CONDUCTIVE INSERTS TO ACQUIRE MYOELECTRIC SIGNALS THROUGH SILICONE LINERS
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INTRODUCTION
Prosthetic socket liners provide both suspension and stability, and they do so best when they cover the remaining limb without breaks in the liner surface. This full coverage conflicts with the need to acquire myoelectric signals directly from the skin. Early solutions to this problem include windows in the liner and metal electrodes piercing and thereby weakening the liner. Windows compromise the integrity of the liner and often lead to discomfort at the edge of the window. Metal electrodes require attachment of external wires after donning. Another alternative is to mount cased electrodes in molded silicone receptacles. This may result in a proper seal, but it requires repeated removal of the electrode from the liner.

The problems identified above can be addressed by passing the myoelectric signals directly though the liner with flexible Conductive Inserts. This approach allows metal electrodes in the outer socket to acquire the myoelectric signals as if they were in direct contact with the skin with no wires attached to the liner. LTI has developed Conductive Inserts that not only pass myoelectric signals through the liner but also allow for misalignment when the liner is inserted into the socket. These Inserts can be installed by prosthetic technicians in a commercial liner, or they can be built into a custom liner. With Inserts installed, a liner is a separate part that can be easily removed for cleaning.

ELEMENTS OF THE INSERT SYSTEM
The system is quite simple. For two electrode sites, five or six of the Inserts shown in figure 1 are installed in a production or custom silicone liner with the wide “overlap” on the outside. The center part of each Insert is 12 mm in diameter and either 2mm or 3mm thick to glue into a hole punched in the liner. The larger diameter overlap is about \( \frac{1}{2} \) mm thick and provides a greater target area for the Metal Electrode. The overlap also provides increased strength because adhesive bonds are strongest in shear.

The resulting liner with Inserts is shown in figure 2. In the meantime, a clear check socket is used to verify the fit of the liner. Once the patient can don the liner and place it into the check socket in a consistent manner, the centers of the Inserts are marked on the check socket for installation of the Metal Electrodes shown in figure 3 (three sizes available). The result is shown in figure 4 where the three cables from an LTI Remote Electrode are connected to metal electrodes. Note that the electrode may be slightly offset from the center of the Insert, but still make contact. The final element is the Remote Electrode itself, shown in figure 5.

Figure 1. Conductive Insert  
Figure 2. Liner with Inserts installed  
Figure 3. LTI Metal Electrode sizes
OPTIONS FOR SUPPLYING SYSTEMS

Option 1: The Inserts are installed by the supplier

The prosthetist determines the residual limb measurements and a correctly sized silicone liner is sent to the facility. The patient dons the liner and the practitioner marks the myoelectrode sites. The liner is then sent back to the central fabrication facility where the Inserts are installed. The patient’s liner with the Inserts is returned to the practitioner along with the appropriate Remote Electrodes. At this point, the practitioner builds a check socket and mounts the Remote Electrodes to align with the Inserts in the liner. Final testing is done to assure good myoelectric signals, and these electrode locations are then transferred to the definitive socket. Most early fittings have been done using this option.

Option 2: A kit for local installation of the Inserts

As an alternative to central fabrication of the Inserts into a production liner, LTI plans to provide these Conductive Inserts as a kit for the local technician to install in a production liner or for installation in a custom silicone liner, thus reducing the turn-around time. The kit will consist of 3 Conductive Inserts, silicone adhesive and a mounting template. At present, we are experimenting with various manufacturers’ upper-extremity silicone liners to insure that the selected adhesive works well. On a trial basis, the proposed kit has been used by two overseas practitioners where shipping back for fabrication would have been prohibitive. The preliminary results with custom liners looks promising. LTI is awaiting the final results before offering this option.

Future options

During field trials with the Conductive Inserts, it became apparent that some applications may need smaller Inserts. In the future, experiments will be done with Inserts measuring 5 or 6 mm in diameter. This reduced diameter will permit a smaller overlap, but will give a more secure bond. However, the diameter of the overlap must not get too small or it will become difficult for users to align the Inserts with the metal electrodes. The small Inserts will be useful for the close muscle sites required for partial hands, Targeted Muscle Reinnervation patients or for sampling multiple sites for use with pattern recognition/classification schemes.