CLINICAL REPORT

Clinical and Laboratory Study of Amputation Surgery and Rehabilitation

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INTRODUCTION

Prosthetics Research Study (PRS) continues its ongoing programs of clinical and laboratory research into amputation surgery; immediate postsurgical amputee management; lower limb prosthetic development, including the automated fabrication of prostheses and other mobility aids; a basic and clinical study of wound healing as it relates to amputation surgery and postsurgical management; engineering investigation into the mechanical properties of soft tissues and the response of living soft tissues to application of force; and technology transfer of automated fabrication methods into the clinical services of the Department of Veterans Affairs medical care system.

PROGRESS AND RESULTS

Prosthesis Force Transducer

Preliminary design and engineering analyses of the prosthesis force transducer have been completed. The design incorporates piezoelectric quartz crystals as force sensing elements to obtain force information at three discrete locations within the transducer. Given these data (9 forces), the complete set of forces and moments (Fx, Fy, Fz, Mx, My, Mz) at the socket due to ground reaction forces can be obtained. The device as designed will be less than 1 cm thick, 7 cm in diameter, and will weigh approximately 800 g. To date, the analog electronics have been purchased as well as the crystals and other raw materials.

Diabetic Footwear

In conjunction with the PRS diabetic footwear study, we have undertaken a study of three-dimensional (3-D) foot morphology. We have obtained digital images of over 100 feet using a Cyberware™ laser scanner, and over 50 pairs of images from an Amfit™ contact scanner. The laser-scanned images provide full 3-D shape information over the entire foot (dorsal and plantar aspects), while the contact scans provide only plantar surface information. Custom software has been written and the DVA/ShapeMaker™ software has been modified to facilitate quantitative comparison of these scans. To date only preliminary analysis of the data has been undertaken, but shows great promise as a tool for understanding foot morphology, as well as designing and fabricating custom insoles and footwear.

Gait Activity Monitor

We have developed a compact, self-contained gait activity monitor (GAM) which records the number of steps taken by a patient over a 2-week period. The GAM does not require patient intervention and has a sealed, waterproof case which prevents tampering. It provides the clinician with an objective, reliable measure of functional outcome for evaluation of new prosthetic devices and medical treatments. We have built four prototype units and collected data from three subjects for up to one week. We are currently refining the mechanical sensor and designing software for data analysis.
Mechanical Properties of Skin

To study the response of skin to mechanical stress, we designed and built an automated mechanical stimulator capable of applying precise, repetitive forces in both the normal and shear directions. The stimulator was applied \textit{in vivo} to the skin of pigs with gradually increasing amplitude over a specified number of days. At the end of the trial period, tissue samples were taken and studied using standard histological procedures. Preliminary experiments suggest there is a change in the structure of collagen fibers in response to the mechanical stress.

Residual Limb Volume Changes

An optical silhouette scanner has been designed and constructed for measuring both diurnal and long-term volume changes in a residual limb. This device utilizes a rotating charge coupled device (CCD) camera and light source to obtain a series of 2-D silhouettes around the residual limb. The silhouettes are then reconstructed into a 3-D computer image of the residual limb from which volume measurements can be made. The device is currently undergoing preliminary testing.

Studies were completed where it was found that gamma irradiation of blood transfusions inhibited their ability to sensitize to minor (non-major histocompatibility) transplantation antigens as part of a project to modify blood so as to prevent sensitization yet maintain the ability to induce tolerance for foreign transplant antigens.

AFMA

The Automated Fabrication of Mobility Aids (AFMA) system makes it possible to produce a limb at reduced price in a shortened time. Rectification techniques permit a consistent socket fit. The data are easily filed with reproducibility of the limb and any needed adjustments easily, quickly, and inexpensively made. These techniques now include a PRS above-knee (AK) socket design unique in its characteristics in that it incorporates the advantages of both the classical quadrilateral socket, the narrow ML (Long) socket and the advantages of a flexible/external frame socket. This technique together with the development of the VA/DAV/PRS Knee has allowed us to complete the lower limb prosthetic system as planned.

Training courses were developed and begun for the technology transfer of AFMA into the VA Medical Centers. Three centers were established on the west coast, two remote sites where AFMA limbs are now designed and fit and one central fabrication site where they fabricate the AFMA sockets.

BIBLIOGRAPHY


