

## TECHNICAL NOTES

### FABRICATION OF SUCTION-CUP ELECTRODES FOR ELECTROMYOGRAPHY

J. C. MOORE, PH.D.

*Department of Anatomy, The University of Michigan Medical School, Ann Arbor, Mich. (U.S.A.)*

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Many kinds of surface electrodes are used today in EMG, the small silver and gold cup being the standard electrode in the United States. A suction-cup surface electrode is rarely used but several years of experience with many kinds of electrodes in our laboratory have led us to the conclusion that this electrode has many practical qualities.

The suction-cup electrode has several advantages over other kinds of surface electrodes. It can be placed on the skin very quickly and easily by a mere pinch of the fingers. No adhesives or tapes are necessary to hold it in place or to insure contact with the skin to which it adheres without slipping during movements. It can be placed on the exact reference point marked on the skin. If suction is lost, the electrode can quickly be relubricated (Cardeez electrode jelly) and replaced exactly on the same spot. Suction can be maintained from one to several hours, depending upon the size of the suction-cup and its electrode, and the amount of electrode jelly used. Because of the slight suction created, continuous contact between the electrode and the skin is insured. Shaving of body hair is not necessary unless the subject is heavily endowed with hair. One precaution is the *prolonged* use of the electrode on flexor surfaces of the body such as the chest or abdomen. Some individuals are more susceptible to the development of petechiae in these areas. The cost is negligible, amounting to a few cents per pair. A dozen sets can be fabricated in a few hours using simple tools. If proper care is taken, these electrodes will last several years.

#### MATERIALS

1 ft. Tygon flexible tubing (transparent)<sup>1</sup>:  
 3/4" × 1/8" (#36)—large size electrode<sup>2</sup>;  
 3/8" × 1/16" (#18)—medium size "standard" electrode;  
 1/4" × 1/16" (#20)—small size electrode.  
 Solid rubber stoppers: sizes 00 and #3.  
 1 tube 3M Super Weatherstrip Adhesive (cream or black)<sup>3</sup>.

<sup>1</sup> Manufactured by: U.S. Stoneware Company, Akron, Ohio.

<sup>2</sup> 3/4" refers to outside diameter of tubing and 1/8" to wall thickness expressed as 3/4 × 1/8 O.D. wall.

<sup>3</sup> Manufactured by: Minnesota Mining and Manufacturing Company, St. Paul, Minn.

1 tube RTV Silicone<sup>4</sup>. (Epoxy resins are too brittle for this work.)

Brass escutcheon pins, #16, 1 1/4" and #12, 2" lengths. Scissors or tin snips; jack knife; soldering iron; wire cutters; hammer; 1/2" electric drill with sanding disc or similar equipment; and flexible-shielded lead wires (#82879 I.T. and T. Federal Cable R.E.C. An type RG-174/u).

#### FABRICATION

The following description pertains to the 3/8 × 1/16 O.D. wall Tygon suction-cup electrodes:

*Sanding.* Sand the cut ends of a length of Tygon tubing until smooth or until there are no shiny surfaces (Fig. 1, A). This may be done by slowly rotating the tubing in the fingers as it is gently applied to a fine grade sanding disc. Be sure the smooth rounded edge obtained is at right angles to the length of the tubing. Cut 1 in. pieces off of both ends. These pieces form the basic part of the suction-cup electrode. Do not bother to sand the cut end of the 1 in. piece. Repeat the above process for additional pairs.

*Rubber stopper.* Cut off a 3/16 in. piece from the smaller end of the rubber stopper with a jack knife (Fig. 1, B).

*Escutcheon pins.* Take a #16 pin and pound it into the center of the rubber stopper piece, driving it through the distal end so that the point of the pin protrudes through the cut end (Fig. 1, C). Place this into the 1 in. tube, with the rounded end of the pin resting about 1/16 in. above the sanded end. Shift the stopper up or down the pin shaft until the pin is properly located. Remove the two parts and make several more pairs before gluing parts together.

*Assembly.* Using 3M super weatherstrip adhesive, coat the shaft of the pin where it enters the stopper, and coat the sides of the stopper. Re-insert the stopper-pin piece into the 1 in. tubing as before (Fig. 1, C). The stopper will have a tendency to slip out of the tube because of its slight taper and because Tygon becomes slippery when adhesives are used. Hold the stopper in place for about 1 min and then place into the jaws of a vise set to hold the stopper in place. Be sure that the cut surface of the stopper meets flush with the cut

<sup>4</sup> Manufactured by: General Electric Company, Waterford, N.Y.

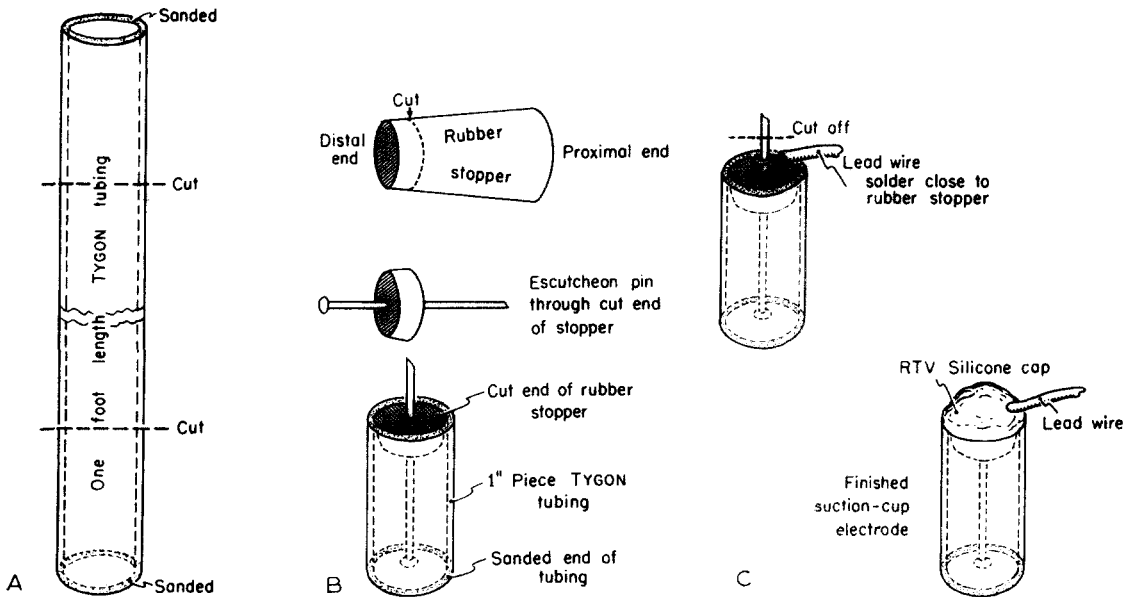


Fig. 1

- A: Cutting and sanding of Tygon tubing for electrode pair.  
 B: Preparation of rubber stopper, escutcheon pin placement, and assemblage of the suction-cup electrode.  
 C: Attachment of lead wires and completion of suction-cup electrode.

end of the tube and that the head of the pin is approximately  $1/16$  in. above the sanded edge of the tube. After making several sets, allow them to cure overnight.

Solder the lead wire to the shaft of the pin which protrudes above the cut end of the stopper, then cut off excess amount of pin which is no longer needed (Fig. 1, C). Coat the entire area with RTV Silicone. This ensures sealing of all areas and secures the lead wire so that usage will not cause the lead wire to break off at the soldered junction.

**Application.** Place Cardeez electrode jelly around the smooth-sanded edge and onto the head of the pin. It is not necessary to load the suction-cup with jelly. Pinch the sides of the suction-cup against the shaft of the pin, and apply to the skin, then release. If too much suction is created, pinch more gently. Because Tygon is transparent one can see exactly where to place the pin of the electrode and can observe whether a good contact has been obtained.

Using the  $3/4 \times 1/8$ " Tygon tubing, #3 rubber stopper, and #12 escutcheon pin, large suction-cup electrodes can be fabricated. Or if one desires very small electrodes, the  $1/4 \times 1/16$ " Tygon tubing can be used with the #16 pins and the #00 rubber stoppers cut and sanded to fit this diameter tubing. Other sizes can be used but the  $3/8 \times 1/16$ " tubing and #16 pin is the most convenient size in our experience.

These electrodes have proven to be most useful in preliminary investigations such as the best area, over a muscle or muscle group, for pick-up of the muscle action potentials; *i.e.*, the areas over the anterior, middle, and posterior deltoid muscle; the two heads of pectoralis major, the thenar and hypothenar muscles, etc. They have been useful for discerning the optimal spacing necessary between the pick-up and reference electrode pair in order to obtain maximal muscle potentials from the muscles under study. Also, in comparing the muscle action potentials of several persons all performing the same action in a given period of time. A ground electrode of the ear-clip variety (Grass Instrument Company, Quincy, Mass.) is usually used in conjunction with the suction-cup electrode pair.

#### SUMMARY

The fabrication of an inexpensive surface suction-cup electrode for use in EMG has been described. It has proven to be a useful tool in preliminary investigations of muscle action potentials of various muscles or muscle groups. The simplicity of application to the skin, as well as ease of removal and/or replacement, is one of the outstanding attributes of this type of electrode.