



The Prosthetic Habilitation of a Congenital, Transradial Limb Deficient Child: A Case Study Analyzing the Functional Effectiveness and the Benefits of Early Prosthetic Fitting, Appropriate Prosthetic Equipment, and Consistent Caregiver Follow up.

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INTRODUCTION

According to Dillingham et. al. [1] there are on average 26 children born with an upper limb deficiency per 100,000 live births each year in the United States. The Dillingham study does acknowledge that previous research from other countries has indicated an upper limb deficiency rate of 50-62.5 per 100,000 live births. Evidence and opinions are conflicted regarding the functional effectiveness and necessity of fitting young, unilateral amputee children with an upper limb prosthesis, especially in regard to the unilateral congenital below elbow deficiency (UCBED)[2-13]. The difficulty in interpreting and comparing the studies' results is that there are different definitions of successful upper limb prosthetic use.

It is this author's assertion that, although these studies have value, the entire picture of a child's needs is not addressed. Not all previous studies assure that the subjects had early and proper fitting of the prosthesis, activity-appropriate and up-to-date prosthetic devices, parental support, therapeutic training, and consistent wearing schedules. In addition, these studies don't often address or evaluate symmetry of upper body muscle development, spinal alignment and proper body mechanics while completing bimanual tasks.

BACKGROUND

This case study follows a female child with a right UCBED from birth to 7 years of age. The

child was born with a "normal" presentation except for the fact that she is missing her right hand and 2/3 of her forearm. She utilizes multiple prosthetic devices.

At six months of age, the child was fitted with a passive prosthesis with a semi-flexible, passive hand attachment. This allowed her to become accustomed to wearing a prosthesis and to begin to explore right upper limb movement such as batting objects with an arm length equal to her left arm. The prosthesis was instrumental in helping to maintain sitting balance and to crawl in a typical manner with normal body mechanics. Later, a prosthetic hand in the pinch grasp shape was added. The thumb could be opened manually to allow the child or her parents to place objects in the device to encourage recognition that the prosthetic hand can hold and carry objects.

The initial plan was for a myoelectric fitting to occur at 12 months of age. This would allow the child to learn how to grasp with her right prosthetic hand at the same time that she was developing grasp patterns with her left hand. At 18 months after a struggle with the medical insurance company, she was fitted with a VASI myoelectric prosthesis with a fixed wrist. The prosthesis was activated with a "cookie crusher," single site electrode on her residual forearm extensor muscles. It performed erratically for 4 months, and it was unknown whether the problem was with the device or with the child's ability. Within 4 days of the device's problem being identified and corrected, the child began to voluntarily control the prosthesis at the

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age of 22 months. Through therapy and parental encouragement, the child began to use the electronically controlled prosthetic hand to reach for and to grasp objects. However, she did not have proportional control of the grasp until she began to use a dual site, proportional control program at age 3. With the new setup, she was able to demonstrate control over the speed and the grip force of the prosthetic hand during functional activities. This led to improved fine motor control. At age 6, her myoelectric prosthesis was switched to an Otto Bock System 2000 hand with a manual, rotating, friction wrist which allowed her to preposition her hand for activities and, as a result, use improved body mechanics.

Although the myoelectric prosthesis was worn full time (10-12 hours a day), it could not be used during sporting activities, sandbox play and other activities that might damage its sensitive electronic equipment and motor. At 3½ years the child was fitted with a passive sports prosthesis with a Free-Flex hand. This allowed her to begin to play sports such as soccer and t-ball. As needed, the hand was removed and easily replaced by other terminal ends such as a fixed hook for doing the “monkey bars” or pull ups, a tumbler for gymnastics, a modified Pinch Hitter for batting, and a Slap Shot Hockey device for playing hockey. These devices have allowed participation in extracurricular activities with age-typical form.

To allow the child to play the violin at age 3, another activity specific prosthesis was created to hold the bow. The custom made device has a spring to allow “wrist” motion, which is extremely important to the mechanics of playing the violin. With this feature, she is able to maintain a relaxed shoulder on the bowing side to help prevent future shoulder injury. Recently, the violin terminal device was switched to a TRS Violin 2 bow adaptor. Violin 2 is similar to the previous device but replaces the “wrist” spring with rubber bands, thus making the wrist friction more easily adjustable for the musician.

Recently, a voluntary closing body powered prosthesis with a figure of 9 harness was provided for active grip during activities that are potentially harmful for a myoelectric prosthesis, such as a dirty or wet environment. The child has found the body powered pros-

thesis to be difficult to use due to the shoulder and scapular movements that are required to control the prosthesis. In order to maintain cable excursion for consistent grasp pressure while the limb is moved toward the body, abnormal shoulder and scapular positions must be used. As a result, she has not used the prosthesis unless her myoelectric prosthesis has been sent away for a glove change or repairs.

RESULTS

This child has developed in a typical manner as compared to her peers during her 7 years and has no significant medical issues. She is of average size with good posture, symmetrical upper body musculature and no noted abnormal spinal curvature. Motor coordination and development appear normal in comparison to her peers. The child appears somewhat shy in new surroundings and with new people, but once she perceives acceptance, she is at ease, friendly and participates wholly. This child has many friends and appears confident. Other children and adults seem to perceive her as a typical 7 year old child once they become accustomed to her limb difference.

Function

Wearing upper limb prosthetic devices has allowed the child to do things that she would otherwise not be able to do such as negotiate the monkey bars (with assistance), play the violin, and participate in gymnastics. She has been able to develop bimanual upper limb skills and fine motor skills with reduced compensatory movements. It is anticipated that body mechanics during functional tasks will be improved further once she receives an electric wrist rotator for her myoelectric prosthesis.

Symmetrical development of upper body musculature

By using her right prosthesis as well as



her sound limb for activities and being able to perform activities with proper body mechanics, upper body musculature has developed symmetrically. In addition, there are no signs of scoliosis. Added weight may be a negative to wearing a myoelectric prosthesis, but for this child, the added weight may have contributed to the strengthening of her right shoulder, upper arm, and residual limb musculature as well as contributed to the maintenance of a straight spine.

Possible prevention of overuse syndromes

The child's development of bimanual upper limb skills with reduced compensatory movements has potentially minimized the effects of orthopedic changes and soft tissue damage that may lead to Cumulative Trauma Syndromes (CTS) in the future.

Self esteem

Measurement of self esteem is difficult because of the many variables that affect it. However, it appears that wearing a myoelectric prosthesis has had a positive effect on this child's self esteem. She likes the function and cosmesis it offers and is proud of her prosthesis. Having the opportunity to use multiple prosthetic devices which allow her to participate in age appropriate activities with her peers has also helped boost her self esteem. She knows she is different, but she feels special, instead of feeling badly about being limb deficient.

DISCUSSION

No objective outcome/standardized measures were performed on this child. Objective tests would be of interest for the sake of comparison. However, the fact that fitting this child with multiple prosthetic devices has been of benefit in terms of function, symmetrical muscular and spinal development, possible prevention of future CTS and development of positive self esteem denotes success to this particular child and the child's parents, therapists, and teachers.

The successful prosthetic outcome for this

child was achieved through the following:

- Early fitting: One of the main prosthetic goals for the child was to have her fitted early with an active terminal device especially since several research studies have concluded that rejection of a prosthesis is less likely if a child is fitted before 2 years of age [3,4,6,9]. The early fitting of a passive prosthesis at 6 months of age allowed her to become accustomed to wearing a prosthesis during most waking hours. She was able to incorporate the prosthesis into her movement strategies as she was developing the ability to reach out, bat an object, roll over, sit up and crawl. This made the transition to a myoelectric prosthesis an easy one. Fitting the child with a functional myoelectric prosthesis at 18 months allowed her to develop a pinch grasp on the right as well as to begin bimanual activities at a generally age appropriate time in her development.
- Properly fitting and up-to-date prosthetic equipment: This child was fortunate to have well fitting sockets and accessibility to prosthetic care when adjustments were required. She also was able to receive the most up-to-date prosthetic components that were available for children. This included lightweight materials and small, lightweight myoelectric batteries. She did have one experience of being fitted with a sports prosthesis that would not stay on. When she attempted to use it for anything functional, it would loosen and fall off. It was of no benefit to her. Once she was fitted with a properly fitting suspension system, she quickly incorporated the prosthesis into the desired activities.
- Therapeutic training: Early childhood special education for Occupational Therapy (OT) services began in home at 2½ years of age and progressed to OT in the pre-school setting at 3½ years of age. This

therapy taught the child to use her prosthesis more spontaneously, to develop a consistent prosthetic finger tip grasp, to learn to use vision in place of sensory feedback, to incorporate the prosthesis into bimanual activities, to develop fine motor control and self help abilities, to develop proper body mechanics, and to develop problem solving skills. Currently she receives OT at least once during each school quarter to assess how she is progressing with fine motor tasks, typing, body mechanics, and repositioning of her myoelectric hand. Recommendations are made to the teacher and parents so that therapy concepts are reinforced in the classroom and at home.

- Full time wearing schedule: The child's prosthetic devices, especially her myoelectric prosthesis, have been treated like a piece of clothing. The prosthesis is put on in the morning and taken off at night. Assuring consistent wearing of a prosthesis and encouraging her to use the prostheses in functional ways has been extremely valuable.
- Opportunity to try multiple devices: One upper limb prosthesis cannot replicate what a natural hand can do. Multiple devices are necessary to accomplish differing tasks. Crandall and Tomhave [12] suggest that providing children with multiple prosthetic devices appears to encourage children to wear prosthetic devices for longer periods. This child has been fortunate to have the opportunity to try different prosthetic devices and as a result has been able to participate in all age-appropriate activities like her peers. If a child is not allowed to try multiple prosthetic devices, great opportunities may be lost.

Most unilateral upper limb amputees will choose to do a one-handed task with the intact upper limb just as a person with two natural hands will prefer his dominant hand to complete a one-handed task. However, when it comes to a bimanual task, the one-handed person is at a disadvantage and will

need to use compensatory movement strategies to complete the task if not wearing a prosthesis. The task will be completed, but at what cost? Compensatory movement strategies which lead to improper body mechanics have the potential to create future CTS or spinal abnormalities such as scoliosis. One of the benefits of wearing an upper limb prosthetic device is the ability to perform bilateral tasks with proper body mechanics and thus help to prevent orthopedic changes or soft tissue injury.

This author was surprised to find that little research has addressed overuse syndromes in upper extremity amputees. Jones and Davidson [14] found that 50% of upper limb amputees in their study reported that they had CTS symptoms. Extrapolating from literature on overuse syndromes in the general population [15] Gambrell suggests that overuse syndromes can occur from compensatory movements and poor body mechanics associated with unilateral upper limb deficiency. In addition, Powers Hahe, Devli, Spence, and Milla [16] found an increased incidence of scoliosis in people with congenital upper limb deficiencies in comparison to the general population. Asymmetrical upper body muscle development, less limb weight on the affected side, and compensatory movements may contribute to the increased prevalence of scoliosis and CTS in UCBD.

An important question is: Does wearing an upper limb prosthesis full time reduce the likelihood of CTS and scoliosis? Further research is necessary to directly correlate unilateral, upper limb amputation to CTS and to compare the incidence of injury between those groups of upper limb amputees who choose not to wear a prosthesis with those who choose to wear a prosthesis. It would also be interesting to determine which type of prosthesis results in the least overuse injuries.

It appears to this author that if the child in this case study has been successful with pros-

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thetic devices, other UCBED children should be able to attain similar success. A child needs to have committed parents or caregivers who will reinforce a full time wearing schedule and encourage the child to incorporate the prosthesis into activities. Therapeutic training should be provided by a therapist who has experience with upper limb prosthetic training. The child should be fitted early with a comfortable, lightweight, passive prosthesis to prepare the child for future active grasp prostheses and activity specific prostheses. Assessing which child and parents are committed to making a prosthetic fit successful is difficult, but all children should be given the opportunity.

CONCLUSION

This case study demonstrates that a child with a unilateral congenital below elbow deficiency can be successful at incorporating prostheses into her daily activities if provided with multiple, properly fitting and up-to-date prosthetic options. Fitting a child early and enforcing a consistent wearing schedule with caregiver and therapeutic follow through also contributes to functional prosthetic success. Along with functional prosthetic success comes the ability for a child to participate in age appropriate activities that may lead to positive self esteem. In addition, using an upper limb prosthetic device may help a wearer to use proper body mechanics during activities. Proper body mechanics may reduce orthopedic changes in the spine and upper body joints and reduce the potential for soft tissue overuse injuries in the future.

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