

## Fitting & Suspension Techniques for a Transhumeral Amputee with Burn Injuries: A Four Year Retrospective Case Study

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### ABSTRACT

A firefighter with burn injuries demonstrated fitting challenges regarding comfort and suspension of a functional upper limb prosthesis. This case study introduces a transhumeral-transfemoral patient who was injured during a volunteer firefighting incident. The patient sustained several injuries which resulted in amputation of the right leg just proximal to the knee and a transhumeral amputation of the left upper limb. The patient has full range of motion in both shoulders and elbows, yet the strength and dexterity of his right hand has been compromised.



This individual sustained burns to 60% of his body, including the skin on his left transhumeral residual limb. Due to the delicate nature of his skin, a suction socket was contraindicated. Over the next four years, different types of custom and non-custom locking and cushion liners were utilized for patient comfort and suspension of both a myoelectric and a conventional (body-powered) prosthesis. The integration of electrodes for dual site myoelectric inputs offered additional challenges that compromised the suspension provided by silicone suction. Shuttle locks, lanyards, and proximal locking mechanisms were used, and the advantages and disadvantages of each system will be compared.

This case study will follow the progression of suspension techniques, interface designs, and other clinical challenges faced by the patient and the clinicians involved with the fitting. As the patient progresses toward his imminent evaluation for Targeted Muscle Reinnervation surgery, his existing

design must be modified to allow additional EMG sites. The challenges of this firefighter's progressive fitting and treatment will be detailed in the discussion.

### CASE STUDY

The patient was injured in August of 2007. While fighting a fire in a townhouse, the second floor collapsed and the debris trapped him. He sustained 3<sup>rd</sup> and 4<sup>th</sup> degree burns on 60% of his body and spent time hospitalized for 24 reconstructive surgeries. The patient's physiatrist prescribed a prosthesis without a harness due to the condition of the skin. The patient also was not interested in utilizing a harness due to its perceived restriction of range of motion.



The patient was initially fit with an externally powered prosthesis with a Dynamic Arm, wrist rotator, and Sensor Hand Speed. As the patient's residual limb presented with burn scars and grafted



skin, initial attempts of a skin-fit suction socket were rejected. For the initial interface, custom silicone liners were fabricated for the patient. This medium provided comfort and optimal linkage. The cushion liners were fabricated with circumferential silicone rings on the liner for suction seals. Although initially successful, frequent volume changes proved to be problematic for long term suction suspension.

The patient requested a mechanical lock be added to the liner for secondary suspension. An air tight shuttle lock was added to the distal end of the liner to supplement the suction seals on the liner. Again, volume fluctuation caused problems with the suction seals. The shuttle lock added a very subtle length discrepancy, but provided the patient with the confidence of having a secure linkage to the prosthesis.

As the patient progressed through his initial myoelectric prosthetic fitting into his definitive prosthesis, shrinkage of the residual limb required smaller liners be provided. Initially, the patient used a 20cm locking liner. He later used a 16cm liner, and eventually lost enough volume to fit comfortably into a 12cm locking liner.

One of the challenges presented while using the non-custom locking liners with holes cut at the electrode locations was the distal migration of the liners following perspiration. This migration would occur after only 20 minutes of wear time in the summer. Ultimately, the liners were changed to Alpha small uniform locking liners. To address the challenge of

the cut holes in the liner, Motion Control snap electrodes were used to eliminate these openings in the liners.

As this required a new socket and frame, the shuttle lock was replaced with a medial 1" Dacron lanyard system for suspension. The lanyard suspension, also anchored from the distal end of the locking liner, did not solve the issue of the distal migration of the liner/socket.

In an attempt to reduce this tendency, a Coyote ratchet lock was added to the proximal lateral locking liner. This addition was successful in reducing the distal migration of the liner/socket. As an added benefit, the ratchet lock prevented any rotation of the residual limb within the prosthesis.

## DISCUSSION

This challenging case study is important because it addresses two critical elements, suspension and myoelectric control. Compromised skin integrity as well as frequent volume fluctuations made the clinical choices less obvious.

For suspension, the initial choice of the custom silicone liners with suction seals would have provided the best linkage between the prosthesis and the residual limb, but the volume changes caused the subject to request the additional positive locking mechanism. The Ossur locking liners were more apt to migrate distally along the skin than the mineral oil-based Alpha equivalent. In both the Ossur and the Alpha locking liners, the holes that allow contact between the skin and socket-mounted electrodes allowed distal migration of the liner.

The main challenge with respect to myoelectric control was using electrodes that allowed the liner to remain in place without migrating. The snap electrodes were a viable solution for this patient; however, they must be secured to the surface of the liner or they unscrew and impair the EMG signal.

## CONCLUSION

This subject presented the clinicians involved with multiple fitting experiments, including the combination of a non-suction socket with myoelectric control. For this case study, the best solution was the non-custom locking liner using snap electrodes with two locking mechanisms in addition to the harness. The redundancy of the suspensory mechanisms (two locks, harness) proved effective in avoiding distal

migration of the socket during the patient's vocational setting (nursing school and EMT training).

The patient has been evaluated, approved for, and scheduled for Targeted Muscle Reinnervation surgery for the summer of 2011. A future challenge will be using 4 electrodes in the new prosthesis, as his current 2-site prosthesis uses snap electrodes. There is insufficient socket coverage to add additional snap electrodes. A custom silicone socket with an internal laminated frame/embedded electrodes is the most probable initial clinical approach.

#### REFERENCES

- [1] ECT. Baars, JHB. Gertzen, "Literature review of the possible advantages of silicon liner socket use in trans-tibial prostheses." *Journal of Prosthetics and Orthotics International*, Vol. 29, Issue 1, pp. 27-37. 2005.
- [2] B. Berman, O.Perez, Konda, BS. Sailesh, BE. Kohut, MH. Viera, S. Delgado, D. Zell, and Q. Li, "A review of the biologic effects, clinical efficacy, and safety of silicone elastomer sheeting for hypertrophic and keloid scar treatment and management." *Dermatologic surgery* 2007; 33:1291-1303.
- [3] A.Colas, J. Curtis, "Silicone biomaterials: History and chemistry & medical applications of silicones." *Biomaterials Science, Second Edition: An Introduction to Materials in Medicine*. 2004.
- [4] L. deLinde, B. Knothe "Therapist's management of the burned hand." In JM. Hunter, EJ. Mackin, AL. Callahan, eds. *Rehabilitation of the Hand and Upper Extremity*. St. Louis: Mosby Inc.: 2002: 1492 – 1526.
- [5] K Farquhar, "Silicone gel and hypertrophic scar formation: a literature review." *Canadian Journal of Occupational Therapy* Vol. 59, No. 2, pp. 78-86. 1992.
- [6] L. Haberman, "Silicone-only suspension (SOS) with socket-loc and the ring for the lower limb." *J Prosthet Orthot* 1995; 7:2.
- [7] KJ.Quinn, JH.Evans, JM. Courtney, JDS. Gaylor, and WH. Reid, "Non-pressure treatment of hypertrophic scars." *Burns*, 12, 102-108. 1985.
- [8] KJ. Quinn, "Silicone based scar therapy." *Care, Science and Practice*. 4, 7-9. 1986.