CUSTOM SILICONE LINERS FOR UPPER EXTREMITY PROSTHETICS

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ABSTRACT

This paper is intended to illustrate some new fitting techniques for the upper extremity amputee using two types of custom silicone liners manufactured at the Bloorview MacMillan Children’s Centre in Toronto.

The need for custom silicone liners for upper extremity clients was discovered with the attempted fitting of off-the-shelf silicone liners. These liners were not able to provide a total contact fit. Many of the prosthetic clients at the Centre have various levels of amputation that are congenital in nature. With the wide variety of shapes (and sizes) presented by our client’s residual limbs custom silicone liners were indicated over off-the-shelf liners.

Two techniques for fabricating custom silicone liners have been developed at the BMCC. The two fabricating procedures are described as custom injected and custom rolled silicone liners. There are advantages and disadvantages to both techniques. Both of these techniques offer greater accuracy in achieving total contact suction suspension for the upper extremity amputee regardless of the complexity of the limb presented.

INTRODUCTION

Techniques for suspending the upper extremity prosthesis have largely remained unchanged for years. Historically, greater resources have been utilized in improving the functional design of the upper extremity prosthesis, while less attention has been directed to improving the existing suspension techniques. Without sufficient suspension the upper extremity prosthesis will fail regardless of how sophisticated the functional design.

The preferred method of suspension by the amputee is that of a self-suspending device. The self-suspending socket, for the most part, provides the amputee with the freedom from the discomfort of a harness, but at a sacrifice in mobility and ranges in motion. The self-suspending socket design, for users with a transverse deficiency of an upper extremity, is one in which suspension is gained by encapsulating (within the socket) the joint prominences that are more proximal to the actual joint axis in the limb segment. This greatly reduces the ability of transverse rotation of the prosthesis by the amputee. It has been noted
that flexion of the prosthesis can also be restricted by the more proximal borders of the socket. Additionally it is recognized that the self-suspending prosthesis is less capable of retaining adequate suspension during situations of heavy perspiration brought on by both physical exertion and elevated climatic temperatures. The temporary loss of suspension can lead to frustration by the wearer and in extreme cases, rejection of the prosthesis. With an appropriately fitted silicone liner and shuttle lock system, these complications can be eliminated.

With the popularity of roll-on-silicone-liner systems available for the lower extremity, the prosthetic community is only now making this technology available for the upper extremity amputee. Despite the numerous options the prosthetist has in selecting lower extremity silicone liners for his or her clients, there are only a few manufacturers supplying upper extremity silicone socket liner systems. Due to the complex nature in fitting the upper extremity amputee one would begin to speculate as to the success rates of fitting the client with so few options with off-the-shelf liners. The Powered Upper Extremity Prosthetics Team at BMCC has discovered few off-the-shelf upper extremity silicone liners are suitable for the types of clients presented. The conical nature of these liners is not compatible with the tapered shapes most often presented. These liners are even more problematic when the pediatric client with a congenital limb deficiency is presented. The attractiveness of a true self-suspended silicone roll-on-liner for all upper extremity clients has led to the exploration of two different techniques for providing services for fabricating custom silicone liners for the clients at BMCC.

METHODS

The two procedures employed at the Centre for fabricating custom roll-on-silicone-liners are described as a custom injected silicone liner technique (figure 1) and a custom rolled-silicone liner technique (figure 2). These techniques have been adapted to allow for the production of the custom silicone liners to be implemented in a cost-effective and timely manner.
Both techniques rely on specific supplies and machinery and in the case of the rolled liner, specific environmental conditions, unique, to even the most modern prosthetic laboratory. The injected silicone liner technique requires a much lower initial investment in equipment and laboratory supplies. A separate dust-free laboratory with reliable environmental controls is essential to produce the custom rolled silicone liners. The machinery involved in the production of rolled silicone liners is also unique, even to the prosthetic industry. Due to the costs involved, it is difficult for the average prosthetic facility to even consider investing in the rolled silicone technology.

Clients assessed to be suitable candidates for a custom silicone liner are measured and casted for the purposes of creating a mold for a silicone suction socket liner. The limb is casted in plaster bandage or alginate, filled with porous plaster, and modified to attain the desired shape and dimensions necessary to achieve a total contact suction socket. It is suggested that the plaster model should be reduced in circumference by approximately 10 to 15 percent, with a greater reduction in circumference proximally as opposed to distally. Any sensitive or scarred areas should be marked as to prevent aggressive reduction in these areas. All measurements should be checked to assure the appropriate reductions have been made to the plaster model prior to fabrication. Liners designed with proximal trimlines which extend past the elbow joint, can be fabricated with pre-flexion to reduce any pinching of the liner or to allow for a greater range in elbow flexion.

The material used in the fabrication of a custom rolled silicone liner is defined as a High Temperature Vulcanization silicone elastomer or HTV silicone. The silicone is processed into sheet form by passing the elastomer between the two stainless steel rollers of a banbury mixer (figure 3). This technique is called Callendaring [1]. The mixer is capable of rolling the silicone into sheets of a desirable thickness. Once in sheet form the silicone is draped over the porous plaster cast. The seams of the silicone sheet are butted together, trimmed, and blended together with specialized tools to form a seamless liner. A shuttle attachment disc can be incorporated into the liner at this stage by sandwiching it in between separate layers of silicone and blending the seams with the first layer. Three wicking layers of stockinette are reflected over the liner. A PVA bag is applied over the model and placed under vacuum for 2 hours. Once the vacuum is removed the wicking layers can be discarded and the silicone can be lightly massaged in order to produce a polished surface. The liner is vulcanized at a temperature of 50 degrees Celsius for 8 hours. Once vulcanized the liner is removed from the cast and any necessary trimming is completed.
Fabricating an injected liner involves the use of Room Temperature Vulcanization silicone gel, or RTV silicone. The fabrication process requires a removable three part mold be designed with a void cavity around the positive cast. A pneumatic injection dispenser forces the silicone gel into this void within the mold. The mold is constructed such that the void area represents the appropriate shape and thickness of the liner after removal from the mold. The void is usually 2 millimeters thick for an upper extremity liner. Thicker or thinner areas can be designed into the liner to accommodate any sensitivity the client may have. The silicone gel is allowed to cure fully before the three-part mold is separated to free the liner from the cast. It is essential that the cast and shuttle disc be secured within the mold to prevent migration. This will facilitate accurate duplication of the liner if the client requests an additional liner. Once the silicone is free from the mold the trim lines can be established and any seams buffed with a silicone-sanding wheel. To facilitate donning and doffing of the roll-on liner, a Lycra cover can be adhered to the exterior surface with a silicone-bonding agent.

RESULTS

Since the custom liner is able to accommodate any shape a true negative atmosphere exists within the liner. This results in a superior suction fit. Only with negative atmosphere is perspiration permitted to transpire through the silicone liner, eliminating loss of suspension with elevated body temperature.

The silicones used in the two techniques differ in physical properties resulting in different characteristics of the liner. A comparison of the properties of gels and elastomers, of the same durometer, reveals elastomers have greater tear resistance and tensile strength due additional cross-linking of the polymer chains [2]. These elastomers are of higher molecular weight than silicone gels. The characteristic of silicone gel is that the polymer has a greater ability to flow reducing the transmission of shear forces to the limb. A wide variety of shore hardesses exist for both types of silicone allowing customization of the silicone properties.
Duplicating the injected liner is much less involved than producing a second rolled liner. To produce an injected liner the mold is reassembled, injected, after curing the liner is trimmed and the edges finished. An exact duplication is easily produced. To produce a second rolled liner the entire fabrication process is repeated with the exception of preparing the cast. It is much more difficult to duplicate the exact thickness and shuttle alignment with this technique. If corrections to the positive cast are required to achieve an appropriate fit, it is easily accomplished on the rolled liner cast. If errors are made in casting with the injected technique, the entire fabrication process must be repeated.

**DISCUSSION/CONCLUSION**

The difference in characteristics of the silicone liners in the two techniques provides the prosthetist with flexibility in tailoring the device to the needs of the client. The rolled liner is more durable but is not as effective in transmitting shear forces away from the limb as is the injected liner. The injected liner is more flexible which allows it to be rolled-on with greater ease. These fabrication techniques have proven to be both successful in providing reliable suspension as well as improving the function of the prosthetic device allowing ranges of motion which were lost with conventional suspension techniques.

**REFERENCES**