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IMPROVEMENTS TO VARIETY ABILITY SYSTEMS INC. POWERED UPPER EXTREMITY PRODUCTS FOR CHILDREN

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INTRODUCTION

Since December 1983, when Variety Ability Systems Inc. (VASI) introduced the VV26 size hand for children, clinicians who provide powered upper extremity prosthetics have been inundated with a wide variety of components for the paediatric amputee population. The availability of the componentry has led to the development of suitable controlling strategies incorporated into electronic modules within the prostheses. These strategies have drawn upon the clinical teams to re-evaluate the selection and training criterion used through-out the fitting process. The evolution in powered upper-extremity prosthetics that has occurred over the last decade has been remarkable. This paper provides an overview of the VASI products now available for the juvenile amputee and discusses recent enhancements.

OVERVIEW

Variety Ability Systems Inc. was established in 1970 by the Variety Club of Ontario, Tent 28, to manufacture and distribute assistive devices that were unobtainable for children with physical disabilities. In 1978, the responsibility for the administration of VASI was assumed by The Hugh MacMillan Rehabilitation Centre (HMRC) and fostered the creation of a team of clinical, design and manufacturing personnel necessary to deliver clinically effective devices.(1)

Since 1983, the team has made available a wrist and several sizes of electric hands, and elbows to the product line for limb deficient children. We considered it practical to provide a range of components that would allow children to be fitted as young as possible to facilitate the acceptance and integration of the prosthesis into their body image and lifestyle The selection of the developments was also based on the needs related by parents, clinics and the availability of technology necessary to resolve the problems. Through comments provided by consumers and clinical colleagues and changes introduced by other manufacturers, VASI products have been continuously updated to help meet the need for an aesthetically pleasing, functional and reliable prosthetic device.

DESIGN REQUIREMENTS

The fundamental design requirements for all hands and elbows called for desirable cosmesis, minimal weight, high reliability, and modular design. Cosmesis in shaping and size has been achieved through injection molding techniques and weight has been minimized by using plastic parts where possible. Reliability has been secured through rigorous testing in the laboratory and the amputee's daily environment. Modular design ensured compatibility with other manufactures' products and options to be provided to the child.

The hand's can be fitted to children as young as 10 months of age and increase in size for children to approximately 9 years of age. The hand's weigh from 130 to 220 grams with the wrist attached and increase in size by 20% respectively. The three-point pinch force is age appropriate and ranges from 17N to 34N. The elbows can accommodate children from 3 years to adulthood. Weight ranges from 280 to 400 grams and torque from 1.63 NM. to 41 NM. While these initial goals have been met, further enhancements have been identified through consumer use and made possible through improvements in technology.

Circuits using surface mount technology have allowed more sophisticated electronic systems to be incorporated into the hand body including one-muscle control strategies with parental access switches. The clinic team can now more easily fit children as young as 1 year who are integrating these devices into their daily lifestyles. As well, smaller designs have improved reliability by removing components from the forearm and wrist areas. Amputees with long forearms and wrist disarticulations are also benefitting from these enhancements. Increased finger to thumb opening widths (50 mm) also allow children to use the grasp function of the VV0-3 electric hands in a much more useful way. Changes in shape to the cover and fingers of the VV5-9 hand are now being made to improve the aesthetic appeal of this device. Faster motors originally introduced in the VV5-9 hand were found to be inappropriate with on/off controllers but are becoming more useful for users of proportional systems.

Wrist units are now available in a wide assortment of lengths, diameters and shapes to help the prosthetist achieve the greatest aesthetic restoration. Amputees with wrist disarticulations can now be fitted with short options and are available with oval contouring. Colouring has been added to the finish of exposed aluminum surfaces to achieve a more natural appearance. Electric wrists have also been found to be beneficial for high level amputees who use either externally or body powered conventional prostheses.

Enhancements to the elbows have primarily concentrated on electrical interconnectability with numerous control and terminal device options available. The system, comprising of a comprehensive series of connectors enables mixing and matching of most manufacturers' components. As well, prosthetic systems can now be fabricated and serviced more effectively. These connectors are fabricated using injection molding to improve appearance, reliability and serviceability. Testing can be completed with simple test lights. A new design implemented into the cable holder of the VV38 elbow accommodates the fitting of smaller children who are also provided with an electric wrist option.

One of the challenges today is to include a suitably sized battery source that will deliver enough energy for a whole day's use while being light and small enough to be incorporated into the prosthesis. It is essential to use a suitably sized battery pack in an electrically powered prostheses to obtain optimum cosmesis. Rechargeable nickel-cadmium (NICAD) batteries are typically used for electrically powered upper extremity prostheses incorporating electric hands and elbows. Aside from the obvious cost savings afforded by reusable NICAD batteries, they can supply the high output currents required by small direct current motors and have a flat discharge curve suitable for electronic controllers such as those found within artificial limbs. While a standard 5-cell 225 mAh battery is usually provided to powered prosthetic users, children are now fitted as young as 8 to 12 months of age. With these youngsters, the use of smaller batteries has become a necessity. We provide a range of batteries from 120 mAh to 600 mAh with 4 or 5-cell battery packs depending on age.

Although VASI supplies overnight charging units, the battery packs typically have a limited life due to inappropriate charging conditions. These include overcharging, and extended periods when the battery is not used. Battery manufacturers recommend that NICAD battery packs be cycled between their fully charged and fully exhausted extremes in order to reduce the occurrence of a so-called "NICAD memory effect", which is characteristic of NICAD batteries that have undergone cycles of only partial discharge. This condition reduces the effective charge the battery can maintain as well as its life. The memory effect can be significantly reduced by cycling the battery between these extremes. To effectively service these limbs, clinical programs require a battery charger that has fast charge capability, can be used with 4 and 5-cell battery packs and has the capability to diagnose battery condition. VASI has recently introduced such a battery charger for the clinical programme and will soon have a similar unit suitable for home use.

TRAINING

Training a child to use a myoelectric prosthesis involves the identification of muscle sites for electrode placement, calibration of the myoelectric control system, and learning of the control technique.

The current practice of finding the optimal location involves repeatedly probing the potential muscle site with an electrode connected to a mivrovolt meter until a consistently large myoelectric signal is found. One difficulty with the traditionally used method occurs when the amputee is not able to repeat the same force of muscle contraction from one reading to another, and may result in control difficulty.

A portable hand-held instrument has been developed which consists of a special probe to measure myoelectric signals simultaneously within a localized area. (2) These electrodes are arranged to detect the myoelectric signals and guide the user to the origin of the best signal.

While this method offers some advantages over traditional methods, clinicians at HMRC find it best to fit young children with simpler control systems that use one muscle systems and avoid the need for precise electrode placement. As mentioned, these systems are available for the VV0-3 and VV2-6 hands. New tools are now available to help motivate children, who use two muscle systems to consistently repeat muscle contractions and develop independent signals for myoelectric control. One tool recently made available through VASI is a Nintendo Entertainment System myoelectric signal interface system (NEMESIS).

EDUCATION

The knowledge gained over the years concerning the fitting of children with powered prostheses has been combined recently into a comprehensive manual. This provides information on VASI's line of products and those from other manufacturers. As well, illustrations and examples of successful applications have been included. Clinical training and fitting methods also highlight considerations concerning the amputee's age and level of amputation.

CONSUMER INPUT

On October 31, 1991, the Ontario Ministry of Health announced the formation of a consortium of health care facilities and universities across the province. A part of the mandate is to encourage research and development in Prosthetics and Orthotics and to transfer the developments to manufacturers of assistive technologies. Within this consortium, consumers are helping to define the need for new components and improve current products. This role has always been an important factor to VASI's developmental activities and has helped to define VASI's products. As a manufacturing partner with the newly established Ontario Rehabilitation Technology Consortium, VASI can assure the consumer of their valuable role as partners throughout the research and development process.

1. Mifsud, M., Milner, M. (1986): "A Model of a Powered Upper Extremity Research Development Program" Proceedings of the 8th Annual Conference of the IEEE/Engineering in Medicine and Biology Society, Texas, April, Vol. 3 of 3, p. 1889.

2. Lehmann, D., Kurtz, I., Mifsud, M. Naumann, S., (1992): "Portable Muscle Site Identification System for Myoelectric Controlled Prostheses" Proceedings of the Seventh World Congress of ISPO International Society of Prosthetics and Orthotics, June.