

CASE REPORT: A PROSTHETIC OPTION FOR THE EXTREMELY SHORT BELOW ELBOW LIMB DEFICIENCY UTILIZING SWITCH CONTROL OF TERMINAL DEVICE

James H. Hughes, C.P.
Scottish Rite Children's Medical Center
1001 Johnson Ferry Road
Atlanta, Georgia 30342

ABSTRACT

The congenital transverse below elbow is the most common limb deficiency seen in our practice today. There is a small group of unilateral deficiencies who have such short forearm segments that they are fit with elbow disarticulation prostheses. When fit with this type prosthesis, the success rate usually drops significantly. This report will focus on our experiences of fitting a three month old male with an extremely short transverse deficiency and our concurrent fittings over the next 27 months. The prosthetic challenges of fitting this young child at the below elbow functional level are numerous. The parent's desire to have a functional hand incorporated into the prosthetic design makes this case more complicated. This case presentation will discuss the prosthetic plan that was followed to find an acceptable solution for the child and his family. Unique to this presentation is the use of a hybrid socket design and the utilization of a one function switch controlled electric hand.

HISTORY

The prosthetic plan for fitting a very short, unilateral below elbow limb deficiency has always been a challenge to the various clinicians around the globe. This group of patients usually have normal range of motion of the affected elbow and adequate strength. However, due to the shortness of the residual radius and/or ulna, quite often these patients are not able to maintain a full ROM in a prosthesis. Also, they do not present enough limb length to allow for adequate control and suspension of a conventional below elbow prosthetic design.

It has been reported by various clinics that when this group of patients are fit with elbow disarticulation type prostheses that their success rate usually drops significantly.^[1] There have been several studies of rejection of upper-limb prostheses by children.^[2,3] However, none of the studies have been conclusive as to why some children adapt to a prosthesis and others reject them. We do know that, at best, the upper extremity prosthesis is a tool. If the prosthesis does not improve the child's function, it will usually be rejected.^[4] When fitting young children with prostheses, it is important to establish a plan of action that will satisfy the child's needs, as well as the parents' desires. The limb deficiency team and parent/guardian must agree to the goals and understand their

roles in progressing the child through his/ her years of development.^[5]

INTRODUCTION OF CASE

Three month old male with a right congenital transverse deficiency is presented at our Limb Deficiency Clinic. Upon evaluation by our occupational therapist and physiatrist, it is reported that the child has normal cognitive and physical development for his age. His residual limb is very short but has a good strength. Range of motion of the affected elbow is also normal. No x-rays are ordered by the orthopedists, however, he says the radial length appears to be about one and one-half centimeters.

According to the social worker, the family is very stable and very interested in their child's needs - both now and in the future. The father is a physician and the mother a homemaker. The couple also has a four year old daughter. They have studied prosthetics and are familiar with the various conventional and myoelectric prosthetic systems. They have expressed that they would like to have their child fit with a hand and not a hook type device that they have seen. The couple is also interested in the possibility of limb lengthening.

After discussing the various issues of limb length, functional improvement, and cosmesis with the parents, a plan of action was agreed to by the limb deficiency team and the parents. We would build a passive prosthesis that would incorporate a cosmetic hand and it would be self-suspending if possible. We would also fit the child as a below elbow deficiency, even though elbow ROM would be limited.

PROSTHETIC GOALS FOR PASSIVE PROSTHESIS

The passive prosthesis is designed to help the limb deficient child achieve his developmental milestones in a close to normal fashion. The prosthetic concerns when fitting a unilateral transverse below elbow deficiency are numerous. First, we must try to improve functional abilities of the child, while also trying to satisfy the cosmetic desires of the parents. During the first year, it is extremely important that the parents support the rehab goals so that prosthetic intervention is successful.^[5] Second, the socket design of the prosthesis must allow for excellent suspension and control of the prosthetic forearm and hand. A third factor is that the prosthesis must allow for rapid growth and the weight of the prosthesis should be kept to a minimum.

Materials and Methods

A custom-made silicone suction liner was used to obtain suspension of the passive prosthesis. The liner was fabricated with a flexion or carrying angle built into the positive mold. A flexion angle of approximately 20% was modified into the liner mold. After fitting the silicone liner to the

child, tension was checked to see if the liner was too tight or too loose. The child was allowed to wear liner for about 20 minutes to verify fit. No redness or complaints were noted during or after removal of liner. Mom could don liner rather easily and this did not appear to be a concern. A second mold was made over the liner and two one-ply socks. Again, the flexion angle was maintained in the casting procedure. The child was then fit with a flexible test socket which incorporated high mediolateral and anterior/posterior walls. Range of motion of the elbow was limited to about 20 degrees of active flexion within the socket. Flexible inner socket was poured with plaster and acrylic outer socket was laminated. Forearm fabrication was carried out in the normal fashion using an Otto Bock passive hand and wrist unit. The finished passive arm consisted of the following: (1) silicone suction liner with velcro attachment strap; (2) flexible thermoplastic inner socket; (3) acrylic outer socket; (4) Otto Bock wrist unit, hand, and cosmetic glove.

Modifications to Design

During the first eight months of use, the only prosthetic changes that were made was the addition of a modified figure 8 harness and the remake of one silicone liner. The modified figure 8 harness was utilized to help the child have better control of the prosthetic forearm while crawling. The harness also helped with the stretching of the silicone liners due to the various weight bearing and gross grasping activities of the child. Weight was added to the distal forearm section at three month intervals in preparation for future prosthetic needs.

Functional Use During First Eight Months

The infant adapted to the passive prosthesis well. Within the first three weeks, the infant was wearing the prosthesis for more than six hours a day. While lying supine, it was noted that the infant would hold objects that were placed over him. While lying prone, a pillow was placed under his chest area so that excessive pressure would not take place at the cubital fold. The pillow modification also put him in a functional position so that he could swat and grasp objects until sitting balance was obtained. From six to eight months the child was able to sit independently and could raise the prosthesis in front of him at various heights without difficulty. Crawling independently was difficult due to inadequate flexion in the prosthetic forearm and shortness of anatomic lever arm. Occupational therapist worked with parents in instructing them to support torso while child was supine and trying to crawl. By eleven months of age all functional goals set by occupational therapist were achieved. Prosthesis had received two weight increases and had a total weight of 240 grams at this time. Growth liner had been removed and socket change was becoming necessary.

ACTIVATION OF TERMINAL DEVICE (11-30 MONTHS)

The parents had already expressed their concerns with their child being fit with a hand. It has been our experience that the present conventional hand components available for this age child are not functional at all.^[6] The conventional body powered hands require too much power and excursion to be of use to a toddler. Because we had success with the suspension, control, and comfort of the passive prosthesis, we decided to use the same methods on the activated prosthesis. The residual limb was so short that we felt the electrode site could not be obtained within the socket design, so myoelectric control was ruled out. If we could use electric switch control of the hand via a control harness, could a child this young understand the body movements needed to open and close the hand?

Materials and Methods

The finished activated prosthesis consisted of the following: (1) a silicone liner and flexible growth liner as previously mentioned; (2) standard figure 8 harness with Otto Bock external battery attached; (3) Variety Ability V-03 electric hand and wrist unit; (4) and Otto Bock 9 x 18 cable pull switch.

Therapy and Problem Solving

After delivery of the prosthesis utilizing the pull switch, the occupational therapist and parents realized that the child was going to have a difficult time distinguished how to operate the switch mechanism. The child was able to open the hand easily with glenohumeral flexion of the affected side, or bicipital abduction of the shoulders. However, he could not understand, nor could the OT teach him how to differentiate between opening and closing of the hand. After about two weeks of trying some parent/therapy ideas and loosening/tightening the figure 8 harness, we decided to see if we could come up with another solution.

Universal Artificial Limb company supplied us with a new circuit that could be used with the same system. The circuit allowed the hand to operate like a St. Anthony's or a one-site/one-function "cookie crunchier" system. The modification was an immediate success for the child.

Functional Use and Prosthetic Modifications

From 13 months to 18 months the child was seen in occupational therapy once a month. Mother and therapist reported that he was beginning to operate the hand but continued to use it as a passive device most of the time. He continued to wear the arm for more than eight hours a day.

The mother stated that he would open the prosthetic hand when reaching toward midline with his sound hand. We decided to add a piece of elastic to the control strap of his figure 8 harness. The elastic strap eliminated the unwanted opening of the hand and gave the child a more natural control motion. By 18 months, the child was operating his one site/one function switch controlled prosthesis in a manner equal to the myoelectric wearers of the same age group.

SUMMARY

For 18 months the child in this case presentation has continued to wear his switch operated below elbow prosthesis. Around 20 to 24 months of age, both the parents and therapist reported on his spontaneous functional patterns. It seems that the age in which he began to independently activate the terminal device without being cued, correlates strongly with the function of the same age children who are fit with standard cookie crunchier myoelectric systems at our center.^[6] From this case, we have concluded that a young child can be fit with a harnessed switch controlled device and master the body control movements with very little training. This case required a lot of problem solving by the Limb Deficiency Team. Without the great parent support and their patience, we would not have had a successful outcome.

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