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ELECTRODES INSTALLED IN ROLL-ON SUSPENSION SLEEVES

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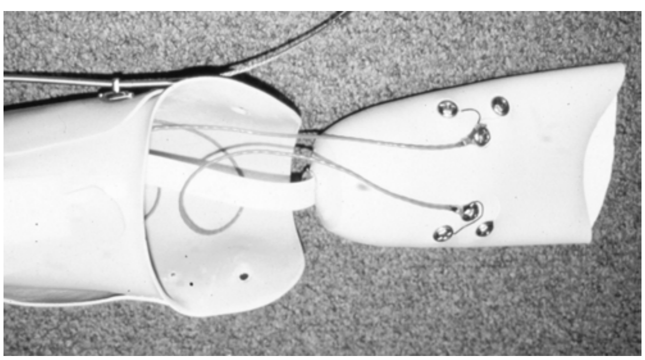
ABSTRACT:

This presentation describes transhumeral and transradial prostheses which have been successfully fit to patients using electrodes installed in roll-on suspension sleeves. Metal electrodes and modified wiring systems have been developed and tested along with techniques for installing electrodes in roll-on sleeves to provide improved suspension and electrode contact. This series of patients has shown that a Roll-on sleeve is an excellent way to achieve superior suspension and greater range of motion. Information will be presented to document the increase in suspension and range of motion in several patients who were fit with both traditional and roll-on suspension systems. This design maintains consistent electrode contact for patients, especially those who have volume changes or experience difficulty with the traditional suspension methods. This system is adaptable to many prosthetic hand and elbow systems and amputation levels. Future research directions will be suggested to improve this system and make it available to a wider population of users.

DESIGN DEVELOPMENT

I first began experimenting with the attachment of myoelectric electrodes through silicone roll-on sleeves in 1996 with a transhumeral prosthesis. The design separated the EMG (electro-myography) pick-up electrodes from the pre-amplification and control electronics. This design preserves the suspension and comfort of the roll-on sleeve and allow the EMG signal to pass through the sleeve without interrupting the suspension, as would cutting holes in the sleeve.[1] The first prototype electrodes were stainless steel bolt heads and had shielded wires leading to the preamp and arm electronics. (Ill 1)



Ill 1 Initial roll-on design

The system worked but had severe durability problems since the wires were attached directly to the electrodes and had a plug connector in the wire harness to allow the wearer to detach the sleeve for cleaning.

Later designs used snap connectors at the electrodes with shielded EKG cables attached to the preamps. Several snap designs were tried with significant corrosion problems

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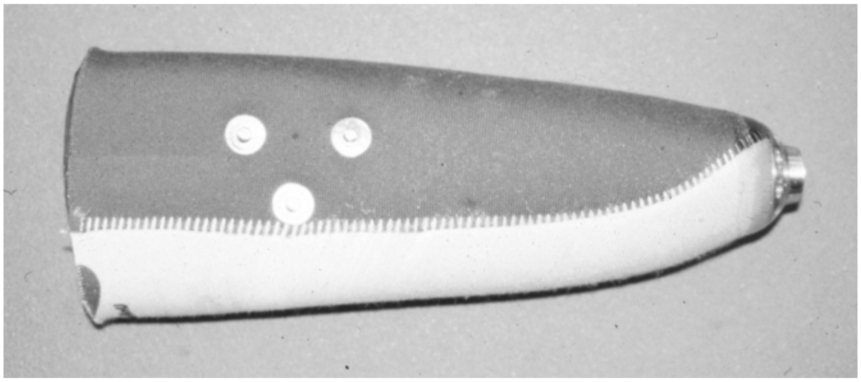
in the electrodes leading to degradation of the EMG signal. The current design uses custom stainless steel snap head electrodes and wires from Motion Control[2] which transfer the EMG signal through the sleeve and can be attached to many electronics packages for control of the prosthesis.(Ill 2)



Ill 2 Stainless steel snap electrodes in a roll-on liner

The original three transradial cases using this design were replacements of conventional myoelectric socket designs and offered a clear comparison of the suspension and ROM (range of motion) capability of each design. (table 1)

Table 1

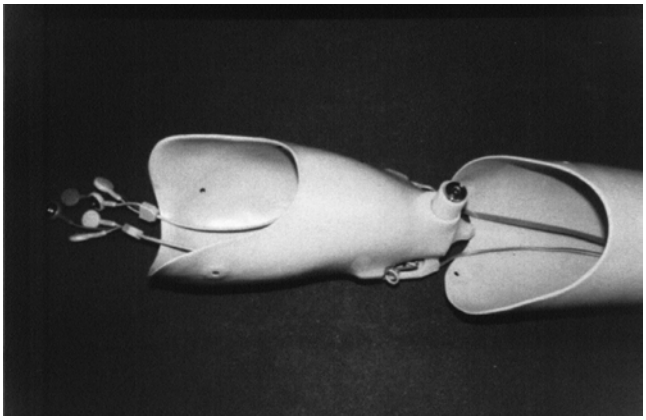
Comparison of ROM and suspension	Conventional supracondular suspension		Roll-on Sleeve Suspension	
Patient	Range of Motion (degrees)	Pull-off force (Lbs)	Range of Motion (degrees)	Pull-off force (Lbs)
R.F.	5-110	30	5-125	50
C.W.	7-90	12	0-110	50
G.J.	30-110	5	5-110	37

This comparison shows a marked improvement in the range of motion and suspension capability of the roll-on sleeve design over conventional socket designs. All of the patients have also commented on improved comfort since the sleeve provides a soft interface between the arm and the hard socket. The full text of the comparison between conventional fittings and the roll-on myoelectric design can be found in the Journal of Prosthetics and Orthotics[3] or at the AAOP web site at http://www.oandp.org/jpo/library/2000_03_088.asp.

Since these first three fittings I have delivered 7 transhumeral and 9 transradial arms using this design. I have had only one transhumeral arm rejected due to discomfort from the sleeve pulling on the distal tissue causing pain.

PRACTICAL CONSIDERATIONS

The design which I have found to work best is as follows. The EMG sites are identified as usual and marked on the appropriate size roll-on sleeve. I have used Ohio Willow Wood[4] Alpha Sleeves on most of the arms since they can be heat molded to the shape of the patients arm and they resist tearing where the electrodes pierce the sleeve. A cast is taken over the sleeve with appropriate landmarks identified. The positive model is modified in the usual manner except for added build-ups over the electrode areas to prevent excessive pressure from the wires and electrodes. A clear check socket is then constructed to check the fit and alignment of the socket. This alignment is then transferred to a removable double wall socket as is customary. The wiring harness is attached to the electronics package of your choice and the wires are passed through slots cut in the socket and the preamps are secured to the socket or the inside wall of the outer socket with double stick foam tape.(Ill 3)



Ill 3 complete transradial prosthesis

The wiring after the preamps is the same as a conventional myoelectric arm. Design help can be found at http://www.utaharm.com/srfaq.htm#alt .

I have found this system to be much less sensitive to volume changes of the arm, this allows myo fittings to be made within a few months of an amputation rather than wait the conventional 6-12 months for the limb volume to stabilize. The liner also provides improved electrode contact and much greater comfort.

FUTURE DESIGN IMPROVEMENTS

The main problem with the current system is that the wiring harness is brittle and tends to fail after 3-12 months. Motion Control is working on an improved design which should eliminate this problem. In the future I would like to see the preamps either built into the liner or sealed against moisture so that they could be placed inside of the liner to eliminate the snap connectors completely.

Experimentation with a multi-electrode array seems to indicate that more than one distinct signal can be gained from a muscle group rather than the one signal per group as is used now. An array of electrodes placed in the liner would allow for several simultaneous functions in the prosthesis without the use of switching.

The system as it is currently in use has been very well accepted by patients and has significantly improved their comfort and function.

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[1] Salam, Y., "The use of silicone suspension sleeves with myoelectric fittings", Journal of Prosthetics and Orthotics. 1994;6: 119-120

[2] Motion Control, 2401 S. 1070 W. St B, Salt Lake City, UT 84119

[3] Daly,W, "Clinical Application of Roll-on Sleeves for Myoelectrically Controled Transradial and Transhumeral Prostheses", Journal of Prosthetics and Orthotics, Vol 12: 3, 88-91

[4] Ohio Willow Wood, 15441 Scioto Darby Rd., Mt Sterling, OH 43143