

## II. Orthotics

### The Role of Pressure Distribution Measurement in Diabetic Foot Care

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Sponsor: VA Rehabilitation Research and Development Service

**Purpose**—The purpose of this study was to determine the value of pressure distribution measurement in the prevention of neuropathic plantar ulcerations in the diabetic individual. Based upon a review of the literature and on our own previous work in this area, specific hypotheses tested were as follows: 1) There will be significantly higher pressures under the forefoot and significantly lower pressures under the toes in the diabetic patients, as compared to the control group. 2) The above trends will become more marked over a two-year period. 3) Quantitative assessment of the plantar pressure distribution will be effective in identifying patients who are “at risk” for the development of lesions. 4) The group of patients receiving a program of enhanced foot care will develop significantly fewer non-traumatic plantar lesions than the group receiving normal foot care.

**Progress**—Phase 1 of the research program was completed. Activities at Penn State University included the completion of a calibration device for the pressure platform, configuration of new computer hardware and development of software for data collection, display and processing. A pool of 100 possible diabetic subjects was identified at the Lebanon VAMC.

Phase 2 was begun with a comprehensive medical screening of 87 diabetic patients and 41 non-diabetic individuals. The examination included detailed measurements of sensation, foot structure and non-invasive vascular tests. Upon completion of the screening process, 60 diabetics were selected for inclusion in the study. The criteria for inclusion were vibratory perception thresholds  $> 20$  units, loss of protective sensation by monofilament testing, history of previous plantar ulceration and structural foot deformities which would predispose the patient

to plantar ulceration. Patients selected were then randomly assigned to two groups—enhanced care and normal care. A third group of 30 subjects was selected from the pool of non-diabetic subjects to serve as age- and weight-matched controls.

Initial pressure data was collected for the control group subjects. Pressure distribution has been measured every 4 months for the normal and enhanced care groups. Three data collection sessions have been completed for each diabetic group with over 2200 trials recorded. The enhanced care group received two pairs of special footwear consisting of extra-depth shoes with soft molded insoles. Patients have attended outpatient clinic visits every 4 to 8 weeks to monitor their progress. An annual patient education conference has been provided to the normal and enhanced care groups. Two of our patients have died, two have had cerebrovascular accidents and two have dropped out of the study for non-medical reasons.

**Preliminary Results**—A subset of data consisting of 12 subjects from each group ( $N = 36$ ) were selected for the purpose of performing a preliminary analysis. Comparison of peak plantar pressure means between groups showed a significant difference ( $p < 0.03$ ) for non-diabetic controls versus diabetics with a history of ulceration. No significant difference was found between non-ulcer diabetics and diabetics with ulcers, but a clear trend was present, suggesting higher pressures in the ulcer group.

Peak pressure at ulcer locations varied from 312 to 1895 kPa. The highest pressures were noted under the second metatarsal head. In general, the peak plantar pressure corresponded with the site of ulceration but exceptions were noted at the toes and heel.

The incidence of plantar lesions at the beginning

of the study was 8 and 13 for the normal and enhanced care group, respectively. Since the delivery of the special footwear to the enhanced care group there have been only 4 lesions. This represents a 69 percent reduction in the incidence of plantar injuries in this group.

Diabetics with a history of ulceration had significantly greater ( $p < 0.005$ ) deformity as compared to the non-ulcer diabetic group. The most common deformity was found to be clawtoes. Monofilament thresholds were significantly greater in the diabetics with ulceration as compared to non-diabetic con-

trols. No significant difference was found between the two diabetic groups. Mean vibratory thresholds were significantly different ( $p < 0.001$ ) between all three groups. The minimum threshold at the site of ulceration was 13.2 micrometers of displacement.

The vascular index did not vary significantly between groups but some trends were noted. The index tended to decrease in the non-ulcer diabetic group suggesting a mild decrement in blood perfusion. In contrast, the index in the diabetic ulcer group was similar to the non-diabetic controls which may indicate decreased arterial compliance.

### **Effectiveness of Shock Absorbing Materials in Reducing Heelstrike Forces in Walking**

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*Sponsor: VA Rehabilitation Research and Development Service; Bioengineering Alliance of South Carolina*

**Purpose**—Degenerative changes have been shown to be caused or worsened by mechanical factors, in particular, repetitive loading. Although forces which arise normally in walking are usually absorbed easily by the musculo-skeletal system, this is not necessarily the case in subjects with joint pathology. Forces may cause damage to joints in people whose shock-absorbing capabilities have diminished due to age, trauma, or deformity. It may be possible to replace some of this shock absorbency by using insole materials inserted into the shoes. The effectiveness of several of these materials was the subject of this investigation.

**Progress**—A heel pad instrumented with eight piezoelectric ceramic discs served as the transducer to measure forces under the feet as subjects walked on a treadmill. The heel pad was placed inside a pair of specially-designed test shoes which all sub-

jects were asked to wear. Subjects walked at a constant, comfortable speed throughout the test. Data was collected, stored and statistically analyzed on a desktop personal computer.

**Preliminary Results**—Preliminary studies on normal individuals showed that 10 materials out of 23 tested were effective in reducing heel strike forces. Four of these were used in a test on 10 subjects who either had to moderate osteoarthritis or had undergone total joint replacement in the hips or knees. All subjects tested each of the materials and these tests were compared to one with no insole in the shoe. Results showed that all four materials significantly reduced both force and impulse (area under the force-time curve) in all subjects. None of the materials was found to be significantly better than the others in this capacity.

## Functional Kinesiology of Knee Bracing

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*Sponsor: VA Rehabilitation Research and Development Service*

**Purpose**—The objective of this project is to investigate the effects of five functional braces on the kinesiology of the injured knee. Measurements will be made using a six-degree-of-freedom goniometry and electromyography during walking and pivoting.

**Progress**—The first major challenge is to measure the kinematics of the braced knee. A six-degree-of-freedom goniometer has been designed and is being fabricated presently for this purpose. Testing of the goniometer and implementing necessary design changes will be accomplished this year.

## Therapeutic Evaluation of the VA San Francisco Therapeutic Molded Shoe and Diabetic Risk Stratification

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*Sponsor: VA Rehabilitation Research and Development Service*

**Purpose**—According to Levin, lesions of the foot are responsible for more than one-fifth of the operations performed on diabetic patients. It would therefore be prudent both financially and medically to define the diabetic population at risk and to develop effective methods of intervention such that pedal ulcerations and amputations can be prevented or minimized. The purpose of this project is to: 1) develop and conduct a series of non-invasive examinations which will be used in assessing the predisposition toward foot ulceration and potential lower limb amputation in the diabetic population; 2) develop a tissue breakdown potential index or risk index based on these noninvasive screening examinations; 3) conduct a prospective evaluation of the natural course of diabetic insensate foot; and, 4) conduct a clinical evaluation of the therapeutic effectiveness of the VA San Francisco Therapeutic Molded Shoe.

**Progress**—The establishment of a multi-disciplinary team was accomplished through the coordination of the STAMP director. A comprehensive history and physical examination was designed specifically for obtaining the most complete information relative to a patient's diabetes, vascular, neurological and biomechanics status. A cross-sectional study of patients in the metabolic endocrine clinic was conducted to determine the frequency of pathological and social

factors presenting to patients with diabetes mellitus.

The VA San Francisco Therapeutic Molded Shoe will be evaluated as to its therapeutic effectiveness. One group of patients determined to be at high risk of ulceration or limb loss will be provided both a molded shoe and sandal. A second similar group of diabetic patients will continue to receive the type of care and shoe gear normally provided to them.

**Preliminary Results**—A cross-sectional study of the frequency of lower extremity complications secondary to diabetes mellitus of patients presenting to a metabolic-endocrine service has been completed. Analysis thus far has indicated that of 92 patients studied, 52 percent had no neuropathy or foot complication, 32 percent had clinical neuropathy without a history of complication and 16 percent have had a lower extremity complication including pedal ulceration and amputation. Further analysis of the 94-patient study is nearing completion.

There has been established a Diabetic Foot Ulcer Clinic in order to both facilitate and standardize a multi-disciplinary treatment plan. Such a clinic provides the clinical staff the necessary tools to employ the talents of a variety of specialties at one location and at one time. It also provides the team a method to more thoroughly evaluate the efficacy of various treatment plans in a timely fashion.

**Future Plans**—Prototype molded therapeutic sandals and oxfords have been designed but as yet not evaluated. Both shoe types appear to achieve the goals of lower fabrication time and cost. The therapeutic effectiveness of the shoes will be evaluated

on those high-risk patients being evaluated and treated by the Diabetic Foot Ulcer Clinic. An additional 40 patients with foot ulcers are now being followed in the clinic. Patients from the clinic will soon be recruited into the clinical trials for the shoe.

### **DataGlove Semi-Automated Hand Function Evaluation System** ---

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**Sponsor:** VA Rehabilitation Research and Development Service (Project #XA458-R)

**Purpose**—Loss of hand function prohibitively influences the patient, his family and society. Annual costs due to hand impairments total \$10 billion. Improvements in hand and upper extremity function would help the patient become more independent and more socially interactive, thus reducing the burden on the family and society.

The DataGlove will address three major problems in treating hand impairments. These are: 1) assessing the exact extent of the impairment; 2) determining the best therapy for the impairment; and, 3) evaluating the results of therapy, whether from surgery or rehabilitation.

The DataGlove will be used to collect data from patients with impaired function secondary to a number of diseases, including spinal cord injuries, peripheral nerve injuries, and other impairments. After therapy, such as surgical tendon transfers, the hand motions will again be recorded and compared to the motions that were recorded pre-operatively.

The effects of specific transfers and the benefits of one transfer or combination of transfers over another will then be analyzed. Other therapeutic modalities such as hand therapy and external splints will be likewise evaluated. A library of normal hand motions, impaired hand motions, and the effect of different modalities for treating the impairments can then be created.

Thus, the goal will be to analyze “new” data obtained from the DataGlove to determine if it will better guide the choice of therapeutic modalities for specific hand impairments. In addition, it will provide patient education with respect to the hand impairment they have and how it changes with an integrated program of therapy. It will help patients to understand what they can expect from a planned surgical treatment for their own impairment based on the library of previously recorded pre- and post-operative DataGlove analyses.

### **A Comparison of the Effectiveness of Flexible and Rigid Shoes in Relieving Pain at the Metatarsophalangeal Joints of Rheumatoid Arthritis Patients** ---

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**Sponsor:** CAFIR, University of Montreal

**Purpose**—Rheumatoid arthritis is a systemic inflammatory disease, characterized primarily by joint inflammation, which can lead to permanent joint damage. The foot is involved in up to 88 percent of cases leading to foot pain, ambulation problems, loss of independence and diminished productivity in both the home and work environment. Traditionally, the treatment of foot pain includes rest, med-

ication and the prescription of orthoses. The type of shoes worn can lead to a new load distribution configuration and limit the effectiveness of the orthosis. According to the authors, there is no scientific data examining the role of the shoe material, on the load distribution beneath the metatarsal heads and muscle activation pattern, in the estimation of the performance of the shoe.

**Progress**—We hypothesized that flexible-sole shoes, which provide cushioning in acute metatarsalgia, can better distribute the load on the metatarsal heads; whereas, rigid-sole shoes, which limit metatarsal motion, will reduce the load acting at the metatarsal heads in chronic metatarsalgia, while still enabling good and efficient foot propulsion. Our study will measure kinematic and kinetic gait parameters (obtained by high speed photography) by placing discrete load cells beneath the metatarsal heads, the lateral border of the foot and the calcaneus: by taking force-plate measurements and by

studying muscle activation patterns in patients with rheumatoid arthritis, whose footwear will be varied from a flexible-sole shoe to a rigid-sole shoe.

The significance of the study will be to obtain a better understanding of the factors which can be controlled in part by the use of different shoe rigidity in the relief of metatarsalgia. Hopefully, measurements will be derived which could have widespread application in determining which patients might benefit best from the purchase of a flexible or rigid shoe.

### Neofrakt versus Scotchcast in the Tone Reducing Ankle Foot Orthosis

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Sponsor: *Hugh MacMillan Medical Centre Student Research Award*

**Purpose**—This project was designed to test the practicality of an alternative material (Neofrakt) in the design of the Tone Reducing Ankle Foot Orthosis (TRAFO). Present TRAFO design incorporates Scotchcast in the hindfoot and shank portion of the device. Modifications to the orthosis following casting are limited, as Scotchcast does not maintain the property of plasticity once it has cured.

**Progress**—The Neofrakt casting procedure required the use of padding and cotton stockinette similar to the Scotchcast procedure. All patients were to have undergone a trial fitting in order to allow the orthotist to complete fine modifications and assess pressure areas.

Patient follow-up was to take place at 2-week intervals for a period of 3 months, using forms that would assist in the collection of data which included the examination of the effectiveness and durability

of the Neofrakt material.

**Preliminary Results**—The casting procedure was assessed to be more difficult with the Neofrakt than with the Scotchcast in all cases. Problems reported in the casting procedure included an excessive material thickness and setting time, poor fit of Neofrakt casting stockinette (resulting in wrinkling on the inner surface of the device), and the leakage of foam through the outer surface of the Neofrakt stockinette. Acceptable limb positioning was obtained in only one of the ten casts taken.

**Future Plans/Implications**—At the present time, the research team cannot recommend the use of Neofrakt in the TRAFO design. Problems with material properties must be cleared up prior to further involvement of Neofrakt in the casting and construction of the Tone Reducing Ankle Foot Orthosis.

### The LSU Reciprocating Gait Orthosis

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Sponsor: *LSU Department of Orthopaedics*

**Purpose**—The objective of this research was to provide patients suffering lower extremity involvement with an orthotic means to ambulate in a safe

and reciprocal (swinging one leg simultaneously with push off with the contralateral leg) manner.

**Progress**—A long leg brace evolved and was modified over the last 10 years to meet the objectives of this project. The brace has—with addition to the leg members—pelvic and thoracic supports that allow a substantial increase in balance and stability. The hip joints are engaged to each other with a pair of sleeved Bowden cables so that, during the swing phase of one leg, force is transmitted to the contralateral hip with the cable to induce hip extension, or “push off.” Special locks are available at the hip and knee joints to allow the patient to sit (hip and knee flexion) and stand up in a semi-automatic mode.

**Preliminary Results**—To date, the brace has been fitted to the following patient categories: cerebral palsy (36); spina bifida (300); muscular dystrophy (60); and paraplegics (225); quadriplegics (36); and, osteogenesis imperfecta (14).

**Future Plans**—Efforts are being focused on improving the energy transmission efficiency in the hip joint-cable mechanism with the objective of reducing the metabolic energy consumption expended by the patient.

### Development of Design Methodology for Anterior Cruciate Ligament-Deficient Knee Braces

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**Purpose**—The objective of this project was to develop design methodology of knee braces that will meet the needs of patients with anterior cruciate ligament ruptures or damage.

**Progress**—A large volume of clinical, physiological and biomechanical data relating to knee performance was evaluated and design criteria developed for the requirements from a knee brace. Evaluation of many commercially available braces demonstrated that

none provided a reliable anterior protection mechanism to prevent tibia subluxation, although varus-valgus protection is available.

**Preliminary Results**—Two designs were implemented, one of which was also evaluated on a patient. The designs provide anterior tibial protection mechanism or reduction of extension velocity to avoid sudden or fast impact on the joint. Additional patient evaluation is in progress.

### Ambulatory Orthoses for the Severely Disabled: A Comparative Study

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*Sponsor: The National Fund for Research into Crippling Diseases (Action Research for the Crippled Child)*

**Purpose**—A great deal of interest is currently being shown, both in the UK and elsewhere, in ambulatory orthoses for the severely locomotor disabled. This has been particularly so in the UK since the recent introduction of the Reciprocating Gait Orthosis (RGO). However, despite the RGO having been available in the USA for a number of years, very little published data is available, and comparative data on alternative devices, particularly the Oswestry Hip Guidance Orthosis, is equally scarce.

In conjunction with a parallel project aimed at determining the physiological benefits of an upright posture and the psychological and sociological effects of various alternative ambulatory orthoses, the aim of this project is to undertake a comparative assessment of four types of orthosis, namely the swivel walker, “full-set” of calipers and the reciprocating devices, the Hip Guidance Orthosis (HGO) and the Reciprocating Gait Orthosis (RGO). A functional assessment of each device, and of the training

of each patient, is to be based on the measurement of the physiological cost of ambulation using a parameter based on heart rate changes, the Physiological Cost Index (PCI), and an analysis of video recordings to obtain the basic temporal distance parameters of the resulting gait. It is also intended to update an ongoing analysis of the total costs to the health service, both of the initial prescription of each device and all subsequent expenditure. Additionally, a procedure for monitoring the long term use of these devices, with a view to assessing their contribution to the everyday lives of their users, is to be initiated.

**Progress**—A portable heart rate and video monitoring system has been developed to enable PCI and video assessments to be carried out on location.

A large number of patients, principally adult traumatic paraplegics and spina bifida children, have already entered the RGO program. Each is assessed in any current device prior to training, and in their

RGO at 2, 6, and 10 weeks post-final fitting and at regular intervals of 3 to 6 months thereafter, for as long as is practical. A similar procedure is to be adopted with patients entering an HGO program. Additionally, a small group of subjects are to be asked to use each of at least three of the devices, but including both the RGO and HGO, in a randomly assigned serial test, for a period of 3 months each.

**Future Plans/Implications**—The project is still in its initial stages. It is anticipated, however, that the results will, at the end of our initial period of study in 1991, provide useful information for the professionals routinely involved with the treatment of the severely ambulatory disabled, particularly as regards the prescription criteria for the various devices. In addition, the techniques developed for orthosis assessment will be useful for the routine short- and long-term assessment of patients seen in our orthotic clinics.

## The Biomechanics of Flat-Foot Running

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**Sponsor:** *NeuroMuscular Research Center*

**Purpose**—The syndrome of flat-feet (extreme lowering of the arches) is quite prevalent in the human population. If left untreated, it usually causes severe pain in the lower limbs, and may contribute to the incidence of injuries in patients engaged in a physical activity such as running. In-shoe orthoses are usually prescribed to counter the adverse effects of such an anatomical anomaly.

**Progress**—A clinical study to test the effect of the

orthoses on the biomechanics of running has been undertaken. This study involves having subjects run over a forceplate. The patterns of foot-floor interaction forces, measured by the forceplate, will be studied for flat-foot runners running with and without their orthoses. The study will document the effect of orthoses on the patterns of foot-floor interaction forces, and then compare this information with the patterns produced by normal subjects.

## Assistance of Upper Limb Mobility

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**Sponsor:** *The Northern Ireland Prosthetic Orthotic and Aids Service*

**Purpose**—The aim of this project is to develop a device which supports the weight of the upper limbs of muscular dystrophy patients, allowing residual muscle strength for useful function.

**Progress**—The former system of overhead supports has progressed from using counterweights and pulleys to suspend the arms, to a design using elastic cords and a lever. The geometry of the design is

such as to provide a constant force throughout the range of movement of a lever from which the arm is suspended. A simple cuff is employed to support the arm, which is so designed to prevent slippage at any position. The device may be fitted readily to wheelchairs, and lifting force can easily be adjusted by an attendant to compensate for varying weights

of clothing. Several prototype units have been assembled for trials, during which final development will take place while seeking a local manufacturer.

#### Publications Resulting from This Research

**Upper Limb Weakness in Children with Duchenne Muscular Dystrophy—A Neglected Problem.** James WV and Orr JF, *Prosthetics and Orthotics International* 8:111-113, 1984.

## Development of a Powered Orthosis for Lower Limbs

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*Sponsor: Office for Life Science Promotion of the Institute of Physical and Chemical Research, Agency of Science and Technology, Japanese Government*

**Purpose**—To obtain an appropriate gait pattern, a powered orthosis for paralyzed lower limbs is being developed that supports the patient's body and controls lower limb movement. As a final goal, the powered orthosis will enable paraplegic patients to walk on level ground with a variable cadence, to stand and sit, and to go up and down a staircase by appropriate command.

**Progress**—Considering the results obtained experimentally through the preceding years, a second prototype was designed and constructed in 1986. Its main purpose was to have a powered orthosis for lower limbs of an appropriate size so that control methods explored in the past several years could be tested on paraplegic patients. The orthosis was fabricated in C-FRP (Carbon Fiber Reinforced Plastic) and in thigh and femur parts; four electrohydraulic actuators were incorporated. These actuators now have digital controls, in contrast with the first prototype which used an analog type. Each actuator is controlled by a single-board microcomputer, and all of these are totally controlled by a

microcomputer. Sensory systems such as foot-switch sensors to detect plantar contact, photo encoder to measure relative joint angle, and posture sensor to measure torso inclination in sagittal and frontal planes, are used to accomplish a stable powered walk.

**Preliminary Results**—By basic experiments on a normal subject, it was verified that this second version of the powered orthosis had sufficient torque for powered walk. The orthosis itself weighs 19.5 kg, and its control wagon 68 kg, which should be moved with the powered walk. A powered orthosis will be realized using these two components.

**Future Plans**—Since the first orthosis of the second version was successful, a second orthosis for paraplegic patients is under construction. As these two orthoses are identical except for geometrical size, all the control methods will be thoroughly tested on normal subjects prior to the clinical tests. The first clinical results will be obtained by late 1987.

## Talus Control Ankle Foot Orthosis: A New Design

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*Sponsor: Special Children's Center, Inc.*

**Purpose**—This ankle foot orthosis (AFO) was developed jointly by two physical therapists and an orthotist. It provides dorsal support, three points of

control, and normal heel contact with shoe. Plantar surface control, such as arch supports, are not required. It has been used on 28 patients with

neurological and orthopedic needs. The principle guiding this design has been that if the talus can be aligned and held in a normal position, it is the "keystone" of the foot and will provide stability for the rest of the foot.

**Progress**—An examination procedure to determine if the patient's foot is structurally sound enough to benefit from this type of support has been developed, based on the talus neutral procedure. Gait analysis using high-speed motion picture photography and Vanguard Motion Analysis with several clients with traditional posterior shell AFO's, barefoot, and talus control ankle foot orthoses have shown variable results. We currently hypothesize that one variable is the amount of upper extremity support required for ambulation. It appears that less weight borne on the lower extremities decreases the benefit during gait. X-ray studies were also made to assist the fabricator to achieve better bony alignment.

**Preliminary Results**—Fabrication of this device requires different procedures for the orthotist. The casting method for creating the positive mold is different. Fitting and trimming this orthosis varies widely from a traditional PSA. Cost will vary with the location and amount of experience of the fabricator. The first few we attempted required several remakes. This design is now the orthosis of choice for providing ankle and foot support in our area.

**Future Plans/Implications**—We would like to share this design with others in our field. We are currently adding more subjects to our study as well as seeking funding to continue this work.

#### Publications Resulting from This Research

**Talus Control Ankle Foot Orthosis: A New Design.** Byers-Hinkley K, Logan L, Brown R, *Orthotics and Prosthetics*, 41(3):22-31, 1987.

## Mechanics of Ankle-Foot Orthoses

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Sponsor: *University of Akron*

**Purpose**—Excess rotations at the ankle-foot complex present a major problem in the comprehensive rehabilitation of certain stroke patients with upper and lower motor lesions. These patients have uncontrolled muscle activity which may develop into the *drop-foot* problem. Abnormal rotations also occur in the case of certain ligament injuries. Ankle-foot orthoses are generally prescribed to mitigate this problem. However, these orthoses have not been evaluated from a biomechanical viewpoint. The purpose of the present investigation is to study the biomechanics of ankle-foot orthoses.

**Progress**—We have developed two-dimensional finite element models of the ankle-foot-orthosis complex and studied various static and dynamic loading conditions. We compared stress and deformation patterns of the normal foot with those fitted with orthoses. In addition, we experimentally examined the strains developed in the orthosis in a walking cycle. Strain gauges were attached to polypropylene

orthoses. The orthoses were fitted to normal test subjects and the strains were recorded during the gait cycle. The orthosis was held in place with a strap anterior to the calf, and a shoe which held the foot in the lower section. Principal strains were determined from three-element Rosett gauges with assumed values for the material properties.

**Preliminary Results**—Peak stresses determined from both static and dynamic finite element models were similar in magnitude. Experimental results with strain gauges were consistent with the results of finite element model simulation. Slight geometric modifications of the orthosis were made to eliminate stresses at undesirable points. These design modifications allow functional plantar flexion, reduce instability at the subtalar joint, and facilitate heel-to-toe gait pattern.

**Future Plans/Implications**—While the present simple two-dimensional analyses demonstrate the feasibility

ity of using finite element models for redesigning the ankle-foot orthoses, further examination of dynamic conditions and more complex three-dimensional dynamic finite element calculations are needed in order to be able to predict the total response of the ankle-foot-orthosis system. Experimental strain analysis could perhaps be done on each orthosis before it is fitted to a patient and should be modified to avoid stresses at undesirable points.

### Publications Resulting from This Research

- Finite Element Modeling of Ankle-Foot Orthoses.** Reddy NP, Pohit G, Lam PC, Grotz RC, *Proceedings of the International Conference on Biomechanics and Clinical Kinesiology of Hand and Foot*, K.M. Patil and H. Srinivasan (Eds.), pp. 97-99, Indian Institute of Technology, Madras, India, 1985.
- One More Step in Redesigning the Ankle-Foot Orthosis.** Lam PC, Downing M, Reddy NP, *SOMA*, 2(1):36-39, 1987.

### Functional Treatment of Perthes Disease

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Sponsor: None Listed

**Purpose**—Perthes Disease remains an enigma. While the pathological process of ischemia, revascularization and healing is well known, the initiating insult or agent remains to be identified. The treatment is, therefore, still somewhat empirical, if treatment is thought to be necessary. Some orthopedic surgeons treat by "supervised neglect" with bed rest and possibly traction for pain relief during periods of hip irritability. However, the literature on the subject would suggest that containment of the femoral head within the acetabulum during the active and healing phases, maintains the shape of the head. A normal spherical shape may not be achieved, but a measure of congruent incongruity results between the femoral head and the acetabulum as an acceptable alternative.

**Progress**—Many orthoses have been produced to maintain the shape of the femoral head. The orthotic devices limit, to a greater or lesser extent, the function of the hip, while maintaining containment by abduction. It was to maintain, as far as possible, the motion of the hip joint, to give a molding effect, that the Trans Pennine Splint (TPS) was designed. This principle is similar to that of the Pavlik Harness used in congenital hip dislocation.

The TPS consists of a polyethylene body jacket, to which the hip abduction flexion hinge is attached. The distal part of this hinge is then attached to a plastic thigh cuff and through a second knee flexion hinge to a calf cuff. These are held in place by elastic strapping with velcro fastening. It is worn throughout the waking hours.

The children have full clinical assessment and initial X-rays of the affected hip and a weightbearing radiograph at initial fitting to check containment. Adjustments to the abduction hinge are made as necessary. The orthosis is worn throughout the day. During periods of irritability, bed rest has been advised. Follow-up weightbearing radiographs are taken at 2-month intervals, until healing is adjudged to have taken place, at which time the children are allowed to discard the orthosis.

To date, 22 children (19 boys and 3 girls) have been fitted in Sheffield, and 6 children (4 boys and 2 girls) fitted in Salford. The full range of Catteral Groupings have been treated. The orthoses have proved to be robust and have allowed most of the usual activities of this age group, though organized games and school physical education sessions are not allowed.

**Preliminary Results**—There have been three children, with four hips involved, who have been allowed to discard the splint. The sphericity of the femoral head assessed by Mose's criteria gave one fair and three good results. Clinically, three hips had full range of movement; one had limitation of rotation in extension. The tolerance of the orthosis by the children has been remarkable, we believe, due to the amount of activity it allows.

**Future Plans/Implications**—Within the next few months, we hope to have more children able to discard the orthosis. However, the true results can only be assessed many years from now, and it is the hope of the authors that this will prove possible.