

SILICONE BLADDER SUSPENSION FOR THE WRIST DISARTICULATION LEVEL AMPUTEE USING A MINI PUMP SYSTEM TO ALTER VOLUMETRIC PRESSURE INSIDE THE SOCKET

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ABSTRACT

The purpose of this article is to describe an alternative fitting technique for the wrist disarticulation amputee. The socket design utilizes a silicone bladder contained in a sealed chamber with a one-way expulsion valve and built in mini pump. This design allows the volumetric pressure inside the socket to be controlled by the amount of air inside the chamber. Once the limb is positioned inside of the socket, the pump can be used to fill the chamber with air and apply controlled volumetric pressure throughout the entire length of the flexible bladder. The pump can also be configured to expand the bladder, and then the one-way release valve can be depressed to the appropriate level of compression. The two patients that have been fit with this system stated improved comfort and optimized suspension. This system provides the patient with the ability to alter the socket fit according to the desired activity.

INTRODUCTION

The primary goal in achieving a successful prosthetic outcome is providing the patient with a well-fit socket that is comfortable, functional and provides optimal suspension. As stated by Farnsworth, without a properly designed and fitted socket that is both comfortable and functional, your ability to benefit from your other prosthetic components will be limited [1]. The purpose for utilizing a flexible bladder design with volumetric adjustability is to provide the patient with these very important socket characteristics. The socket design is also beneficial for bulbous distal ends or irregular shapes due to the expandable properties of the silicone bladder. The silicone bladder can offer the patient a self-suspending socket design with improved cosmesis due to the absence of straps or windows, which other designs require for adequate suspension.

The bladder system can also be used in myoelectric fittings. Standard or remote electrodes can be used depending on the specific needs for each patient. Standard electrodes can be used if they can be placed high enough on the forearm to allow for optimal placement of the bladder. If the ideal electrode placement is located more distal on the forearm then remote electrodes may be your best option since they can be placed inside of the silicone bladder. To determine the appropriate location of the silicone bladder a measurement is taken at the widest point of the distal end using an ML gauge. Moving the ML gauge proximal on the forearm until you reach the dimension of the distal end will determine the proximal location of the silicone bladder. Generally, the silicone bladder will end at the apex of the distal end of the limb.

METHOD

The fabrication process for the silicone bladder system for wrist disarticulations is very similar to that used in fabricating silicone Syme's prostheses. When modifying the mold for a silicone bladder system the ideal bladder location should be identified and marked on the mold. Once marked, a circumferential reduction in volume is made in the proposed bladder location to insure that suction will be maintained in the socket. The most ideal method for fitting the test socket is to fabricate the inner socket, as it would be finished in the final prosthesis. The use of flexible plastics for diagnostic purposes typically will not give you an accurate assessment of the socket fit when using a silicone bladder for the finished product. To begin the fabrication process, a PVA bag is applied to the mold then approximately 6-8 layers of elastic stockinette. The stockinette at the distal end can either be saturated with resin prior to laminating in order to pinpoint the area needed to be rigid or laminated into the first lay up. If laminating into the first lay up apply the PVA bag then tie off the areas with string where the bladder will begin and end. Apply tape over the string to secure the string to the bag. This will prevent the bag from slipping and also apply compression to the stockinette to prevent resin from leaking into the bladder area. Cut away the proximal and distal ends of the bag at the location of the string leaving just the middle section PVA bag to protect the material in this area from being saturated by resin. The middle section will be laminated with silicone resin at a later stage. Apply the outer PVA bag to the mold and laminate the proximal and distal segments. Laminating should be done at low vacuum to minimize resin leaking into the bladder location. Once cured, remove the bag and apply pressure sensitive tape over the laminated sections and apply a new PVA bag to the mold. The tape will keep the lamination clean from silicone when laminating the bladder section. Laminate the middle section using silicone resin. The PVA bag can be removed once the silicone has completely cured. A thin polyethylene sheet or X-ray paper is then used to create the void for the expandable wall between the inner and outer sockets. The polyethylene sheet or X-ray paper should be placed on the mold to completely cover the area of the flexible bladder. Make sure to build up enough to accommodate the necessary expansion required to allow the limb to easily pass through without hitting the outer socket wall. Fill the polyethylene with bee's wax and let harden. Once hardened, shape the bee's wax to the appropriate shape and then prepare for the second lamination. Prior to laminating the second lay up, you will need to rough up the proximal and distal lamination to allow for proper adhesion of the inner and outer laminations. Apply your lay up directly over the bee's wax (no inner bag required) and laminate. Once cured, drill a small hole in the outer lamination in the location of the bladder and heat in oven at low temperature to remove the bee's wax. Prepare the socket for fitting by installing the mini pump (pneufit) and tubing into the hole drilled to remove the bee's wax. Creating an air tight seal around the tube is necessary when evaluating the silicone bladder for any leaks. A small hole should be drilled at the distal end to temporarily install a peewee valve for the fitting. Once the socket has been donned, the pressure inside of the socket can be controlled by depressing the mini pump. Pressing on the release valve of the pump will reduce the pressure inside the socket. Remove all of the air from the chamber and press the peewee valve to remove the limb from the socket.

DISCUSSION

The first patient that was fit with the system was previously wearing a flexible inner liner made with Proflex with silicone and a two-inch elastic tension band just proximal to the styloids. His main concern with this design was that in order to achieve optimal suspension the tension band had to fit snug and was uncomfortable over extended periods of time. Also, he had to put lotion on his limb and force his limb into the socket. The silicone bladder system that was designed for him had a peewee valve located at the distal end of the socket to maintain and release suction when needed, and a pneu-fit mini pump with an expulsion valve to alter the amount of pressure inside of the socket. The release valve that is attached to the pump would release air inside the chamber and allow easy doffing of the prosthesis.

The second patient that was fit with the design was a nine-year-old congenital amputee with Poland's Syndrome. Poland's syndrome is a congenital deformity consisting of ipsilateral syndactyly and pectoral girdle muscle deficiency [2]. The patient presented with a shortened radius, ulna and humerus with syndactyly. The patient was fit with a silicone bladder design, single site myoelectric control using remote electrodes and an Otto Bock system 2000 hand. The silicone bladder allowed for easy donning even with the syndactyly associated with his condition. He was able to maintain suction within the socket by the intimate fit of the silicone to his limb and the peewee valve located at the distal end. The electrodes were placed inside the silicone bladder located in the palmar area of his limb as shown in Fig. 1. Due to the shape of his limb, the electrodes needed to be able to move as he donned the prosthesis, otherwise he would not be able to pass by the electrodes and fully don the socket. By placing the electrodes inside the silicone bladder, he was able to don the socket with ease and achieve total contact with the electrodes at all times.



Fig. 1

RESULTS

The two patients that were fit with the silicone bladder system were different in many ways but had similar prosthetic requirements. They were both looking for adjustability within the socket to not only allow for easy donning and doffing of the prosthesis but to be able to adjust the socket fit as needed throughout the day. The silicone bladder system provided them with a streamline self-suspending socket design that could be self adjusted according to their specific activities. The first patient that was fit with the silicone bladder system was looking for improved comfort throughout a full day of use. He also

stated that his limb volume changed throughout the day, and he would like the ability to adjust the socket fit if necessary. The silicone bladder system provided him with the necessary adjustability to accommodate his limb volume change throughout the day. He also stated improved comfort over an extended period of wear time. The nine year old had a very slender build and a streamline design was important to him and his family. The silicone bladder system required no external straps or removable windows to provide optimal suspension. Other self-suspending designs may have been too bulky, complicated and less cosmetically appealing to him and his family. He was able to don and doff the prosthesis with ease while maintaining suction and total contact with the electrodes at all times.

CONCLUSION

Wrist disarticulation amputees, as well as all other levels, require a prosthesis that is not only comfortable but provides optimal suspension. Combining the expandable properties of silicone with the ability to adjust the pressure inside of the socket can offer patients new levels of comfort and fitting options. Other designs that are being considered could have silicone bladders in specified locations that apply pressure to isolated areas. For instance, silicone bladders could be placed along the antecubital depressions in an ACCI socket design for a trans-radial amputee to assist in lifting power and protect the radius during heavy lifting. Also, placing silicone bladders over the stabilizing wings of a trans-humeral socket can increase stability and rotational control when needed. Miniaturized electro-pneumatic motors can also be placed inside of the socket, which can activate the pump and fill the bladders with air. Available microprocessors or remote power switches can be used to activate the motors. When used in a myoelectric system, the motor can be activated by various control strategies such as a high/low configuration or co-contraction to switch between hand function and pump activation. In conclusion, silicone has many beneficial characteristics that can be implemented with our current technologies to offer patients alternatives to traditional fitting techniques and optimize their functional ability.

1. Farnsworth, T. Enhancing Your Comfort and Function Through Upper Extremity Socket Technology. *In Motion*. Vol. 14. Issue 6. November/December 2004.
2. Lord M, Laurenzano K, Hartmann R. Poland's Syndrome. *Clinical Pediatrics* Vol. 29 No. 10 October 1990.