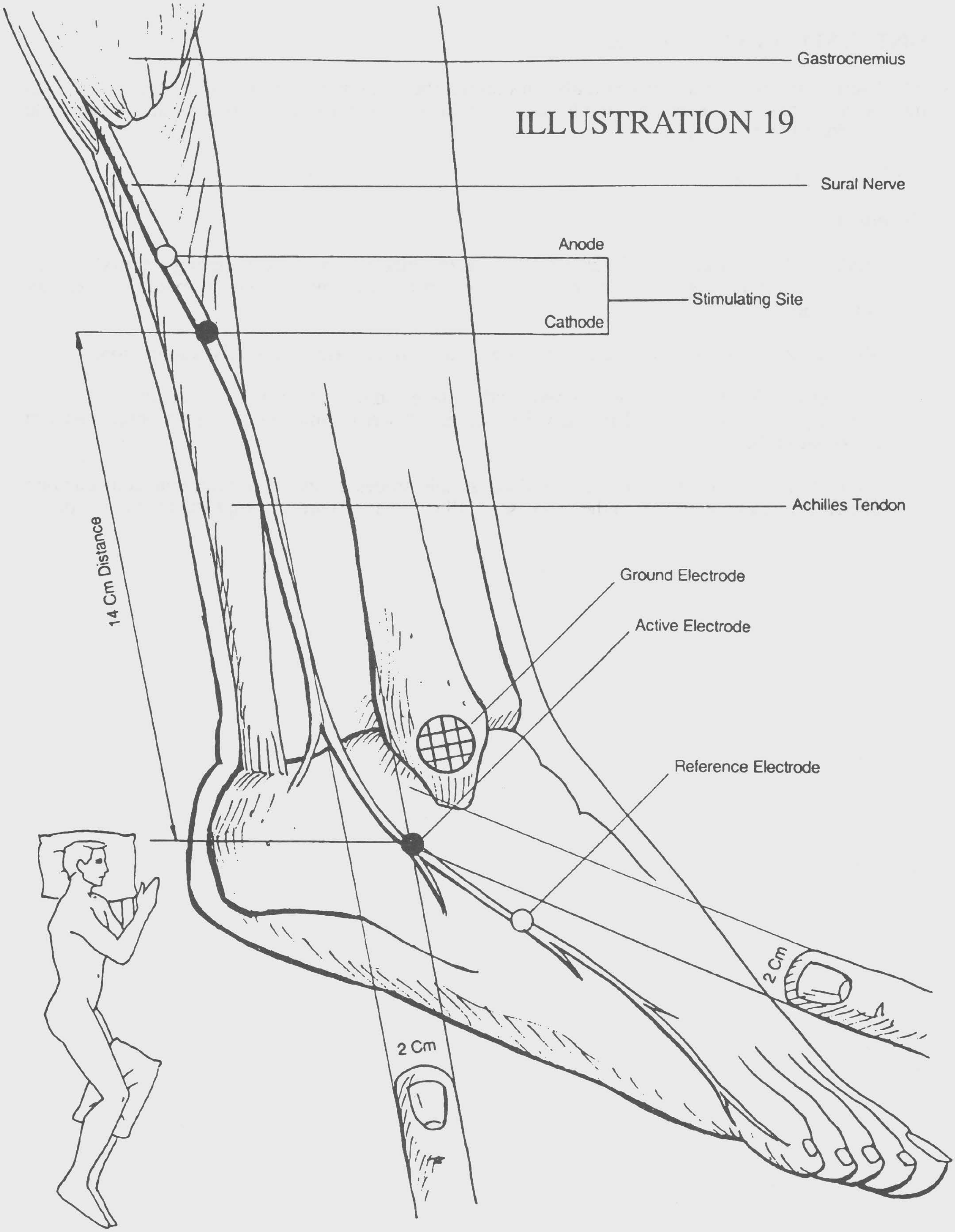
Antidromic surface stimulation of the sural nerve is performed 14 cm proximal to the center of the active electrode. Stimulation is performed slightly distal to the lower border of the bellies of the gastrocnemius muscle at or about the junction of the gastrocnemius muscle and the Achilles tendon. Stimulation begins 14 cm proximal to the active electrode in the midline of the posterior calf and proceeds laterally (maintaining the 14 cm distance) until a satisfactory evoked sensory response is obtained.

TECHNICAL COMMENTS:

The major difficulty encountered in stimulating the sural sensory nerve is locating the nerve in the posterior calf. The subject may be able to help by reporting "tingling" along the posterior, lateral calf and/or lateral foot when a stimulus is delivered.

The sensory response is often obscured by a large muscle response. This may be avoided by using a low voltage stimulus intensity with a short pulse duration.

ILLUSTRATION 19



DISTAL STIMULATION SITES

The determination of distal (wrist) stimulation sites may be accomplished in any of four methods. Each method is acceptable. The method established in individual laboratories should be standardized and held constant for all tests performed.

WRIST: (Illustration 20)

Examples

Method #1: Measure exact distance from the active electrode to the stimulating electrode; i.e., 8 cm for median and ulnar motor nerve stimulation and 14 cm for median and 12 cm for ulnar sensory stimulation.

Method #2: Measure exactly 2 cm proximal to the wrist crease for all wrist stimulations.

Method #3: Secure the ground electrode with 1" tape and extend this tape around the wrist. This tape is placed just proximal to the wrist crease. All wrist stimulations are accomplished just proximal to the tape.

Method #4: Palpate the radial and ulnar distal styloid processes and mark a line connecting a point one fingerbreadth proximal to the processes. All stimulations are accomplished from this point.

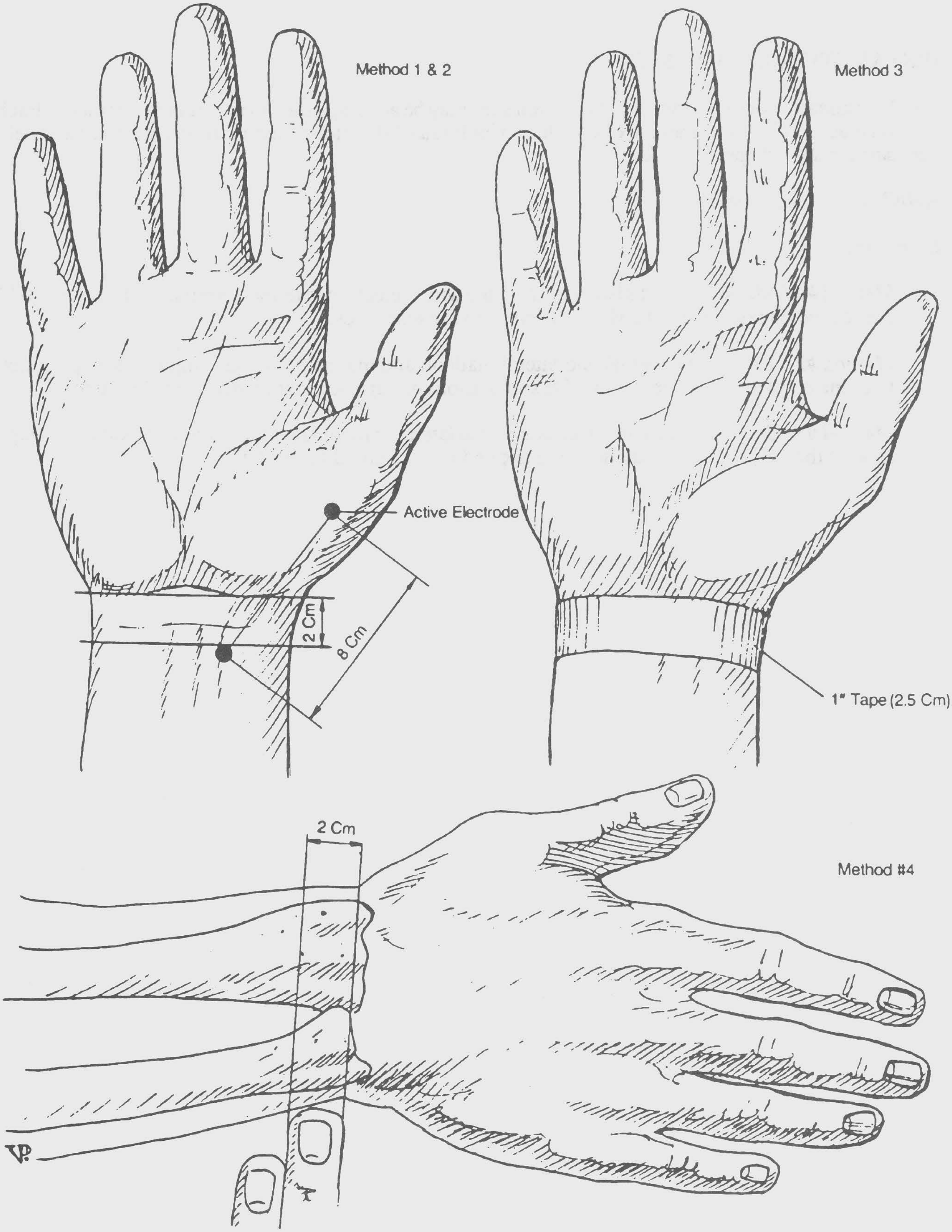


ILLUSTRATION 20

DISTAL STIMULATION SITES

The determination of distal (ankle) stimulation sites may be accomplished in any of three methods. Each method is acceptable. The method established in individual laboratories should be standardized and held constant for all tests performed.

ANKLE: (Illustration 21)

Examples

Method #1: Measure exact distances from the active electrodes to the stimulating sites; i.e., 8-12 cm for motor responses and 10-14 cm for sensory responses.

Method #2: Palpate the medial and lateral malleoli and mark a point one fingerbreadth proximal to a line connecting the malleoli. All stimulations are applied just proximal to this site.

Method #3: Secure the ground electrode on the lateral malleolus with 1" tape and extend this tape around the ankle. All stimulations are applied just proximal to this site.

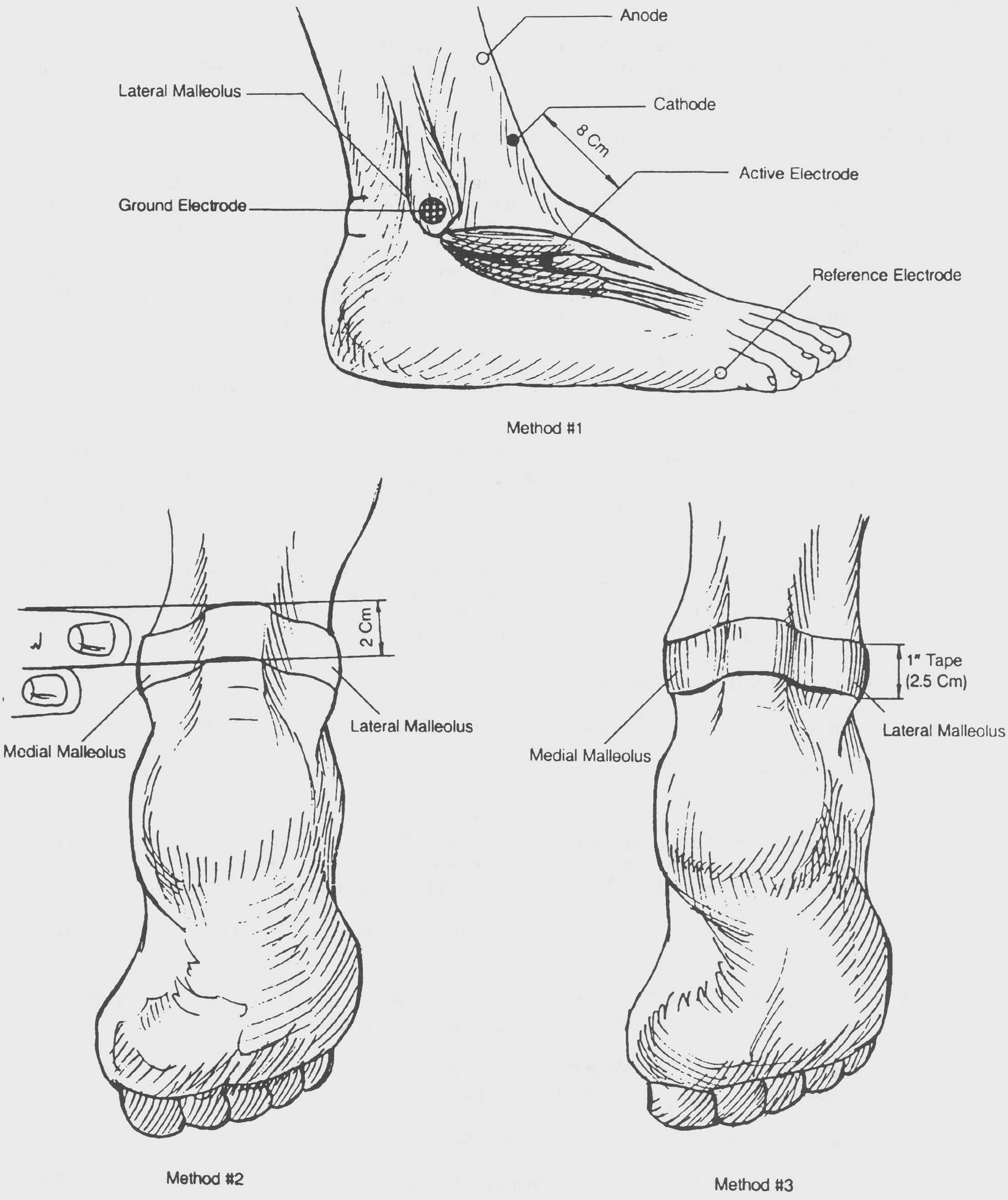


ILLUSTRATION 21

TROUBLESHOOTING

When performing nerve conduction velocity studies you sometimes will get no response. Because such nonresponse can result from many causes, a careful step-by-step analysis of the nerve stimulation technique is necessary.

Motor Nerve Stimulation But No Response Is Seen

1. Check to be sure the stimulator is delivering an impulse. Most patients will feel the stimulus, but you can check it with your finger while increasing the voltage. If no stimulus is being delivered, then check the switches to see if they are set properly; remove the stimulator wires from their sockets and reinsert them properly. Next, check the stimulator wires for a defect, first visually and then electrically with an ohmmeter to determine whether the wire has electrical continuity. If after following these steps you find nothing amiss, then the problem lies within the stimulator. It must be tested by an electronics specialist.

2. If the stimulator is found to be working, then check the anatomical location of the stimulation electrodes. Occasionally a beginner will place the electrodes in the wrong area or over the wrong nerve.

3. If the stimulating electrodes are in the proper position, then check the amount of gel under the anode and cathode. Too much gel or patient sweat will create an anode-cathode bridge and will render nerve stimulation impossible. Little or no gel will deliver a SUBmaximal stimulus strength.

4. If the stimulating electrodes are in the proper position, then gradually increase the stimulus strength to the full output of the stimulator. If there is still no response, increase the pulse width duration of the stiumlus slowly. This procedure is often necessary in extremely obese persons or in those patients with edema or severe nerve disease.

Muscle Contraction But No Evoked Response

1. Check the switch controlling the input on the preamplifier to be sure it is in the "ON" position.

2. Confirm that the recording electrodes are over the motor-point area of the muscle being studied.

3. Remove excessive gel which can cause a bridge between the active and reference electrodes. This will result in either a very small or no response. Add gel wherever it is insufficient under the recording electrodes. (Insufficient gel can have the same effect as too much gel.)

4. Check the recording electrodes and connecting wires with an ohmmeter to ensure electrical continuity.

5. On a multichannel EMG machine, if you still get no response, check the connections between the preamplifier and amplifier to ensure proper channel connections.

6. Check the ground lead. When the ground is not in contact with the subject, the trace on the video display apparatus will be off the screen.

7. Ensure that the evoked response trace is centered on the video display screen.

8. Set the video display screen sweep speed so that the expected response is on the screen. (Try using a slower sweep speed, 5 or 10 msec/div, to see if the response is off the screen.)

9. In the event that the evoked response is of low voltage, increase the sensitivity by decreasing the gain on the amplifier to adequately display the evoked response trace on the video display apparatus.

Stimulus Artifact

If the record shows a large stimulus artifact, look into these possibilities:

1. The ground is not functioning. Be sure that the ground electrode gel is adequate. Ensure that the ground is in contact with the subject. Be sure that the ground electrode is located **BETWEEN** the stimulating and recording electrodes. Test the electrode wire with an ohmmeter to ensure its electrical continuity.

2. A recording electrode is defective. Again, be sure the electrode gel is adequate, the electrodes are on tightly, and the electrode and wire are checked with an ohmmeter for a defect. Defective electrodes should be repaired or replaced.

3. Check the stimulating electrodes to ensure that there is no electrode gel bridge between the anode and cathode electrodes.

4. Make sure recording and stimulating electrode connection cables are not crossed and touching.

Abnormal Recorded Potential

If the recorded potential voltage is abnormal, follow these steps:

1. Move the stimulating electrodes in small increments until the best response is obtained. Be sure that the stimulus strength is supramaximal (submaximal stimulus may appear to give a decremental type of response, especially if the stimulator is not directly over the nerve).

2. Check the recording electrodes to ensure they are over the appropriate muscle and that the amount of electrode gel is adequate.

Initial Positive Deflection

If the evoked response seen on the display screen has an initial positive deflection, do the following, except for the posterior tibial and radial nerves, where recording from the abductor hallucis often results in an initial positive deflection.

1. Move the active recording electrode until it is over the motor point of the muscle.

2. Make sure that the appropriate nerve is being stimulated and that there is no volume conduction (crossover) to another, faster conducting nerve (which can be checked by stimulating that other nerve).

3. Consider whether a crossover is present that would stimulate more remote muscles sooner than the one being tested.

4. Check for reverse electrode connections to preamplifier input jacks.

GLOSSARY

The Glossary on the following pages is reprinted from ***AAEE Glossary of Terms in Clinical Electromyography****, Second Edition, AAEE 1987, with permission of the American Association of Electromyography and Electrodiagnosis, Copyright 1987. The Glossary was compiled by the AAEE Nomenclature Committee:*

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Charles K. Jablecki, Chairman
Charles F. Bolton, M.D.
Walter G. Bradley, D.M.
William F. Brown, M.D.
Fritz Buchthal, M.D.
Roger Q. Cracco, M.D.
Ernest W. Johnson, M.D.
George H. Kraft, M.D.
Edward H. Lambert, M.D., Ph.D.
Hans O. Lüders, M.D., Ph.D.
Dong M. Ma, M.D.
John A. Simpson, M.D.
Erik V. Stalberg, M.D., Ph.D.

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Action Potential - (Abbr. AP). Strictly defined, the all-or-none, self-propagating, nondecrementing voltage change recorded from an excitable cell. The source of the action potential should be specified, e.g. nerve (fiber) action potential or muscle (fiber) action potential. Commonly, the term refers to the nearly synchronous summated action potentials of a group of cells, e.g., Motor Unit Potential. To avoid ambiguity in reference to the recording of nearly synchronous summated action potentials of nerve and muscle as done in nerve conduction studies, it is recommended that the terms Compound Nerve Action Potential and Compound Muscle Action Potential be used.

Active Electrode - See Recording Electrode.

Amplitude - With reference to an Action Potential, the maximum voltage difference between two points, usually baseline to peak or peak to peak. By convention, the amplitude of the Compound Muscle Action Potential is measured from the baseline to the most negative peak. In contrast, the amplitude of a Compound Sensory Nerve Action Potential, Motor Unit Potential, Fibrillation Potential, Positive Sharp Wave, Fasciculation Potential, and most other Action Potentials is measured from the most positive to the most negative peak.

Anode - The positive terminal of a source of electrical current.

Antidromic - Said of an action potential or of the stimulation causing the action potential that propagates in the direction opposite to the normal (dromic or Orthodromic) one for that fiber--i.e., conduction along motor fibers toward the spinal cord and conduction along sensory fibers away from the spinal cord. Contrast with Orthodromic.

Artifact - A voltage change generated by a biological or nonbiological source other than the ones of interest. The Stimulus Artifact is the potential recorded at the time the stimulus is applied and includes the Electrical or Shock Artifact, which is a potential due to the volume conducted electrical stimulus. The stimulus and shock artifacts usually precede the activity of interest. A Movement Artifact refers to a change in the recorded activity due to movement of the recording electrodes.

Baseline - The potential difference recorded from the biological system of interest while the system is at rest.

Bipolar Needle Electrode - A recording electrode with two insulated wires side by side in a metal cannula whose bare tips act as the active and reference electrodes. The metal cannula may be grounded.

Bizarre High-Frequency Discharge - See Complex Repetitive Discharge.

Cathode - The negative terminal of a source of electrical current.

Clinical Electromyography - Loosely used to refer to all electrodiagnostic studies of peripheral nerves and muscle. See Electrodiagnosis.

Coaxial Needle Electrode - See synonym, Concentric Needle Electrode.

Complex Action Potential - See Serrated Action Potential.

Complex Motor Unit Potential - See Serrated Action Potential.

Complex Repetitive Discharge - Polyphasic or serrated action potentials that may begin spontaneously or after a needle movement. They have a uniform frequency, shape, and amplitude, with abrupt onset, cessation, or change in configuration. Amplitude ranges from 100 microvolts to 1 microvolt and frequency of discharge from 5 to 100 Hz.

Compound Action Potential - Evoked response from a muscle by a single electrical stimulus to its motor nerve. By convention, the compound action potential elicited by supramaximal stimulation is used for motor nerve conduction studies. The recording electrodes should be placed so that the initial deflection of the evoked potential is negative. The Latency, commonly called Motor Latency, is the latency (milliseconds) to the onset of the first negative phase. The amplitude (millivolts) is the baseline-to-peak amplitude of the first negative phase, unless otherwise specified. The Duration (milliseconds) refers to the duration of the first negative phase, unless otherwise specified. Normally, the configuration of the compound action potential (usually biphasic) is quite stable with repeated stimuli at slow rates (1-5 Hz). See Repetitive Stimulation, Compound Mixed Nerve Action Potential, Compound Motor Nerve Action Potential, Compound Nerve Action Potential, Compound Sensory Nerve Action Potential, and Compound Muscle Action Potential.

Compound Mixed Nerve Action Potential - A compound nerve action potential is considered to have been evoked from afferent and efferent fibers if the recording electrodes detect activity on a mixed nerve with the electrical stimulus applied to a segment of the nerve which contains both afferent and efferent fibers.

Compound Motor Nerve Action Potential - A compound nerve action potential is considered to have been evoked from efferent fibers to a muscle if the recording electrodes detect activity only in a motor nerve or a motor branch of a mixed nerve, or if the electrical stimulus is applied only to such a nerve or a ventral root. The amplitude, latency, duration, and phases should be noted. See Compound Nerve Action Potential.

Compound Muscle Action Potential - The summation of nearly synchronous muscle fiber action potentials recorded from a muscle commonly produced by stimulation of the nerve supplying the muscle either directly or indirectly. Baseline-to-peak amplitude, duration, and latency of the negative phase should be noted, along with details of the method of stimulation and recording.

Compound Nerve Action Potential -The summation of nearly synchronous nerve fiber action potentials recorded from a nerve trunk, commonly produced by stimulation of the nerve directly or indirectly. Details of the method of stimulation and recording should be specified, together with the fiber type (sensory, motor, or mixed).

Compound Sensory Nerve Action Potential - A compound nerve action potential is considered to have been evoked from afferent fibers if the recording electrodes detect activity only in a sensory nerve or in a sensory branch of a mixed nerve, or if the electrical stimulus is applied to such a nerve or a dorsal nerve root, or an adequate stimulus is applied synchronously to sensory receptors. The amplitude, latency, duration, and configuration should be noted. Generally, the amplitude is measured as the maximum peak-to-peak voltage, the latency as the Peak Latency to the negative peak, and the duration as the interval from the first deflection of the waveform from the baseline to its final return to the baseline. The compound sensory nerve action potential has been referred to as the Sensory Response or Sensory Potential.

Concentric Needle Electrode - Recording electrode that measures the potential difference between the bare tip of a central insulated wire in the bare shaft of a metal cannula. The bare tip of the central wire (active electrode) is flush with the bevel of the cannula (reference electrode).

Conduction Block - Failure of an action potential to be conducted past a particular point in the nervous system. In practice, a conduction block is documented by demonstration of a reduction in amplitude of an evoked potential greater than that normally seen with electrical stimulation at two different points on a nerve trunk; anatomical nerve variations and technical factors related to nerve stimulation must be excluded as the source of the reduction in amplitude.

Conduction Velocity - Speed of propagation of an Action Potential along a nerve or muscle fiber. The nerve fiber studied (motor, sensory, autonomic, or mixed) should be specified. For a nerve trunk, the maximum conduction velocity is calculated from the Latency of the evoked potential (muscle or nerve) at maximal or supramaximal intensity of stimulation at two different points. The distance between the two points (Conduction Distance) is divided by the difference between the corresponding latencies (Conduction Time). **The calculated velocity represents the conduction velocity of the fastest fibers and is expressed as meters per second (m/sec). As commonly used, the term Conduction Velocity refers to the Maximum Conduction Velocity. By specialized techniques, the conduction velocity of other fibers can be determined as well and should be specified, e.g., minimum conduction velocity.**

Contraction - A voluntary or involuntary reversible muscle shortening that may or may not be accompanied by Action Potentials from muscle.

Cycles Per Second - Unit of frequency. (Abbr. C/sec or CPS). Preferred equivalent is Hertz (Abbr. Hz).

Delay - Interval between onset of oscilloscope sweep and onset of a stimulus. Had been used in the past to designate the interval from the stimulus to the response. Compare with Latency.

Denervation Potential -Use of term discouraged. See Fibrillation Potential.

Depolarization - A decrease in the electrical potential difference across a membrane from any cause, to any degree, relative to the normal resting potential.

Discharge Frequency - The rate of repetition of an Action Potential. When potentials occur in groups, the rate of recurrence of the group and the rate of repetition of the individual components in the groups should be specified.

Discrete Activity - The pattern of electrical activity at full voluntary contraction of the muscle is reduced to the extent that each individual Motor Unit Potential can be identified. The firing frequency of each of these potentials should be specified together with the force contraction.

Distal Latency - See Motor Latency and Sensory Latency.

''Dive Bomber'' Potential - Use of term discouraged. See preferred term, Myotonic Discharge.

Duration - The time during which something exists or acts. (1) The durationof individual potential waveforms is defined as the interval from the first deflection from the baseline to its final return to the baseline, unless otherwise specified. One common exception is the duration of the Compound Action Potential, which usually refers to the interval from the deflection of the first negative phase from the baseline to its return to the baseline. (2) The duration of a single electrical stimulus refers to the interval of the applied current or voltage. (3) The duration of recurring stimuli or action potentials refers to the interval from the beginning to the end of the series.

Earthing Electrode - Synonymous with Ground Electrode.

Electrical Artifact - See Artifact.

Electrical Silence - The absence of measureable electrical activity due to biological or nonbiological sources. The sensitivity, or signal-to-noise level, of the recording system should be specified.

Electrode - A device capable of conducting electricity. The material (metal,fabric), size, configuration (disc, ring, needle), and location (surface, intramuscular, intracranial) should be specified. Electrodes may be used to record an electrical potential difference (Recording Electrodes) or to apply an electrical current (Stimulating Electrodes). In both cases, two electrodes are always required. Depending on the relative size and location of the electrodes, however, the stimulating or recording condition may be referred to as ''Monopolar''. See Ground Electrode, Recording Electrode, and Stimulating Electrode. Also see specific needle electrode configurations: Monopolar, Concentric, Bipolar, and Multilead Needle Electrodes.

Electrophysiologic Evaluation - General term used to refer to the recording of responses of nerves and muscle to electrical stimulation and the recording of insertional, spontaneous, and voluntary action potentials from muscle.

Electromyelography - The recording and study of electrical activity from the spinal cord. The term is also used to refer to studies of electrical activity from the cauda equina.

Electromyograph - An instrument for detecting and displaying Action Potentials from muscle and nerve.

Electromyography - (Abbr. EMG). Strictly defined, the recording and study of insertional, spontaneous, and voluntary electrical activity of muscle. It is commonly used to refer to nerve conduction studies as well. Compare with Clinical Electromyography and the more general term, Electrophysiologic Evaluation.

Electroneurography - The recording and study of the action potentials of peripheral nerves. See preferred term, Nerve Conduction Studies, and the more general term, Electrophysiologic Evaluation.

End-Plate Activity - Spontaneous electrical activity recorded with a needle electrode close to muscle end-plates. May be either of two forms:

1. **Monophasic.** Low-amplitude (10-20 microvolts), short-duration (0.5-1 msec), monophasic (negative) potentials that occur in a dense, steady pattern and are restricted to a localized area of the muscle. Because of the multitude of different potentials occurring, the exact frequency, although appearing to be high, cannot be defined. These potentials are miniature end-plate potentials recorded extracellularly. This form of end-plate activity has been referred to as End-Plate Noise and is associated with a sound not unlike that of a seashell, which has been called a Sea Shell Noise or Roar.

2. **Biphasic.** Moderate-amplitude (100-300 microvolts), short-duration (2-4 msec), biphasic (negative-positive) spike potentials that occur irregularly in short bursts with a high frequency (50-100 Hz), restricted to a localized area within the muscle. These potentials are generated by muscle fibers excited by activity in nerve terminals. These potentials have been referred to incorrectly, as ''Nerve'' Potentials.

End-Plate Noise - See End-Plate Activity, Monophasic.

End-Plate Potential - Graded, nonpropagated potential recorded by microelectrodes from muscle fibers in the region of the neuromuscular junction.

Evoked Action Potential - Action potential elicited by a stimulus.

Evoked Compound Muscle Action Potential - The electrical activity of a muscle produced by stimulation of the nerves supplying the muscle. Baseline-to-peak amplitude of the negative phase, duration of the negative phase, and Latency should be measured, details of the method of stimulation should be recorded.

Evoked Potential - Electrical waveform elicited by and temporally related to a stimulus, most commonly an electrical stimulus delivered to a sensory receptor or nerve, or applied directly to a discrete area of the brain, spinal cord, or muscle.

Excitability - Capacity to be activated by or react to a stimulus.

Fasciculation - The random, spontaneous twitching of a group of muscle fibers which may be visible through the skin. The electrical activity associated with the spontaneous contraction is called the Fasciculation Potential. Compare with Myokymia.

Fasciculation Potential - The electrical potential associated with Fasciculation which has dimensions of a motor unit potential that occurs spontaneously as a single discharge. Most commonly these potentials occur sporadically and are termed ''single fasciculation potentials.'' Occasionally, the potentials occur as a grouped discharge and are termed ''grouped fasciculation potentials''. The occurrence of large numbers of either simple or grouped fasciculations may produce a writhing, vermicular movement of the skin called Myokymia. Use of the terms Benign Fasciculation and Malignant Fasciculation is discouraged. Instead, the configuration of the potentials, peak-to-peak amplitude, duration, number of phases, and stability of configuration, in addition to frequency of occurrence, should be specified.

Fatigue - Reduction in the force of contraction of muscle fibers as a result of repeated use or electrical stimulation. More generally, it is a state of depressed responsiveness resulting from protracted activity and requiring appreciable recovery time.

Fiber Density - (1) Anatomically, fiber density is a measure of the number of muscle or nerve fibers per unit area. (2) In single-fiber EMG, the fiber density is the mean number of muscle fiber potentials under voluntary control encountered during a systematic search.

Fibrillation Potential - The electrical activity associated with fibrillating muscle fibers, reflecting the action potential of a single muscle fiber. The action potentials may occur spontaneously or after movement of the needle electrode. The potentials usually occur repetitively and regularly. Classically, the potentials are biphasic spikes of short duration (usually less than 5 msec) with an initial positive phase and a peak-to-peak amplitude of less than 1 microvolt. The firing rate has a wide range (1-50 Hz) and often decreases just before cessation of an individual discharge. A high-pitched regular sound is associated with the discharge of fibrillation potentials and has been described in the old literature as "rain on a tin roof." In addition to this classic form of fibrillation potentials, Positive Sharp Waves may also be recorded from fibrillating muscle fibers; the difference in the configuration of the potentials is due to the position of the recording electrode.

Firing Pattern - Qualitative and quantitative description of the sequence of discharge of potential waveforms recorded from muscle or nerve.

Firing Rate - Frequency of repetition of a potential. The relationship of the frequency to the occurrence of other potentials and the force of muscle contraction may be described. See Discharge Frequency.

Frequency - Number of complete cycles of a repetitive waveform in 1 second. Measured in Hertz (Hz), a unit preferred to its equivalent, Cycles per Second (C/sec).

F Wave - A late compound action potential evoked intermittently from a muscle by a supramaximal electrical stimulus to the nerve. Compared with the maximal amplitude Compound Action Potential of the same muscle, the F wave has a reduced amplitude and variable configuration and a longer and more variable latency. It can be found in many muscles of the upper and lower extremities, and the latency is longer with more distal sites of stimulation. The F wave is due to antidromic activation of motor neurons. It was named by Magladery and McDougal in 1950.

"Giant" Motor Unit Action Potential - Use of term discouraged. It refers to a motor unit potential with a peak-to-peak amplitude and duration much greater than the range recorded in corresponding muscles in normal subjects of similar age. Quantitative measurements of amplitude and duration are preferable.

Ground Electrode - An electrode connected to a large conducting body (such as the earth) used as a common return for an electrical circuit and as an arbitrary zero potential reference point.

Grouped Discharge - Intermittent repetition of a group of Action Potentials with the same or nearly the same waveform and a relatively short interpotential interval within the group in comparison with the time interval between each group. It may occur spontaneously or with voluntary activity and may be regular or irregular in its firing pattern.

Hertz - (Abbr. Hz). Unit of frequency representing cycles per second.

Hoffman Reflex - See H Reflex.

H Reflex - A late compound muscle action potential having a consistent latency evoked regularly, when present, from a muscle by an electrical stimulus to the nerve. It is regularly found only in a limited group of physiologic extensors, particularly the calf muscles. The reflex is most easily obtained with the cathode positioned proximal to the anode. Compared with the maximal amplitude Compound Action Potential of the same muscle, the H wave has a reduced amplitude, a longer latency, and a lower optimal stimulus intensity; its configuration is constant. The latency is longer with more distal sites of stimulation. A stimulus intensity sufficient to elicit a maximal-amplitude Compound Action Potential reduces or abolishes the H wave. The H wave is thought to be due to a spinal reflex, the Hoffman reflex, with electrical stimulation of afferent fibers in the mixed nerve to the muscle and activation of motor neurons to the muscle through a monosynaptic connection in the spinal cord. The reflex and wave are named in honor of Hoffman's description (1918). Compare with F Wave.

Insertional Activity - Electrical activity caused by insertion or movement of a needle electrode. The amount of the activity may be described qualitatively as Normal, Reduced, Increased, or Prolonged.

Interference Pattern - Electrical activity recorded from a muscle with a needle electrode during maximal voluntary effort, in which identification of each of the contributing action potentials is not possible, because of the overlap or interference of one potential with another. When no individual potentials can be identified, this is known as a **Full Interference Pattern**. A **Reduced Interference Pattern** is one in which some of the individual potentials may be identified while other individual potentials cannot be identified because of overlapping. The term **Discrete Activity** is used to describe the electrical activity recorded when each of the motor unit potentials can be identified. It is important that the force of contraction associated with the interference pattern be specified.

Involuntary Activity - Action potentials that are not under voluntary control. The condition under which they occur should be described, e.g., spontaneous, or, if elicited by a stimulus, the nature of the stimulus. Compare with Spontaneous Activity.

Latency - Interval between the onset of a stimulus and the onset of a response unless otherwise specified. Latency always refers to the onset unless specified, as in Peak Latency.

Membrane Instability - Tendency of a cell membrane to depolarize spontaneously or after mechanical irritation or voluntary activation.

Miniature End-Plate Potential - When recorded with microelectrodes, monophasic negative discharges with amplitudes less than 100 microvolts and duration of 4 msec or less, occurring irregularly and recorded in an area of muscle corresponding to the myoneural junction. They are thought to be due to small quantities (quanta) of acetylcholine released spontaneously. Compare with End-Plate Activity.

Monopolar Needle Electrode - A solid wire, usually of stainless steel, coated, except at its tip, with an insulating material. Variations in voltage between the tip of the needle (active or exploring electrode) positioned in a muscle and a conductive plate on the skin surface or a bare needle in subcutaneous tissue (reference electrode) are measured. By convention, this recording condition is referred to as a monopolar needle electrode recording; it should be emphasized, however, that potential differences are always recorded between two electrodes.

Motor Latency - Interval between the onset of a stimulus and the onset of the resultant Compound Muscle Action Potential. The term may be qualified as Proximal Motor Latency or Distal Motor Latency, depending on the relative position of the stimulus.

Motor Point - The point over a muscle where a contraction of a muscle may be elicited by a minimal-intensity, short-duration electrical stimulus.

Motor Unit - The anatomical unit of an anterior horn cell, its axon, the neuromuscular junctions, and all the muscle fibers innervated by the axon.

Motor Unit Action Potential - (Abbr. MUAP). See synonym, Motor Unit Potential.

Motor Unit Potential - (Abbr. MUP). Action potential reflecting the electrical activity of that part of a single anatomical motor unit that is within the recording range of an electrode. The action potential is characterized by its consistent appearance with and relationship to the force of a voluntary contraction of a muscle. The following parameters should be specified, quantitatively if possible, after the recording electrode is placed so as the minimize the Rise Time (which by convention should be less than 0.5 msec), which generally also maximizes the amplitude:

I. Configuration
- A. Amplitude, peak-to-peak (microV or mV)
- B. Duration, total (msec)
- C. Number of Phases (Monophasic, Biphasic, Triphasic, Tetraphasic, Polyphasic)
- D. Direction of each Phase (negative, positive)
- E. Number of Turns of Serrated Potential
- F. Variation of shape with consecutive discharges

II. Recruitment characteristics
- A. Threshold of activation (first recruited, low threshold, high threshold)
- B. Onset Frequency (Hz)
- C. Recruitment Frequency (Hz) or Recruitment Interval (msec) of individual potentials

Multilead Electrode - Three or more insulated wires inserted through a common metal cannula with their bared tips at an aperture in the cannula and flush with the outer circumference of the cannula. The arrangement of the bare tips relative to the axis of the cannula and the distance between each tip should be specified.

Muscle Action Potential - Strictly defined, the term refers to the action potential recorded from a single muscle fiber. However, the term is commonly used to refer to a compound muscle action potential. See Compound Muscle Action Potential.

Muscle Fiber Conduction Velocity - The speed of propagation of a single muscle fiber action potential, usually expressed as meters per second. The muscle fiber conduction velocity is usually less than most nerve conduction velocities, varies with the rate of discharge of the muscle fiber, and requires special techniques for measurement.

Myokymia - Involuntary, continuous quivering of muscle fibers which may be visible through the skin as a vermiform movement. It is associated with spontaneous, rhythmic discharge of Motor Unit Potentials.

Myokymic Discharges - Action potentials with the configuration of Motor Unit Potentials that occur spontaneously, recur regularly, and may be associated with clinical myokymia. Two distinct firing patterns are recognized. Commonly, the discharges are grouped with a short period (up to a few seconds) of firing at a uniform rate (2-20 Hz) followed by a short period (up to a few seconds) of silence, with repetition of the same sequence for a particular potential. Less commonly, the potential recurs continuously at a fairly uniform firing rate (1-5 Hz). Myokymic discharges are a subclass of Grouped Discharges and Repetitive Discharges.

Myopathic Motor Unit Potential - It is used to refer to low-amplitude, short-duration, polyphasic motor unit action potentials. The term incorrectly implies specific diagnostic significance of a motor unit potential configuration. See Motor Unit Potential.

Myopathic Recruitment - It is used to describe an increase in the number of and firing rate of motor unit potentials compared with normal for the strength of muscle contraction.

Myotonic Discharge - Repetitive discharge of 20-80 Hz of biphasic (positive-negative) spike potentials less than 5 msec in duration or monophasic positive waves of 5-20 msec recorded after needle insertion, or less commonly after voluntary muscle contraction or muscle percussion. The amplitude and frequency of the potentials must both wax and wane to be identified as myotonic discharges. This change produces a characteristic musical sound in the audio display of the electromyograph due to the corresponding charge in pitch, which has been likened to the sound of a "dive bomber."

Myotonic Response - Delayed relaxation of muscle after voluntary contraction or percussion and associated with a myotonic discharge.

Needle Electrode - An electrode for recording or stimulating, shaped like a needle. See specific electrodes: Bipolar Needle Electrode, Concentric Needle Electrode, Monopolar Needle Electrode, Multilead Electrode.

Nerve Action Potential - Strictly defined, refers to an action potential recorded from a single nerve fiber. The term is commonly used to refer to the compound nerve action potential. See Compound Nerve Action Potential.

Nerve Conduction Studies - Refers to all aspects of Electrophysiologic Evaluation of peripheral nerves. However, the term is generally used to refer to the recording and measurement of Compound Nerve and Compound Muscle Action Potentials elicited in response to a single supramaximal electrical Stimulus under standardized conditions that permit establishment of normal ranges of amplitude, duration, and latency of Evoked Potentials and the calculation of the Maximum Conduction Velocity of individual nerves. See Compound Nerve Action Potential, Compound Muscle Action Potential, Conduction Velocity, and Repetitive Stimulation.

Nerve Conduction Velocity - (Abbr. NCV). Loosely used to refer to the maximum nerve conduction velocity. See Conduction Velocity.

Nerve Potential - Equivalent to Nerve Action Potential. Also commonly, but inaccurately, used to refer to the biphasic form of End-Plate Activity. The latter use is incorrect because muscle fibers, not nerve fibers, are the source of these potentials.

Neuropathic Motor Unit Potential - It is used to refer to abnormally high-amplitude, long-duration, polyphasic Motor Unit Potentials. The term incorrectly implies a specific diagnostic significance of a motor unit potential configuration.

Neuropathic Recruitment - It has been used to describe a recruitment pattern with decreased number of Motor Unit Potentials firing at a rapid rate. See preferred terms, Discrete Activity, Reduced Interference Pattern.

Noise - Strictly defined, an Artifact consisting of low-amplitude, random potentials produced by an amplifier and unrelated to the input signal. It is most apparent when high gains are used. It is loosely used to refer to end-plate noise. Compare with End-Plate Activity.

Orthodromic - Said of Action Potentials or stimuli eliciting action potentials propagated in the same direction as physiological conduction, e.g., motor nerve conduction away from the spinal cord and sensory nerve conduction toward the spinal cord. Contrast with Antidromic.

Peak Latency - Interval between the onset of a stimulus and a specified peak of the evoked potential (usually the negative peak).

Phase - That portion of a Wave between the departure from and the return to the Baseline.

Polarization - As used in neurophysiology, the presence of an electrical potential difference across an excitable cell membrane. The potential across the membrane of a cell when it is not excited by input or spontaneously active is termed the Resting Potential; it is at a steady state with regard to the electrical potential difference across the membrane. Depolarization describes a decrease in polarization to any degree, relative to the normal resting potential. Hyperpolarization describes an increase in polarization relative to the resting potential. Repolarization describes an increase in polarization from the depolarized state toward, but not above, the normal or resting potential.

Positive Sharp Wave - Strictly defined, one form of electrical activity associated with fibrillating muscle fibers. It is recorded as a biphasic, positive-negative Action Potential initiated by needle movement and recurring in a uniform, regular pattern at a rate of 2-50 Hz, which may decrease just before cessation of discharge. The amplitude and duration vary considerably but the initial positive deflection is usually less than 5 msec in duration and up to 1 mV in amplitude. The negative phase is of low amplitude, with a duration of 10-100 msec. A sequence of positive sharp waves is commonly referred to as a Train of Positive Sharp Waves. Positive sharp waves are recorded from the damaged area of fibrillating muscle fibers. Loosely defined, positive sharp waves refer to any action potential recorded with the waveform of a positive wave, without reference to the firing pattern or method of generation.

Pseudomyotonic Discharge - Use of term discouraged. It has been used to refer to different phenomena, including (1) Myotonic Discharges occurring in the presence of a neurogenic disease, (2) Complex Repetitive Discharges, and (3) Repetitive Discharges that wax or wane in either frequency or amplitude but not in both.

Recording Electrode - Device used to monitor electrical current or potential. All electrical recordings require two Electrodes. The electrode close to the source of the activity to be recorded is called the Active Electrode, and the other electrode is called the Reference Electrode. Active electrode is synonymous with the older terminology G1 or Grid 1, and the reference electrode with G2 or Grid 2. By current convention, a potential difference that is negative at the active electrode relative to the reference electrode causes an upward deflection on the oscilloscope screen. The term "monopolar recording" is not recommended, because all recording requires two electrodes; however, it is commonly used to describe the use of an intramuscular needle exploring electrode in combination with a surface disc or subcutaneous needle reference electrode.

Recruitment - The orderly activation of the same and new motor units with increasing strength of voluntary muscle contraction. See Motor Unit Potential.

Recruitment Frequency - Firing rate of a Motor Unit Potential when an additional motor unit potential first appears during gradually increasing strength of voluntary muscle contraction.

Recruitment Interval - The Interdischarge Interval between two consecutive discharges of a Motor Unit Potential when an additional motor unit potential first appears during gradually increasing strength of voluntary muscle contraction. The reciprocal of the recruitment interval is the Recruitment Frequency.

Recruitment Pattern - A qualitative and/or quantitative description of the sequence of appearance of Motor Unit Potentials with increasing strength of voluntary muscle contraction. The Recruitment Frequency and Recruitment Interval are two quantitative measures commonly used. See Interference Pattern for qualitative terms commonly used.

Repetitive Discharges - General term for the recurrence of an Action Potential with the same or nearly the same form. The term may refer to recurring potentials recorded in muscle at rest, during voluntary contraction, or in response to single nerve stimulus. The discharge may be named for the number of times a potential recurs in a group (e.g., Double Discharge, Triple Discharge, Multiple Discharge, Coupled Discharge) or other characteristics (e.g., Complex Repetitive Discharge, Myokymic Discharge).

Repetitive Stimulation - The technique of utilizing repeated supramaximal stimulation of a nerve while quantitatively recording Compound Action Potentials from muscles innervated by the nerve. It should be described in terms of the frequency of stimuli and number of stimuli (or duration of the total group).

Residual Latency - Refers to the calculated time difference between the measured distal latency of a motor nerve and the expected distal latency, calculated by dividing the distance between the stimulus cathode and the active recording electrode by the maximum conduction velocity measured in a more proximal segment of a nerve.

Rise Time - By convention, the shortest interval from the nadir of a positive phase to the peak of a negative phase of a Compound Action Potential.

Sensory Peak Latency - Interval between the onset of a Stimulus and the peak of the negative phase of the Compound Sensory Nerve Action Potential. Note that the term ''Latency'' refers to the interval between the onset of a stimulus and the onset of a response.

Serrated Action Potential - An action potential waveform with several changes in direction (turns) which do not cross the baseline. This term is preferred to the term Complex Action Potential. See Turns.

Single Fiber Needle Electrode - A needle Electrode with a small recording surface (usually 25 microns in diameter) permitting the recording of single muscle fiber action potentials. See Single Fiber Electromyography.

Somatosensory Evoked Potential - (Abbr. SSEP). Electrical Waves recorded from the head or trunk in response to electrical or physiological stimulation of peripheral sensory fibers. Recordings over the spine may be referred to as Spinal Evoked Potentials.

Spinal Evoked Potential - Electrical Wave recorded over the spine in response to electrical stimulation of peripheral sensory fibers. See Somatosensory Evoked Potential.

Spontaneous Activity - Action potentials recorded from muscle or nerve at rest after insertional activity has subsided and when there is no voluntary contraction or external stimulus. Compare with Involuntary Activity.

Stimulating Electrode - Device used to apply electrical current. All electrical stimulation requires two electrodes; the negative terminal is termed the Cathode and the positive terminal, the Anode. By convention, the stimulating electrodes are called "Bipolar" if they are roughly equal in size and separated by less than 5 cm. The stimulating electrodes are called "Monopolar" if the cathode is smaller in size than the anode and is separated from the anode by more than 5 cm. Electrical stimulation for Nerve Conduction Studies generally requires application of the cathode to produce depolarization of the nerve trunk fibers. **If the anode is inadvertently placed between the cathode and the recording electrodes, a focal block of nerve conduction (Anodal Block) may occur and cause a technically unsatisfactory study.**

Stimulus - Any external agent, state, or change that is capable of influencing the activity of a cell, tissue, or organism. In clinical Nerve Conduction Studies, an electrical stimulus is generally applied to a nerve or a muscle. The electrical stimulus may be described in absolute terms or with respect to the evoked potential of the nerve or muscle. In absolute terms, the electrical stimulus has a strength or intensity measured in voltages (volts) or current (milliamperes) and a duration (milliseconds). With respect to the evoked potential, the stimulus may be graded as subthreshold, threshold, submaximal, maximal, or supramaximal. A Threshold Stimulus is that electrical stimulus just sufficient to produce a detectable response. Stimuli less than the threshold stimulus are termed Subthreshold. The Maximal Stimulus is the stimulus intensity after which a further increase in the stimulus intensity causes no increase in the amplitude of the evoked potential. Stimuli of intensity below this and above threshold are Submaximal. Stimuli of intensity greater than the maximal stimulus are termed Supramaximal. Ordinarily, supramaximal stimuli are used for nerve conduction studies. By convention, an electrical stimulus of approximately 20% greater voltage than required for the maximal stimulus may be used for supramaximal stimulation. The frequency, number, and duration of a series of stimuli should be specified.

Strength-Duration Curve - Graphic presentation of the relationship between the intensity (Y axis) and various durations (X axis) of the threshold electrical stimulus for a muscle with the stimulating cathode positioned over the motor point.

Temporal Dispersion - A waveform of longer duration than normal. Commonly used to refer to an increase in the duration of an evoked potential with more proximal sites of stimulation of a greater degree than that normally seen.

Terminal Latency - A waveform of longer duration than normal. Commonly used to refer to an increase in the duration of an evoked potential with more proximal sites of stimulation of a greater degree than that normally seen.

Threshold - The level at which a clear and abrupt transition occurs from one state to another. The term is generally used to refer to the voltage level at which an Action Potential is initiated in a single axon or a group of axons. It is also operationally defined as the intensity that produced a response in about 50% of equivalent trials.

Turns - Changes in direction of a waveform which do not necessarily pass through the baseline. The minimal excursion required to constitute a turn should be specified.

Unipolar Needle Electrode - See synonym, Monopolar Needle Electrode.

Visual Evoked Potential - Electrical waveforms of biological origin recorded over the cerebrum and elicited by light stimuli.

Volume Conduction - Spread of current from a potential source through aconducting medium, such as the body tissues.

Voluntary Activity - In electromyography, the electrical activity recorded from a muscle with consciously controlled muscle contraction. The effort made to contract the muscle, e.g., minimal, moderate, or maximal, and the strength of contraction in absolute terms or relative to a maximal voluntary contraction of a normal corresponding muscle should be specified.

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