2012 Annual Meeting

"Professionals Helping Kids be Kids"

ABSTRACTS

THURSDAY, April 12th	Kinnear Centre for Creativity & Innovation, Rooms 101/103/105

7:00-8:00 AM	**CONTINENTAL BREAKFAST –** KCCI Rooms 201/203/205
7:00 AM-5:00 PM	**REGISTRATION -** KCCI 2nd Floor Galleria (Foyer)
8:00 AM-5:40 PM	**SCIENTIFIC PROGRAM -** KCCI Rooms 101/103/105
8:00-8:10 AM	**Welcome – *Janet G. Marshall, CPO, President*** *(n)*
	SESSION I – UPPER EXTREMITY AND SPINE
Moderator:	***Janet G. Marshall, CPO*** *(n)*
8:10-8:20 AM Paper 1	Emerging Trends in Adolescents, with Congenital Partial Hand Absence, Fit with Electric Multi-articulation Digit Prostheses ***Diane J. Atkins, OTR, FISPO*** *(3B- Touch Bionics)*
8:20- 8:30 AM Case Study 1	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 ***Jennifer K. Peterson, MA, PT*** *(n)*
8:30-8:40 AM	Discussion
8:40- 8:50 AM Case Study 2	A Novel Research and Clinical Approach to Using Gel Liners for Collection of Surface EMG Data for Myoelectric Control ***Robert D. Lipschutz, CP*** *(n)*
8:50-9:00 AM Case Study 3	Ultra Thin PE Custom Molded WHFO in Arthrogrypsis and Musculoskeletal Hand/Wrist Conditions ***Nancy M. Hylton, PT, CO*** *(n)*
9:00-9:10 AM	Discussion
9:10-9:20 AM Paper 2	Functional Changes Seen with SPIO Compression TLSO ***Nancy M. Hylton, PT, CO*** *(n)*
9:20-9:30 AM Case Study 4	TLSO Design for Spinal Muscular Atrophy ***Donald T. McGovern, CPO, FAAOP*** *(n)*
9:30-9:40 AM Paper 3	Biomechanical Goals and Techniques Used in Custom Molded TLSOs for the Treatment of Idiopathic Scoliosis ***Sun Hae Jang, CO*** *(n)*
9:40-9:55 AM	Discussion
9:55 AM	**BREAK**

THURSDAY, April 12th Kinnear Centre for Creativity & Innovation, Rooms 101/103/105

SESSION II – LOWER EXTREMITY

Moderator:	***J. Ivan Krajbich, MD*** *(n)*
10:40-10:50 AM Paper 4	Van Nes Rotationplasty for Proximal Femoral Focal Deficiency: Long-Term Follow Up ***Jeffrey Ackman, MD*** *(n); Haluk Altiok, MD (n); Ann Flanagan, PT, PCS (n); Mary Peer, PT (n); Adam Graf, MS (n); Joseph Krzak, PT, PCS (n); Sahar Hassani, MS (n); and Gerald F. Harris, PhD (n)*
10:50-11:00 AM Case Study 5	Using Motion Analysis Laboratory to Document Changes in Gait Pattern after Undergoing Valgus Osteotomy ***Hank White, PT, PhD*** *(n)**; JJ Wallace, MS (n); Sam Augsburger, MS (n); Janet L. Walker, MD (9-Association of Children's Prosthetic and Orthotic Clinics)*
11:00-11:10 AM Clinical Case 1	Challenging Case: Toddler with Quadrimembral Acquired Amputation ***Beth A. Watkins, BSc, PT*** *(n)*
11:10-11:25 AM	Discussion
11:25 AM-12:25 PM	***Presidential Speaker*** Back to the Future: Do Today's Orthotics Optimize Long Term Function in Cerebral Palsy? ***Diane L. Damiano, PhD, PT*** *(n)*
12:25-1:25 PM	**LUNCH**
1:25-5:40 PM	**WORKSHOPS**
Moderator: 1:25-3:10 PM A1	***Robert C. Crandall, MD*** *(4 Stryker;9 Orthopaedic Rehabilitation Association)* Physician Guided Clinical Forum
	or
Moderator: B1	***Joanne Shida-Tokeshi, OTR/L*** *(n)* Assessing Gaze Behaviour in Upper Limb Prosthesis Users ***Peter J. Kyberd, PhD*** *(n)**; Florin A. Popa, Bsc (n); Ali Hussaini, Bsc (n); Philippa Gosine (n)*
	Workshop B1/B2 located in room 303
3:10 PM	**BREAK**
Moderator: 3:55-5:40 PM A2	***Robert C. Crandall, MD*** *(4 Stryker;9 Orthopaedic Rehabilitation Association)* Physician Guided Clinical Forum
	or
Moderator: B2	***Janet L Walker, MD*** *(9-Association of Children's Prosthetic and Orthotic Clinics)* Fabrication of Soft Active Arching Assist for Balance, Stability and Improved Biomechanical Alignment ***Nancy M. Hylton, PT, CO*** *(n)*
	Workshop B1/B2 located in room 303
5:40 PM	**ADJOURN**

FRIDAY, April 13th	Kinnear Centre for Creativity & Innovation, Rooms 101/103/105

7:00-8:00 AM	**CONTINENTAL BREAKFAST** – KCCI, Rooms 201/203/205
	SESSION III – PROSTHETICS AND LOWER EXTREMITY
Moderator:	***David B. Rotter, CPO*** *(n)*
	Symposium I
8:00-8:35 AM	Proximal Femoral Focal Deficiency: A Day in the Life ***Brian J. Giavedoni, CP*** *(n)**;** Jorge Fabregas, MD (n); and Coleen Coulter, PT, DPT, PhD, PCS (n)*
8:35-8:45 AM	Discussion
8:45-8:55 AM Clinical Case 2	Challenging Case Study of Patient with Bilateral Knee Disarticulations and Abduction Contractures ***Janet G. Marshall, CPO, LPO*** *(n)*
8:55-9:05 AM Clinical Case 3	Challenging Case Study of Patient with Phocamelia of Lower Extremities but with Full Feet ***Janet G. Marshall, CPO, LPO*** *(n)**;** and Bryan Sinnott, CPO (n)*
9:05-9:15 AM	Discussion
	Symposium II
9:15-9:50 AM	Prosthetic Management of Patients with Quadrimembral Limb Loss ***Nicole T. Soltys, CP*** *(n); and* ***Robert D. Lipschutz, CP*** *(n)*
9:50-10:00 AM	Discussion
10:00 AM	**BREAK**
10:45-10:55 AM Paper 5	Using Dynamic Foot Pressure Systems to Quantify a Vaulting Gait Pattern in Children with Unilateral Lower Limb Deficiencies ***Hank White, PT, PhD*** *(n)**;** JJ Wallace, MS (n); Sam Augsburger, MS (n); and Janet L Walker, MD (9-Association of Children's Prosthetic and Orthotic Clinics)*
10:55-11:05 AM Paper 6	The Boyd Amputation: Indications and Outcomes ***David E. Westberry, MD*** *(n)*
11:05-11:15 AM Clinical Case 4	Knee Disarticulation Amputation in the Treatment of Bilateral Tibial Deficiency: A Challenging Pediatric Case Study ***Kristen Matthews, CP(c)*** *(n)**;** Shirlene Campbell, PT (n); Wilson Cisneros, RPT(c) (n); Bryan Steinnagel, CP(c) (n); Shane Glasford, CP (n); and Ricardo Torres-Moreno, PhD (n)*
11:15-11:30 AM	Discussion
11:30-11:40 AM Paper 7	Utilizing EMG from Individuals with Lower Limb Amputations to Control Powered Prostheses ***Robert D. Lipschutz, CP*** *(n)*

FRIDAY, April 13th	Kinnear Centre for Creativity & Innovation, Rooms 101/103/105

11:40-11:50 AM Paper 8	Classification of EMG Data from an Individual with Congenital Abnormality of the Femur: A Single Case Study ***Robert D. Lipschutz, CP*** *(n)*
11:50 AM-12:00 PM Paper 9	A Survey of Prosthetic Foot Clinical Selection Criteria ***Gerald E. Stark, Jr., MSEM, CPO/L, FAAOP*** (*3A- The Fillauer Companies, Inc.)*
12:00-12:15 PM	Discussion
12:15-1:15 PM	**BUSINESS MEETING LUNCH *(MEMBERS ONLY)***
1:15-2:15 PM	**Hector Kay Lecture** The Joys and Challenges of Providing Pediatric Orthopaedic Care in the Vast Area of the Pacific Basin ***Ellen M. Raney, MD*** *(9 - AAP SoOR;WOA)*
	Orthopaedic Rehabilitation Symposium
2:15-3:15 PM	Lower Extremity Amputation Level Selection ***Robin C. Crandall, MD*** *(4 Stryker;9 Orthopaedic Rehabilitation Association)*
3:15 PM	**BREAK**
	SESSION IV – LOWER EXTREMITY
Moderator:	***Eric L. Miller, CPO*** *(9- Vice-Chair for the Kentucky Board of Prosthetics, Orthotics and Pedorthics)*
4:00-4:10 PM Paper 10	Comparison of Temporal-Spatial and Oxygen Consumption Data of Children Diagnosed with Lower Limb Deficiencies ***Hank White, PT, PhD*** *(n)**;** JJ Wallace, MS (n); Sam Augsburger, MS (n); and Janet L Walker, MD (9-Association of Children's Prosthetic and Orthotic Clinics)*
4:10-4:20 PM Paper 11	Radiographic Parameters Improve Lower Extremity Prosthetic Alignment ***Ryan Mooney, PA-C*** *(n)**;** Abby Schultz, BA (n); Bryan Mcnair, MS (n); Carol Page, PT (n); Susan Biffl, MD (n); and Travis Heare, MD (n)*
4:20-4:30 PM	Discussion
4:30-4:40 PM Paper 12	Significant Differences Between Reported and Measured Wear-Rates in Clubfoot Bracing Via a Novel Pressure Sensor ***Janet L. Walker, MD*** *(9-Association of Children's Prosthetic and Orthotic Clinics)**;** Aaron Morganstein (n); Neeley Buhr (n); Vishwas R Talwalkar, MD (n); Henry J. Iwinski, MD (n); and Todd A. Milbrandt, MD (7 Wolters Kluwer Health - Lippincott Williams & Wilkins;8 Wolters Kluwer Health - Lippincott Williams & Wilkins;9 Pediatric Orthopaedic Society of North America; AAOS)*
4:40-4:50 PM Paper 13	Verebelyi-Ogston Procedure for Management of Club Foot Deformity in Cerebral Palsy and Meningomyelocele ***Vipal Shah, MD*** *(n)*
4:50-5:00 PM	Discussion

FRIDAY, April 13th	Kinnear Centre for Creativity & Innovation, Rooms 101/103/105

5:00-5:10 PM Paper 14	Botulin Toxins for Management of Equinus in Children Less Than 5 Years with Cerebral Palsy (CP) – A Comprehensive Approach ***Vipal Shah, MD*** *(n)*
5:10-5:20 PM Case Study 6	Serial Casting 55 Degree PF Contracture, CP ***Nancy Hylton, PT, CO*** *(n)*
5:20-5:30 PM Case Study 7	Challenging Current Practices and Beliefs in Using AFOs on Pediatric Patients with Cerebral Palsy ***Curt A. Bertram, CO, FAAOP*** *(4 Hanger, 9 American Board for Certification in Orthotics, Prosthetics and Pedorthics)*
5:30-5:45 PM	Discussion
5:45 PM	**ADJOURN**
6:00-9:00 PM	Dinner *(optional)* Balken ~ The Greek Restaurant

SATURDAY, April 14th	Kinnear Centre for Creativity & Innovation, Rooms 101/103/105

7:00-8:00 AM	**CONTINENTAL BREAKFAST** – KCCI, Rooms 201/203/205
	SESSION V – LOWER EXTREMITY
Moderator:	***Jorge A. Fabregas, MD*** *(n)*
8:00-8:10 AM Paper 15	Non Operative Management of Pediatric Post Injection Nerve Palsy-Lessons Learnt ***Vipul Shah, MD*** *(n)*
8:10-8:20 AM Paper 16	Long Term Correlates of Pediatric Hyperlax Flat Feet - Not So Benign Any More ***Vipul Shah, MD*** *(n)*
8:20-8:30 AM Paper 17	Physical Functioning in Children with Lower Limb Length Discrepancies: A Review of Current Outcomes Measures ***Corinne Mercier, PT*** *(n)*; *Reggie C. Hamdy, MD (8 BMC Musculoskeletal Disorders;9 Limb Lengthening Research Society); and Noémi Dahan-Oliel, BSc(OT), MSc (n)*
8:30-8:45 AM	Discussion
	Symposium III
8:45-9:45 AM	Clinical Experience of Designing, Aligning and Tuning AFO Footwear Combinations Based on Segment Kinematics ***Donald T. McGovern, CPO, FAAOP*** *(n),* ***Kenneth R. Boggs, CO*** *(n),and* ***Corrine Jordan, DPT*** *(n)*
9:45-10:00 AM	Discussion
10:00 AM	**BREAK**

SATURDAY, April 14th Kinnear Centre for Creativity & Innovation, Rooms 101/103/105

SESSION VI – LOWER EXTREMITY AND GENERAL

Moderator:	***Janet G. Marshall, CPO*** *(n)*
10:30-10:40 AM Paper 18	Impact of Fine-Tuning Hinged Ankle Foot Orthoses on Abnormal Knee Kinematics in Children with Gastrocnemius Spasticity ***Jennifer L. Hutchens, PT*** *(n)****; Andrea N. Dennis, PT*** *(n)****;*** *Adam Miller, Engineer (n); and Cathy Harro, PT (n)*
10:40-10:50 AM Clinical Case 5	Use of Resistance in the Sagittal Plane at Ankle to Control Knee Crouch and Hyperextension ***Keith M. Smith, CO, LO, FAAOP*** *(2 Ultraflex Systems)*
10:50-11:00 AM Clinical Study 8	Comparison of 3D Gait and Balance Effects from an Adjustable Dynamic Response versus Fixed Ankle Orthosis in a Child with Hemiplegis Cerebral Palsy: How did it do and can we do better? ***Mark D. DeHarde*** *(3A Ultraflex Systems, Inc.)****;*** *Diane L. Damiano, PhD, PT (n); Lindsey Curatalo (n); and Katharine E. Alter, MD (n)*
11:00-11:15 AM	Discussion
11:15-11:25 AM Paper 19	Acceptability of a Functional Electrical Stimulation Device for Foot Drop in Children and Adolescents with Cerebral Palsy ***Laura A. Prosser, PT, PhD*** *(n)****;*** *Lindsey A. Curatalo, MS (n); Katharine E. Alter, MD (n); and Diane L. Damiano, PhD, PT (n)*
11:25-11:35 AM Clinical Study 9	Long-Term Use of Conservative Night Splint to Manage Functional Knee Extension ***Nancy Hylton, PT, CO*** *(n)*
11:35-11:45 AM	Discussion
11:45 AM	**ADJOURN**

POSTERS

Located in Kinnear Centre for Creativity & Innovation, Rooms 201/203/205

Poster #1
Prosthesis for a Patient with Proximal Femoral Focal Deficiency: A Case Report
Kristopher P. De Leon, MD *(n)*

Poster #2
Functional Outcomes of Van Nes Rotationplasty with Ipsilateral Partial Fibular Deficiency
Hugh G. Watts, MD *(n), Anna V. Cuomo, MD (n)*

Poster #3
Treatment of Tibial Deficiency with Transposition of Fibula
Anthony A. Scaduto, MD (8-Orthopedics; Journal of the American Academy of Orthopaedic Surgeons; Journal of Pediatric Orthopedics , 9-AAOS; Pediatric Orthopaedic Society of North America), Nicholas M. Bernthal, MD (n), and Hugh Godfrey Watts, MD (n)

Poster #4
Pilot Study to Determine Pediatric Subspecialists Education and Comfort in Prescribing Orthotics, Prosthetics, Wheelchairs and Durable Medical Equipment
Joshua A. Vova, MD *(n)*

Poster #5
Measuring Outcomes in Children and Youth with Osteogenesis Imperfecta: Top Picks
Marie-Elaine LaFrance, BSc, OT *(n)*

Poster #6
Teddy Bear Splint: How a Comforting Toy Can Achieve Orthotic Goals of a Volar Resting Splint
Jordan D. Raugust, MD *(n)*

SESSION I – UPPER EXTREMITY AND SPINE

THURSDAY, April 12th
8:10-8:20 AM
Paper 1

Emerging Trends in Adolescents, with Congenital Partial Hand Absence, Fit with Electric Multi-articulation Digit Prostheses

Diane J. Atkins, OTR, FISPO

It has long been the belief of many rehabilitation professionals that fitting an individual with congenital partial hand absence, with a prosthesis, would not enhance their functional well-being. The sensation that would be scarified, and the abilities of these individuals to be totally independent, appeared to outweigh the advantages a prosthesis might afford.

Since the advent of electric, multi-articulating digits, however, there is an increasing interest in adolescents wishing to explore the advantages, if any, of these state-of-the -art electric prostheses. Is it advantageous to fit an adolescent, with congenital partial hand absence, with an electric, multi-articulating prosthesis, and if so, what is the benefit?

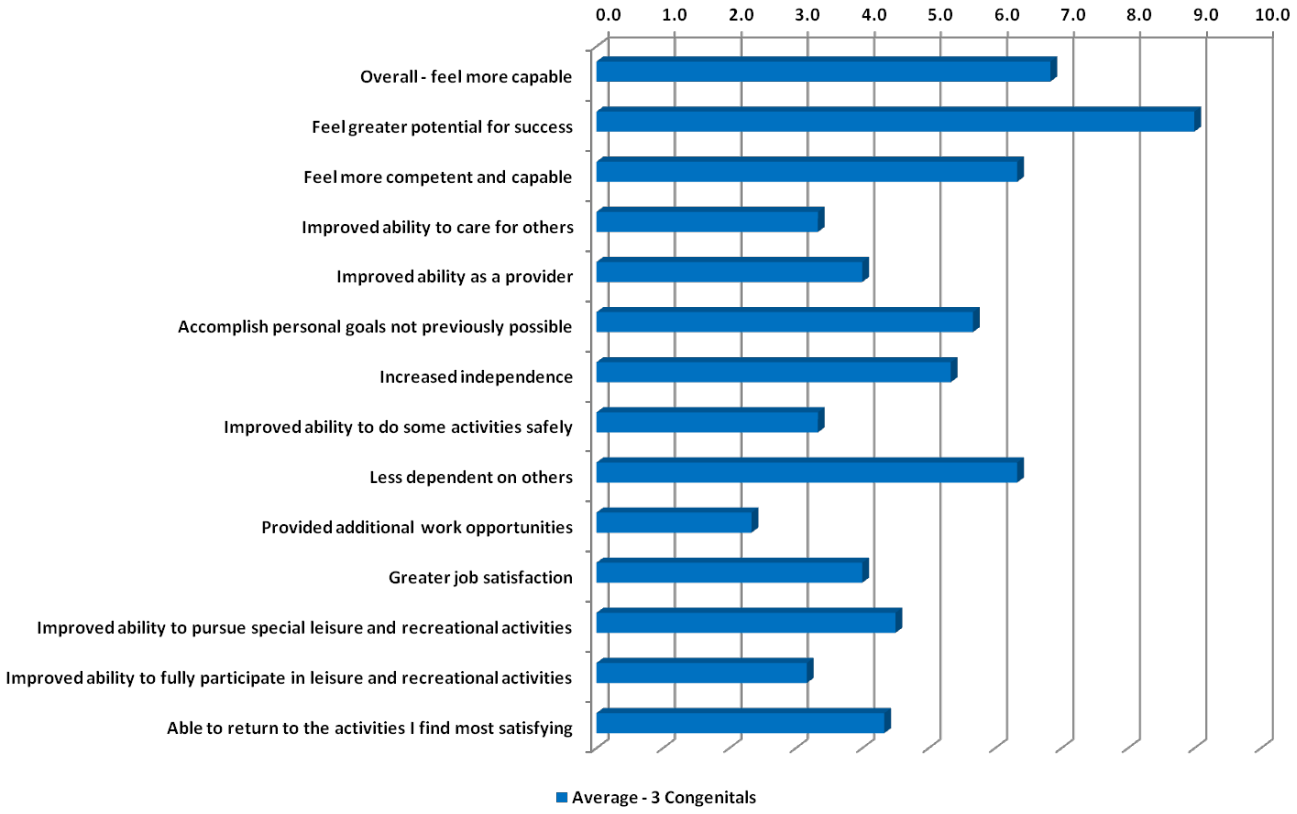
This study includes 3 adolescents, with congenital partial hand absence, who have been fit with an electric, multi-articulating digit prosthesis. A comprehensive evaluation and functional profile of these individuals was obtained at the outset of the fitting. Short and long term goals were identified, and advantages and disadvantages of the prosthesis were discussed.

At 3 months following the delivery of the electric, multi-articulating digit prosthesis, and occupational therapy directed training, a comprehensive follow-up evaluation was conducted. This assessment included parameters such as functional independence, one's ability versus perception of others to feel more capable, and their perception of pain relief from previous overuse and body compensatory techniques.

The data of these 3 individuals was comprehensively analyzed as it related to these domains and expressed below:

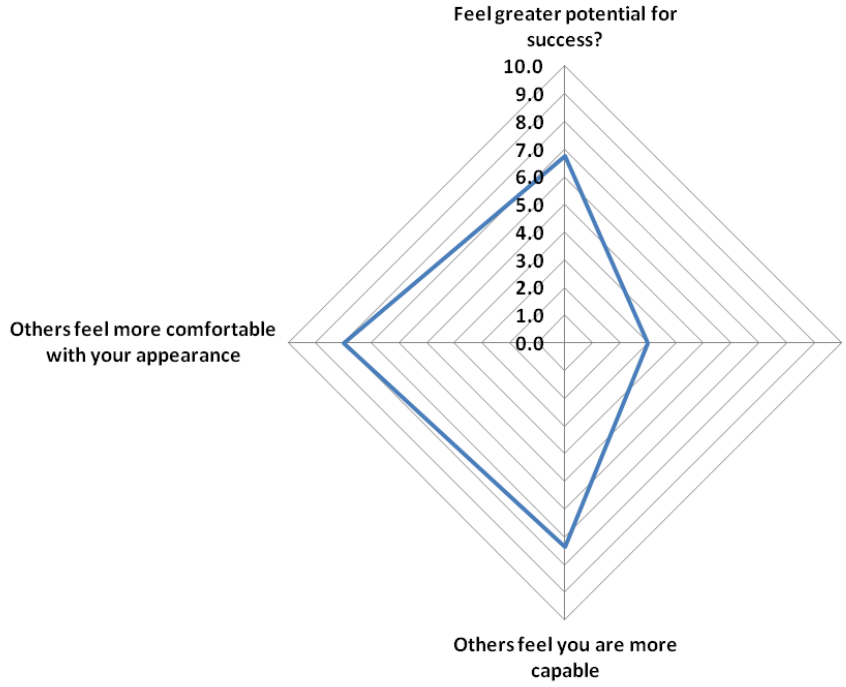
Overview of 3 Adolescents with Congenital Partial Hand Absence

INCREASED INDEPENDENCE



Overview of 3 Adolescents with Congenital Partial Hand Absence

ABILITY VS. PERCEPTION



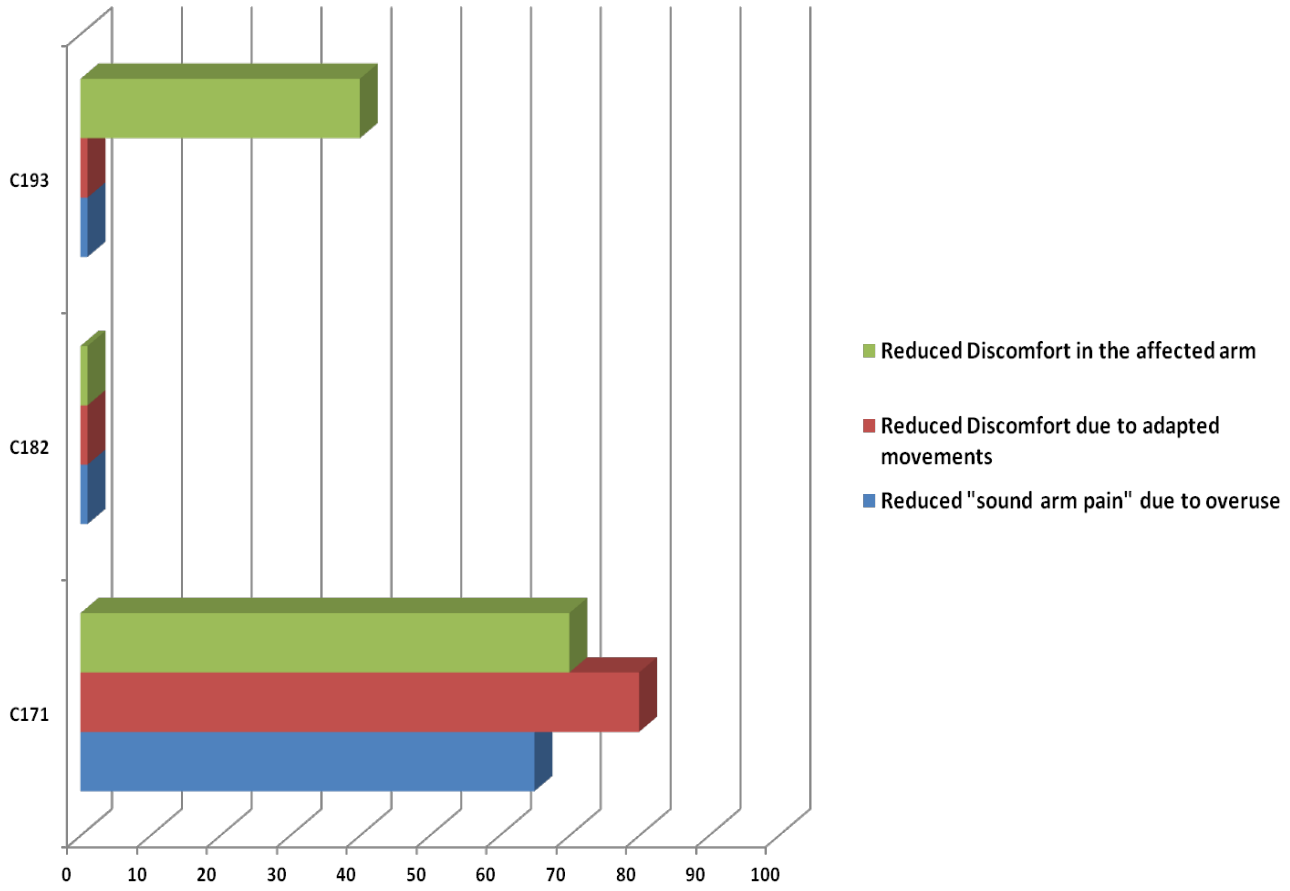
es to

sed.

Absence

ensation

ts



The results of these findings suggest that not only are there functional advantages to fitting the adolescent with congenital partial hand absence, but there are other benefits that include a perception of “reduced discomfort in the affected arm.”

The findings of the this preliminary study demonstrate the possibility of an emerging trend in this unique population as it relates to the consideration of an electric, partial hand prosthesis for adolescents. Additional subjects are required to evaluate this observation and additional evidence-based outcome studies are indicated.

Discussion of these results and direction for future study will be addressed.

THURSDAY, April 12th
8:20- 8:30 AM
Case Study 1

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

Jennifer K. Peterson, MA, PT
Advanced Arm Dynamics
Maple Grove, MN 55369, USA

There is conflicting evidence regarding the functional effectiveness and the necessity of fitting young, unilateral, transradial amputee children with an upper limb prosthesis. This case study follows a child with a congenital, transradial limb difference from birth to 7 years of age.

The child was fitted with a passive prosthesis at the age of 6 months and with a myoelectric prosthesis at 18 months. The prostheses were incorporated into the child's daily activities. Other activity specific prostheses such as a violin prosthesis and a sports prosthesis with various terminal ends were added as needed. At the age of 7 years, the child is a full-time prosthetic wearer with multiple prosthetic devices.

Being a prosthetic wearer has been valuable for this child in terms of function, development of bimanual upper limb skills with reduced compensatory movements, symmetrical upper body muscle development, self esteem, and the possible prevention of overuse injuries. In addition, without prosthetic intervention, activities such as playing the violin with proper form would not be possible.

This case study demonstrates the need for early fitting; well fitting and functioning prosthetic equipment; a full time wearing schedule initially; the opportunity to try multiple prosthetic devices; and motivated caregivers for consistent follow up care in order to achieve successful upper limb prosthetic habilitation in young children with transradial limb differences. The need for further research to address the relationships between upper limb deficiency, prosthetic use, proper posture, and proper body mechanics and overuse injuries is emphasized as a result of this case study.

THURSDAY, April 12th
8:40- 8:50 AM
Case Study 2

A Novel Research and Clinical Approach to Using Gel Liners for Collection of Surface EMG Data for Myoelectric Control

Robert D. Lipschutz, CP
Blair A. Lock, MSc
Rehabilitation Institute of Chicago, Center for Bionic Medicine
Chicago, Illinois, USA

Gel liners constructed from a variety of materials have proven successful in the fitting of individuals with lower limb amputations for longer than two decades. Prosthetists have also fit gel liners to individuals with upper limb amputations and have reported moderate success in combination with externally powered, prosthetic fittings. At the Rehabilitation Institute of Chicago, we have explored a novel approach to collecting EMG data from individuals with both lower limb and upper limb amputations using gel liners with embedded electrodes. Early designs have proven more comfortable and easier to don than traditional designs and have permitted us to eliminate the need to connect the pre-amplifiers separately. We believe that this technology will be very beneficial to patients and eliminate some of the clinical challenges and reported drawbacks of myoelectric fittings. The next step in this research is to combine the new liner technology with advanced electronics to control actuated drive units in both upper limb and lower limb prostheses. The evolution of this liner technology, experiences, current status, and future directions is described in this contribution.

THURSDAY, April 12th
8:50- 9:00 AM
Case Study 3

Ultra Thin PE Custom Molded WHFO in Arthrogrypsis and Musculoskeletal Hand/Wrist Conditions

Nancy M. Hylton, PT, CO
Dynamic Orthotic Systems
Children's Therapy Center of Kent
Kent, WA

Hand and wrist bracing must begin very early for infants with Arthogryposis and other hand/wrist deformities. Traditionally these have been made by Occupational Therapists of low temperature plastics, but it is quite difficult to get precise positioning of thumb, fingers and wrist when molding directly to the patient. We have instead found that making a cast mold in the most corrected position and fabricating from that a plaster positive, it is possible to get a much more precise rectification in the positive mold and form a highly flexible WHFO from 2 mm polyethylene which is tolerated very well and provides maximum correction of the specific joint and muscle deformities.

When this system is initiated in the first few months of life, we have found that the resulting early hand function is much improved and we use this system to manage ROM to preserve and develop hand function over time.

Presentation will provide information about specific casting procedure, positive mold rectification and orthotic fabrication with examples of children at different ages and function. This system has also proved very helpful for children with other types of musculoskeletal hand and wrist deformities and in cases of severe CP to manage ROM in hands and wrists.

THURSDAY, April 12th
9:10-9:20 AM
Paper 2

Functional Changes Seen with SPIO Compression TLSO

Nancy M. Hylton, PT, CO
Dynamic Orthotic Systems
Children's Therapy Center of Kent
Kent, WA

We now have nearly 20 years of experience using SPIO double-layer compression TLSO at our Center with spastic, ataxic and athetoid CP, hypotonia and other conditions causing shoulder-trunk-hip instability and weakness. This type of orthosis provides even circumferential compression in addition to longitudinal axial compression to assist with the functional "dynamic cylinder" or "core" activation. Full daytime wear and long-term wear has caused no increased dependency, rather, a gradual improvement in axial muscle strength and balance control. Because of 2-panel construction, the amount of compression in the upper, middle and lower trunk and hips can be varied and there is significant length and breadth growth potential within the orthosis.

The posterior panel is fabricated from vented Neoprene and can be reinforced when desirable with thermoplastic material to assist with dynamic scoliosis management.

The older teen-age or adult version is a custom double layer Lycra compression TLSO made to exact patient measurements, with a front half zipper closure and crotch strap to manage axial compression and ease of toileting.

Functional changes in balance, active stability and movement control are related to the relationship between "core" activation and peripheral control of limbs, respiration and mouth. Improved head, neck and trunk centering for active sitting, standing and walking balance are often immediately seen with application of this orthosis. Improvements in active hip-leg and shoulder-arm-control are also seen.

Compliance is excellent with this type of orthosis because it breathes well and permits, in fact, invites active triplanar motion while providing enhanced stability and deep pressure sensory input without noticeable restriction of movement.

THURSDAY, April 12th
9:20-9:30 AM
Case Study 4

TLSO Design for Spinal Muscular Atrophy

Donald T. McGovern, CPO, FAAOP
Rehabilitation Institute of Chicago
Chicago, Illinois, USA

Spinal Muscular Atrophy (SMA), the number one genetic killer of children under the age of two, is a group of inherited and often fatal diseases that destroys the nerves controlling voluntary muscle movement, which affects crawling, walking, head and neck control, and even swallowing.[1] SMA is an uncommon disease, which affects one in every 6,000 births.[2] The population affected by SMA usually has average or better intelligence. The disease is progressive according to the amount of a protein deficiency; in addition as a child grows more physical stress is applied to a limited number of functional muscle neurons.

Most of the people with SMA will need Orthotic intervention to decrease energy consumption for efficient gait, preserve joint integrity, and to maintain the ability to stand and walk for as long as possible. Most children with SMA will develop scoliosis at a very early age; specific TLSO design considerations are needed to have a positive impact on the wearer's postural stability, with little or no oxygen saturation impact.

A simple TLSO design has evolved from serving the SMA population since 1998. The design starts with discussion and assessment of the individuals' spinal deformity and respiratory status. Radiographs are helpful, but often unavailable. The goal of the Orthosis, especially in the very young Type 1 and 2 populations is postural support without respiratory inhibition. The procedure includes a careful measurement and impression procedure in supine. It is critical to allow full respiration of the individual as the impression is taken, careful demarcation of the inferior costal margins, umbilicus, anterior superior iliac crests and the trochanters. The modifications of the positive model, construction of the device, fitting and follow up will be discussed.

Several TLSOs of the design to be reviewed have been provided with no measurable effect on the oxygen saturation rate of the individual when a monitor was present. In the event of a TLSO fitting when an Oxygen saturation monitor is unavailable a simple procedure will be shared that can provide the Orthotist with some confidence of not interfering with respiration.

[1] Families of SMA Webpage, http://www.fsma.org/sma_facts.shtml
[2] Families of SMA Webpage, http://www.fsma.org/sma_facts.shtml

THURSDAY, April 12th
9:30-9:40 AM
Paper 3

Biomechanical Goals and Techniques Used in Custom Molded TLSOs for the Treatment of Idiopathic Scoliosis

Sun Hae Jang, CO
Jennifer Hutson, OTR/L, ATP
Gillette Childrens Specialty Healthcare,
Assistive Technology Department
Saint Paul, MN, USA

Objectives: It is the aim of this study to identify the current practice goals of orthotic treatment for idiopathic scoliosis patients and to describe the techniques used during the orthotic evaluation, fabrication and fitting process for custom molded TLSOs.

Methods: Qualitative research methods were used to investigate the current approach of spinal orthotists towards the orthotic treatment of idiopathic scoliosis. Seven spinal orthotists at Gillette Children's Specialty Healthcare, Minnesota USA with an average experience of 16.7 years in treating IS, were interviewed about a specific case example following SRS inclusion criteria. Six contributed to a focus group discussion. Sessions were audio-taped, transcribed and data was analyzed using open and axial coding. Triangulation of data was completed.

Results: "Achieving a balanced and aligned spine and trunk in all 3 planes in the orthosis" emerged as the primary biomechanical goal for all 7 participants (100%).

Their narratives also revealed multiple techniques such as:
• drawing an iliac-clavicle rectangular box on the PA x-ray • determining the location and the degree of a corrective force needed, and evaluating the flexibility of the curve with a hand technique • reducing lumbar lordosis during casting • re-aligning and de-rotating the trunk during casting using the "hand impression method" and during cast modification using the "cut and paste method"• creating space on the lateral posterior area of the concave side of curve and the mid-posterior area of the spine if a patient has hypo-kyphosis and hyper-lordosis • carving and re-shaping the model to achieve desired forces • employing design options such as sternal extension, anterior rib panel or trochanteric extension • sequencing and balancing corrective forces • establishing appropriate trimlines for alignment • palpating the spinous process and checking skin pressures at correction sites.

Conclusion: This study identifies the biomechanical goals and methods used by spinal orthotists to build effective a custom molded TLSO for idiopathic scoliosis. Specific strategies and techniques used throughout the orthotic treatment process were also documented.

To achieve the biomechanical goal of "realigning the 3D deformity of IS", the participants applied an anterior loading force and a lateral translational force on the lateral side of the convex side of the curve, and also created space on the opposite side of the forces applied.

SESSION II – LOWER EXTREMITY

THURSDAY, April 12th
10:40-10:50 AM
Paper 4

Van Nes Rotationplasty for Proximal Femoral Focal Deficiency: Long-Term Follow Up

Jeffrey Ackman, MD
Haluk Altiok, MD
Ann Flanagan, PT, PCS
Mary Peer, PT, PCS
Adam Graf, MS,
Joseph Krzak, PT, PCS,
Sahar Hassani, MS
Gerald F. Harris, PhD, PE
Shriners Hospitals for Children, Chicago, IL

Introduction: Proximal focal femoral deficiency (PFFD) is a congenital anomaly that presents challenges for orthopaedic and prosthetic management. The Van Nes rotationplasty is one treatment in which the extremity is surgically rotated to utilize the ankle and foot as a functional knee joint in a prosthesis.

Clinical Significance: The purpose of this study is to determine the long-term functional and quality of life (QOL) outcomes for individuals who have undergone rotationplasty surgery for congenital PFFD compared to age and gender matched controls.

Methods: This prospective study had 12 prosthetic participants (PFFD Group: 8 M, 4F, age range 16-57 years) average 31.6±13.5 years and 12 control participants (Control Group: 8M, 4F) with an average age 32.6±14.1 years. The PFFD group had rotationplasty performed at an average age of 6.5±3.9 years with follow up testing done 25.1±11.2 years later. Participants completed the following outcome questionnaires: SF-36, Revised-Faces Pain Scale (R-FPS), Harris Hip Score, Oswestry back pain score; and underwent lower extremity range of motion (ROM), hand held dynamometry, gait analysis, computerized dynamic posturography, and Timed 'Up & Go' (TUG) testing. The PFFD Group also completed the Prosthetic Evaluation Questionnaire© (PEQ). The Wilcoxon Signed rank test was used to statistically compare each PFFD Group participant to the matched Control Group participant with values statistically significant at $p < 0.0123$.

Results: All adult subjects were working full time in a variety of manual and office/desk jobs. No significant issues were seen for body image.

Pain: The PFFD and Control Groups both reported similar degrees of low back pain with 6.8±9.7% and 7.0±13.0% disability respectively on the Oswestry back pain questionnaire. On the day of testing, only 1 PFFD participant reported mild low back pain on the R-FPS. The average Harris Hip Score for the PFFD Group was 92.7±9.2 out of 100, indicating excellent outcome. Two participants reported pain on their non-prosthetic hip.

ROM: The PFFD Group showed significantly decreased hip flexion and ankle dorsiflexion, and increased ankle plantarflexion ROM on the prosthetic side compared to the Control Group. The PFFD Group had significantly greater ankle abduction ROM on their non-prosthetic side compared to the Control Group.

Strength: The PFFD Group demonstrated significantly weaker hip flexion, hip abduction and ankle plantarflexion on the prosthetic side compared to the Control Group.

TUG: The PFFD Group scored an average of 8.5±1.6 seconds on the TUG, demonstrating a low fall risk. The Control Group scored significantly lower with an average of 6.5 ±1.0 seconds.

SF-36: There were no significant differences between the Groups in overall health and well-being.
PEQ©: The PFFD Group scored lower in areas of satisfaction, appearance, and sounds of the prosthesis. However, participants reported that others perceived them well and they did not see themselves as a social burden.

Gait Analysis: Temporal-spatial gait parameters for the PFFD Group demonstrated significant decrease in cadence, stride time, opposite foot off, single support and walking speed compared to Control Group.

Posturography: The PFFD Group showed significant decrease in symmetry in stance, as well as a decrease in end point and maximum excursion in limits of stability testing compared to the Control Group.

Discussion and Conclusion: Overall, long-term follow up of teens and adults who underwent Van Nes rotationplasty showed that they maintained a high level of function, participation and QOL. They did present with significant differences in temporal spatial and posturography parameters compared to the Control Group.

THURSDAY, April 12th
10:50-11:00 AM
Case Study 5

Creative Solutions: Using Motion Analysis Laboratory to Document Changes in Gait Pattern After Undergoing Valgus Osteotomy

Hank White, PT, PhD [1]
JJ Wallace, MS [1]
Sam Augsburger, MS [1]
Janet L. Walker, MD [1,2]
[1]Shriners Hospitals for Children and [2]
University of Kentucky Department of Orthopaedic Surgery,
Lexington, KY

Two patients with primary diagnosis of proximal femoral focal deficiency, status post knee fusion and Symes amputations were evaluated in the motion analysis laboratory before and after undergoing proximal femoral valgus osteotomy to decrease their Trendelenburg gait pattern due to coxa vara. Both subjects were community ambulators without an assistive device pre- and post-operatively. Subject 1(AB) underwent knee fusion and Symes amputation at 3 years of age and no other orthopaedic surgeries until underwent proximal femoral valgus osteotomy at 12 years of age. Pre-operatively she wore an ischial containment socket with silicone sleeve suspension, hydraulic knee and energy storing foot. Her first motion study was performed day before surgery and follow up motion study was performed 5 years later. At post-operative gait study she wore an ischial containment socket with Iceross liner, hydraulic knee and Elation foot (energy storing).

Subject 1 postoperatively demonstrated more symmetrical step lengths and a 2 cm decrease in step width. However, she also demonstrated a decrease in cadence and stride length resulting in a decrease in walking speed.

In the frontal plane, a decrease in pelvic obliquity during stance and a change from hip abduction to hip adduction throughout the gait cycle was noted. A 10-15 degree decrease in trunk tilt during stance was noted. Because of the combination of decrease in trunk tilt, pelvic obliquity and the change from hip abduction to hip adduction the involved side hip moment demonstrates a change from a negligible moment to more appropriate hip adductor moment. She also demonstrated a change in trunk tilt from posterior to anterior and small changes in her trunk rotation.

Subject 2 (NH) prior to his amputation underwent a valgus osteotomy of his left femur 4 years of age and then subsequently underwent left knee fusion and Symes amputation at 7 years of age. He then underwent a second proximal femoral valgus osteotomy and femoral shortening (residual limb too long for effective prosthetic fit) at 14 years of age. Preoperatively he wore an above knee prosthesis with expandable bladder, plug socket, small wonder knee and dynamic foot. Postoperatively continued to wear an above knee prosthesis plug socket with total knee and dynamic foot. The postoperative motion study was performed 1 year post-op.

Subject 2 postoperatively demonstrated a small decrease in walking speed due to a decrease in stride length, but an increase in cadence. His step lengths continued to be asymmetrical, and his step width increased 8 cm.

His pelvic tilt, trunk tilt, pelvic and trunk rotations were essentially unchanged. In the frontal plane, a 5-degree decrease in trunk tilt and a change in pelvic obliquity from involved side up 5-10 degrees to involved side down 10-degrees during stance. The involved hip demonstrates a change from neutral

to 20-degrees of abduction during stance. However, in the frontal plane, he continued to demonstrate negligible hip moment.

For both subjects, their oxygen consumption and oxygen cost when walking were essentially unchanged.

Differences in radiographic findings and discussion of why discrepancies in outcomes will be presented.

THURSDAY, April 12th
11:00-11:10 AM
Clinical Case 1

Challenging Case: Toddler with Acquired Quadrimembral Amputations

Beth A. Watkins, BSc, PT
Glenrose Rehabilitation Hospital
Edmonton, Alberta, Canada

KB is an 18 month old girl who required the following amputations at age 12 months after respiratory and cardiac arrest secondary to infection: right transfemoral, left transtibial, right wrist disarticulation, left proximal phalanx of D2, complete D3 and 4 with extensive skin grafting. She was initially fit with a right stubby prosthesis and later a left transtibial prosthesis and right transfemoral prosthesis without a knee joint. She does not have any upper extremity devices. Her push toy has been modified with a trough made from thermoplastic to support the right forearm.

Our team has a number of issues that we would like to discuss with ACPOC attendees. These include possible adaptations of gait aids, any suggestions for prosthetic management including the right upper limb, and potential devices for ADLs. KB's parents are aware that future independence will include power mobility.

THURSDAY, April 12th
11:25 AM-12:25 PM
Presidential Speaker

PRESIDENTIAL SPEAKER

Back to the Future: Do Today's Orthotics Optimize Long-term Function in Cerebral Palsy?

Diane L. Damiano, PhD, PT

This presentation will focus on orthotic management "philosophies" in ambulatory children with cerebral palsy. We will start with the "future" with is the ambulatory prognosis for adults with CP. Nearly half f those who are ambulating at the onset of adulthood continue walking into middle age. WE will briefly review current scientific evidence on the effectiveness of AFOs and discuss benefits and trade-offs of some of the current treatment strategies. WE will present data from our recently completed clinical trial using the WalkAide footdrop stimulator and CP. Finally we will discuss ways we can improve AFOs to optimize muscle structure and motor functioning.

THURSDAY, April 12th
1:25-3:10 PM
Workshop B1

Assessing Gaze Behaviour in Upper Limb Prosthesis Users

Peter J. Kyberd, PhD[1]
Florin A Popa, BSc[1]
Ali Hussaini, BSc[2]
Philippa Gosine[3]
[1] *Institute of Biomedical Engineering, University of New Brunswick, Canada*
[2]*George Brown College, Canada*
[3] *Memorial University of Newfoundland, Canada*

Background: A functional assessment of the user of upper limb prostheses is based on the ability of users to employ their devices effectively. This ability is the result of sustained practice and accommodation with the prosthetic device. This study is part of a program developing assessment tools to determine the level of attention needed while using an upper limb prostheses. This particular study monitors the gaze behaviour for individuals performing tasks with their prosthesis. The few previous studies of gaze behaviour suggest that with practice comes a changes in visual attention. These changes can be interpreted as a reduction in cognitive load for the experienced users versus the inexperienced ones, i.e. the point of focus moves from the terminal device to the target object. This study is focused on identifying those factors that are related to changes in gaze behaviour and performance of prosthetic devices. The primary goal is to estimate the cognitive load of users based on gaze information.

Subjects are asked to perform simulated activities of daily living (ADLs) using the Southampton Hand Assessment Procedure (SHAP). During the tasks, visual attention is monitored and recorded using an eye tracking device placed on the subject's head. Video data of the scene is collected together with information on eye movement, including the coordinates of the point at which the subject is gazing, the Point Of Regard (POR). By using a scheme which codifies where the POR is resting at any one time, the gaze information is then analysed in relation to a series of Areas Of Interest (AOIs). The AOIs are defined by taking into consideration the characteristics of the ADL that is captured in the scene, such as the type of activity and the objects involved. Investigation of the visual attention is then achieved by evaluating the amount of time the POR is fixated in specific AOIs throughout a given ADL.

Subjects: Data was collected from twelve able-bodied subjects and four prosthesis users (ethical approval through the UNB Research Ethics Board, REB 2010-099). Each performed the SHAP tasks while using the eyetracker and a Vicon motion analysis system to track their movements). The data was recorded and analysed using custom software.

Results: Compared to the able-bodied population, the users employ longer fixation times on the target (approximately 58% longer for the page turning task) and more frequent glances away towards the final destination of the object.

Discussion: Without other forms of feedback the prosthesis users tend to check on the object and how it is held more than able-bodied subjects. When a study compared inexperienced (simulated) users with long term genuine users, they showed that the inexperienced users transfer their gaze to other parts of the scene far more often than the experienced users of prosthesis, which supports the idea that they have acquired more skill in controlling their prosthesis.

THURSDAY, April 12th
3:55-5:40 PM
Workshop B2

Fabrication of Soft Active Arching Assist for Balance, Stability, and Improved Biomechanical Alignment

Nancy M. Hylton, PT, CO
Dynamic Orthotic Systems
Children's Therapy Center of Kent
Kent, Washington, USA

The focus of this course is the understanding the active arching structures of the foot and how to support them in order to invite activation of muscles which interact with ankle, knee, hip and whole body active balance and movement control.

We have been exploring the support of these structures in our orthotic fabrication and use over the past 35-40 years. Precise support of these arching structures positively impacts active biomechanical chain stability and alignment, interacts through sensory mechanisms with postural movement control throughout the body, and permits far less restriction of triplanar movement in order to manage spasticity and dynamic deformity control.

An excellent trial system will be demonstrated, which can be incorporated into a typical shoe, molded FO or AFO or even the base of a KAFO to positively impact movement control, stability and balance.

SESSION III – PROSTHETICS AND LOWER EXTREMITY

FRIDAY, April 13th
8:00-8:35 AM
Symposium 1

Proximal Femoral Focal Deficiency: A Day in the Life

Brian J. Giavedoni, MBA, CP, LP
Jorge Fabregas, MD
Colleen Coulter, PT, DPT, PhD, PCS
Children's Healthcare of Atlanta
Atlanta, Georgia, USA

Proximal Femoral Focal Deficiency (PFFD) is a very well known condition that most practitioners in the field of pediatric orthopedics are very familiar with. It presents as a spectrum of defects that involves the femur, the hip joint, and knee joint and respective musculature. It remains one of the most challenging congenital limb deficiencies to not only assess but to treat effectively. Decisions made at initial assessment are often not accurate enough to make final recommendations on the course of treatment until several years down the road.

Experienced physicians, prosthetists and therapists knowledgeable about the condition occasionally stumble upon the challenging case that balances on a tight wire between different treatment options. Through the eyes of a very challenging patient, we will delve behind the scenes to present the years dedicated to making the most informed clinical, developmental and social decisions.

Options are often linked to appropriate timing but what is optimal and what is not? Optimal time for revision must encompass surgical and prosthetic options and, of course, must be balanced with the family needs and beliefs. Rarely, if ever, is the decision to revise critical to growth and development. Prosthetic options allow the fitting of most every child with limb deficiencies.

This symposium will focus on the surgical, prosthetic, therapy and family dynamics using a difficult case followed over a six year period to expound on the various academic and clinically relevant decisions used to achieve optimal outcomes in the both the family's and teams eyes.

FRIDAY, April 13th
8:45-8:55 AM
Clinical Case 2

Challenging Case Study of Patient with Bilateral Knee Disarticulations and Abduction Contractures

Janet G. Marshall, CPO, LPO
Shriners Hospitals for Children
Tampa, Florida, USA

A three year old male transfer patient presented to our clinic with bilateral phocomelia of the lower extremity with full feet. The femurs, tibias, and fibulas were completely absent. The feet were relatively intact, but not significantly functional other than some limited balance while stationary. The upper extremity was normal with good strength. Trunk control was assisted with the use of the upper extremity. He "walked" with a swing through gait, but his feet dragged and were noticeably scuffed. Shoes were difficult to fit. To stand independently without his arm support was only achieved with a baby "Bumble Seat", which he had outgrown. Expectations of prosthetics had been discussed in the previous facility, so the parents were interested in pursuing this. Options of a swivel stander, modified RGO's, and an adaptive wheelchair were presented and weighed as to their practicality. This case study will present the solutions and the challenges for adapting devices to better enable the patient to participate in daily life.

FRIDAY, April 13th
8:55-9:05 AM
Clinical Case

Challenging Case Study of Patient with Phocamelia of Lower Extremities but with Full Feet

Janet G. Marshall, CPO, LPO
Bryan Sinnott, CPO, LPO
Shriners Hospital for Children
Tampa, Florida, USA

A 22 month old female presented to our clinic with multiple congenital anomalies. There was limited medical history as she was recently adopted from Africa. The upper extremity was normal. The lower extremity has bilateral hip abduction tightness with limited range of motion, flexion contractures at the knees greater than 90 degrees, anteriorly bowed femurs, and significant foot deformities of missing rays and the feet were positioned backwards. Knee disarticulations were performed two months later. Possible future surgical intervention includes osteotomies to straighten the bowed femurs and soft tissue releases to achieve improved alignment for prosthetic fitting.

Prosthetic and orthotic treatment began soon after the amputations. The compression socks were made into shorts to begin adducting the lower extremity while a molded adduction orthosis for nighttime was being fabricated. At ~27months of age the initial prosthesis was fit which was bilateral stubbies attached to a modified twister cable pelvic band. Intense therapy with goals of independent walking and improved positioning of the lower extremity was challenging due to the abductor tightness, weakness of the hip extensors, and limited lower extremity strength overall.
At the age of 2 years 9 months, a new set of legs was made that included the feet and increased height. The pelvic band was more rigid with a modified abductable hinge, but with a dynamic adduction feature. Ongoing physical therapy and prosthetic challenges will be explored in greater detail to discuss unique solutions to this complex case study.

FRIDAY, April 13th
9:15-9:50 AM
Symposium II

Prosthetic Management of Patients with Quadrimembral Limb Loss

Nicole T. Soltys, CP
Robert D. Lipschutz, CP
Rehabilitation Institute of Chicago
Chicago, IL

Quadrimembral and trimembral limb loss present a unique challenge in that the combination of upper and lower limb loss has a profound impact on both functional activities and mobility. Our center draws patients from throughout the world for comprehensive rehabilitation at the inpatient and outpatient level. In the past 8 years, we have cared for at least 20 patients with trimembral and quadrimembral limb loss. I will draw upon these experiences and available literature to guide the team in prosthetic management of these individuals: determining when the patient is ready to begin prosthetic fitting (or recommending alternatives to prosthetic fitting), guiding the team in a prosthetic recommendation, and assisting the patient in returning to real life after discharge.

FRIDAY, April 13th
10:45-10:55 AM
Paper 5

Using Dynamic Foot Pressure System to Quantify A Vaulting Gait Pattern In Children with Unilateral Lower Limb Deficiencies

Hank White, PT, PhD[1]
JJ Wallace, MS [1]
Sam Augsburger, MS [1]
Janet L. Walker, MD [1,2]
[1]Shriners Hospitals for Children
[2]University of Kentucky Department of Orthopaedic Surgery
Lexington, Kentucky, USA

"Vaulting" is a term used to describe the compensatory gait pattern of ankle plantar flexion during single limb stance to compensate for a perceived or true leg length discrepancy for unilateral lower limb deficiencies. Vaulting is easily observed, however visual observation is not quantifiable. Vaulting can be measured by the ankle power generation during single limb stance using a three-dimensional (3-d) motion analysis system. Because of the time and cost constraints, most clinicians do not perform 3-d motion studies to document this gait abnormality. Dynamic foot pressures provide objective data of force, pressure, and contact time of the foot when walking. These data can be collected in a matter of minutes, and the outputs (foot prints) are relatively easy to interpret. Therefore, we performed a retrospective study assessing the relationship between ankle power generation in single limb stance with measures obtained from dynamic foot pressure system. If significant correlations are present, then dynamic foot pressure systems could be used to quantify vaulting gait patterns for children with unilateral lower limb deficiencies.

A retrospective review of 11 subjects, (8 male; 2 female) who previously underwent 3-d motion study as part of routine clinical care was performed. Subject's age ranged from 11-20 years old. Some subjects had data collected with their new and old prosthesis, therefore a total of 15 gait studies and dynamic foot pressures were used in this study. Subject's diagnoses were: AKA (n=3), fibular deficiency (n=2), knee disarticulation (n=2), unilateral BKA (n=1), and Pffd-symes conversion (n=3). For statistical comparison subjects were placed into two groups (AKA, BKA). Ankle kinematic and kinetic data were calculated from kinematic data collected with motion analysis corporation system (8 eagle cameras) and post-processing were performed using Orthotrak software. Dynamic foot pressure data were collected and calculated using the NOVEL hardware and software system.

Statistical comparison between the three groups were performed (paired t-test) using SPSS 15.0.

Nine of the 15 visits demonstrated vaulting on the uninvolved side. Those with no vaulting demonstrated mean ankle power -.23 (Watt/kg), while those with vaulting demonstrated mean power generation .56 (Watt/kg) (p=.001).

The center of pressure line of the foot print demonstrated a reversal in direction on the uninvolved side for all trials that subjects demonstrated a vaulting gait pattern. The length of the center of pressure line within the hind-foot, mid-foot and forefoot was calculated by the Novel software. A ratio was calculated by dividing the length of the center of pressure line with the length of the forefoot, mid-foot and hind foot, respectively.

The ankle power during single limb stance of the uninvolved side demonstrated significant correlations with ipsilateral: contact time of the forefoot (r .865), contact time of the hind foot (r -.573), contact time of the mid-foot (r -.737), and with the length of the center of pressure line of the forefoot (ratio to forefoot segment)(r .594).

Findings from this study indicate, the potential exist to use dynamic foot pressure systems to quantify a vaulting gait pattern for children with lower limb deficiencies.

FRIDAY, April 13th
10:55-11:05 AM
Paper 6

The Boyd Amputation in Children: Indications and Outcomes

David E. Westberry, MD
Linda I. Pugh, RN
Shriners Hospitals for Children – Greenville
Greenville, South Carolina, USA

Background: Amputation level in the pediatric population requires appropriate planning to provide an optimal residual limb for prosthetic-fitting and must include long-term strategies to accommodate future growth of the extremity. In 1939 Dr. Harold Boyd described an ankle level amputation by retaining the calcaneus and heelpad and performing a fusion of the calcaneus to the distal tibia. The advantages of this procedure are that it provides heelpad stabilization, improves prosthetic suspension, and allows for complete weight-bearing through the residual limb.

Methods: A retrospective review over a 15 year period was performed of all Boyd procedures in the pediatric limb deficiency population at a single institution. A chart review and radiographic analysis was performed to identify the indications, surgical outcomes, complications, need for additional surgical intervention, and nature of the postoperative prosthetic management. Optimal positioning of the calcaneotibial fusion as well as growth-dependent changes in the morphology of the fusion site were determined by radiographic analysis. Outcomes for the entire cohort as well as between diagnostic groups were described and compared using basic descriptive statistics and Student's t-tests.

Results: For the review period, 109 children (117 limbs) were identified for inclusion in the study. The average age at the time of the Boyd procedure was 2.8 years. The most common indication for the Boyd procedure was a diagnosis of post-axial limb bud deficiency (fibular deficiency and/or PFFD), which accounted for 66% of cases. Fixation utilizing 2 k-wires was performed in 94% of cases. If present, the fibula was resected by an average distance of 2.8 cm above the level of the calcaneotibial fusion. The calcaneus was positioned at an average pitch angle of 78.0 degrees with slight posterior translation measured at 34 % of the length of the calcaneus.

Concomitant procedures were performed in 24% of cases and included proximal tibial epiphyseodesis, tibial osteotomy, or knee fusion in the majority of cases. For the entire cohort, the complication rate was 14% and included would healing issues (5%), nonunion at the site of the calcaneotibial fusion (4%), and incomplete treatment of the initial pathology (4%). Complications were most common when the Boyd procedure was used as a treatment strategy for congenital pseudoarthrosis of the tibia. Additional procedures were required in 30% of cases either for treatment of complication (7%) or optimization of the residual limb (23%). Prosthetic management utilizing supramalleolar suspension with complete end-bearing through the residual limb was possible for the majority of cases.

Conclusions: The Boyd procedure is an effective treatment for various conditions of the lower extremity. The overall union rate for the calcaneotibial fusion was 95% and the position of fusion remained stable during the growth of the child. Concomitant or additional procedures after the initial intervention may be required for complete optimization of the residual limb.

FRIDAY, April 13th
11:05-11:15 AM
Clinical Case 4

Knee Disarticulation Amputation in the Treatment of Bilateral Tibial Deficiency: A Challenging Pediatric Case Study

Kristen Matthews, CP(c)
Shirlene Campbell, PT
Wilson Cisneros, RPT(c)
Bryan Steinnagel, CP(c)
Shane Glasford, CP(c)
Ricardo Torres-Moreno, PhD
Holland Bloorview Kids Rehabilitation Hospital
Toronto, Ontario, Canada

Background: At birth, the subject of this case study was diagnosed with bilateral tibial hemimelia. Indications included absent tibiae, hyperplastic fibulae, bilateral flexion deformities at the knee, and bilateral inversion deformities of the feet. The right foot presented with three metatarsals and soft tissue syndactyly with one triphalangeal digit. The left foot presented with four rays and incomplete formation of the hindfoot. Bilateral forefoot valgus, bilateral parallel orientation of the talus/calcaneus, and bilateral rocker bottom deformities of the feet were present. Fusion of sacral segments of the spine (S3-S4), lower than normal termination of the conus medullaris (L4), dysplastic right hip, and atypical muscular arrangements bilaterally were identified. The child had adapted to being carried until, at age 32 months, surgeons opted to perform bilateral knee disarticulation amputations. Post-amputation, the child was able to bear weight distally on both femoral segments and was able to move around independently by crawling on distal residual limbs and knuckles, resulting in severe knuckle calluses. Due to inconsistencies between femurs and hips, the right residual limb was slimmer and shorter than the left counterpart, necessitating accommodation prosthetically.

Rehabilitation: The child and family were first seen by the multidisciplinary rehabilitation team (prosthetists, social worker, PT and OT) at Holland Bloorview Kids Rehabilitation Hospital three weeks post-amputation. The child was fitted with bilateral thermoplastic stubbies as preparatory devices. Compliance was an issue initially; five months were spent developing tolerance and balance while increasing wear time. Educating the family and helping them to adapt were facilitated by introducing them to another family with a similarly aged child at a slightly more advanced stage of fitting for the same level of bilateral amputations. Once wearing time had been established, height was increased gradually to preserve and develop balance. Half inch height adjustments at approximately one month intervals were necessary for three months. Prosthetic feet were then incorporated into the devices. Due to growth and volume changes the sockets also needed to be replaced, and the child was fitted with laminated sockets. Prosthetic alignment incorporated the identified need for stability as well as information gleaned from diagnostic imaging acquired through Ontario's electronic Child Health Network. These images provided information about skeletal integrity and the development of the child's hips bilaterally, which was helpful in developing a useful physiotherapy plan. Ongoing physiotherapy was crucial to preserving hip range of motion and encouraging physical development and family compliance.

Discussion: Goals and objectives are to continue adjusting height until prosthetic knees can be incorporated and to keep striving towards more efficacious gait. In bringing this case study to ACPOC, the rehabilitation team aspires to generate discussion on methods of incorporating knees into bilateral devices – e.g., locking versus bending knees – and the effects of each on gait training, confidence and function. The team also hopes to stimulate discussion among professionals on the multidisciplinary nature of treating and fitting challenging congenital cases, and the relevance of family-centered care, in keeping with our mandate for "A World of Possibilities for Kids with Disabilities."

FRIDAY, April 13th
11:30-11:40 AM
Paper 7

Utilizing EMG from Individuals with Lower Limb Amputations to Control Powered Prostheses

Robert D. Lipschutz, CP
Heather Daley, MSc
Levi J. Hargrove, PhD
Ann M. Simon, PhD
Suzanne B. Finucane, MS, PTA
Rehabilitation Institute of Chicago, Center for Bionic Medicine
Chicago, Illinois, USA

Technological advancements in lower limb prostheses have resulted in actuated motors in both knees and ankles. Currently, these components are being controlled by the information measured from various electro-mechanical sensors attached to the prosthesis. At the Rehabilitation Institute of Chicago, and elsewhere, our aim is to explore the ability to enhance the control information provided to powered prosthetic components with input from the user via interpreted electromyographic (EMG) data. To extract useful control information, it is imperative that consistent and high-quality EMG data be collected from the patients each time they don the socket. In this work; we present approaches to maintain consistent electrode placements on individuals with transfemoral and transtibial amputations during 1) static, non- weight bearing conditions, and 2) during dynamic weight-bearing activities. Our results show that a variety of methods, similar to those used in upper limb fittings, may be used to collect high quality EMG data during static non-weight bearing conditions. These outcomes are presented in a real-time environment utilizing both active prostheses and virtual environments. EMG data collection during dynamic weight-bearing activities is more challenging. The type, size, shape, and placement of electrodes must be carefully chosen to maintain contact with the individual without comprising comfort when weight bearing through the socket. Results of data collection and classification will be presented as we attempt to define parameters for “state-changes” within the control of powered knees and ankles.

FRIDAY, April 13th
11:40-11:50 AM
Paper 8

Classification of EMG Data from an Individual with Congenital Abnormality of The Femur: A Single Case Study

Robert D. Lipschutz, CP
Levi J. Hargrove, PhD
Ann M. Simon, PhD
Suzanne B. Finucane, MS, PTA
Rehabilitation Institute of Chicago, Center for Bionic Medicine
Chicago, Illinois, USA

A research study has begun to determine the viability of using electromographic (EMG) data from individuals with lower limb amputations to provide additional information defining parameters within powered, lower limb prostheses. Most of the subjects that have partaken in this study have transfemoral or transtibial amputations. Thus, the placement of electrodes, for collection of EMG, has been over palpable muscles that perform primary functions, i.e. hip AB/ADduction, Flexion/Extension. Muscles that are either bi-articular to the hip and knee or mon-articular to the knee alone have also been targeted in an attempt to gain additional data for input to the control algorithm.

A single case study has been investigated on an individual with congenital abnormality of the femur. Although muscles that provide a primary function were not palpable to the degree of transfemoral limbs, patterns of EMG were elicited, in a static, non-weight bearing condition for control of a virtual environment avatar. Results of this data collection and experimental testing relative to the classification of “virtual movements” will be shared.

FRIDAY, April 13th
11:50 AM-12:00 PM
Paper 9

A Survey of Prosthetic Foot Clinical Selection Criteria

Gerald E. Stark, Jr., MSEM, CPO/L, FAAOP
The Fillauer Companies, Inc.
Chattanooga, Tennessee, USA

Introduction: With the increasing number of prosthetic foot designs promising an ever widening spectrum of functions, the prosthetist is faced with new patient recommendation decisions. Although significant research has been done with regard to gait analysis, energy consumption, and kinetic movement, very little quantitative research data seems to have permeated to the clinical level that directly aids prosthetic decision making. Along with assessing weight, activity level, and unique functional goals, practitioners currently rely on empirical statements by the patient and observation of the dynamic function using basic gait analysis emphasizing the dynamic presentation of the rocker motions during stance. This dynamic clinical observation greatly relies on functional assessment and load transitions during the rollover at the first, second, and third rockers during stance phase confirmed by patient feedback. Examination of the clinical paradigms by which the prosthetic foot is selected is important to understand what current practices and information is most helpful to the clinician. A previous small sample telephone survey of 19 pre-selected clinicians representing innovators, early adopters, early majority, late majority, and traditionalists, were interviewed regarding their individual foot selection criteria. Of the over 105 foot designs presently available, prosthetists chose from a surprisingly small number of 4-5 predominant "mainstay' designs, and deviated only when special needs or functions dictated a unique solution. Performance assessment was based on a variety of functional foot selection factors including: cadence speed, uneven terrain, stability and balance, amputation level, weight, size of foot, special functions, effect of alignment, product warranty and maintenance, and cost. This limited initial survey identified factors affecting foot selection used in the present study, but did not provide any additional information from which to develop a more detailed and weighted profile of prosthetic foot selection criteria. The current survey was developed to utilize common terminology, delineate functional subsets, and determine clinical priorities with mutually exclusive and weighted responses.

Method: *Apparatus*: A ten-question survey was created using the selection factors identified earlier in the preliminary survey of 19 prosthetists. Survey was posted with a third-party independent web based service for 3 weeks and was solicited on the OANDP-L List Serv.

Subjects: Exactly 130 participants logged into the survey, 31 did not complete the second page and were excluded with from the remaining 99 participants. The third party web based service allowed only one participation occurrence from each IP address.

Procedures: Participants answered 10 questions with single, multiple, small group rankings, percentage distribution, and weighted ratings.

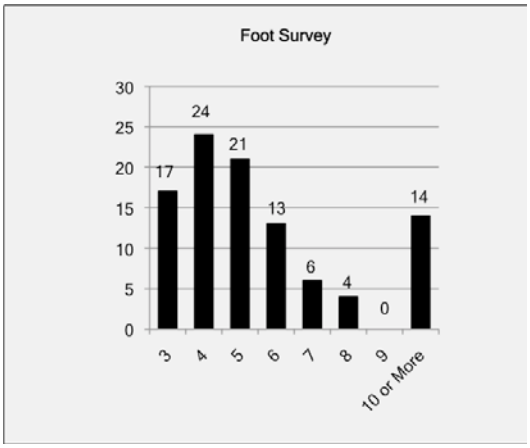


Figure 1: Number of Core "Mainstay" Feet

Data Analysis: Data was collected with distribution for each answer. The weighted responses were collected to produce a weighted Pareto Diagram to determine targeted 80% compliance of clinical values utilized by design engineers to determine product specifications.

Results: The largest experience group was those with 20 or more years of experience at 22.2%, 80.8% cumulatively indicated they had 5 or more years. The smallest number was 7.1% of less than 2 years of experience. With respect to the number of feet recommended per week the largest group with 53.5% was 0-2 feet per week. Second highest was 2-5 with 43.4% so 0-5 feet per week constituted 96.9% of all answers. Somewhat surprising was the small number of feet that practitioners consider as their “mainstay” feet. The largest group was 24.2% with 4 different feet. 3 feet was 17.2%, 5 was 21.2% 6 was 13.1%. Choosing from 3-5 feet included 62.6% of the answers, and 3-6 was 75.7%. There was a drop off at 7,8, and 9 feet, but 14.1% said they chose from 10 or more. The percentage distribution of patients by activity level reflected a symmetric distribution curve with "One Speed Walking/Occasional Fast Speed Walking" getting 38.2% followed by "Standing/One Speed Walking" getting 27.18% and "Frequent Fast Speed Walking/Occasional Running" getting 19.25. Cumulatively these received 84.63% of the distribution. When asked about the top 4 clinical selection features that most influence foot selection “Amputation Level” was, as expected, the highest at 3.100, followed by "Evidence Based Quantitative Data" and "Special Vocational/Avocational Feature" at 2.87 and "Maximum Stability and Balance" at 2.81. Lowest was "Warranty and Maintenance" at 2.05. The four most important factors for Multi-axis feet favored outdoor activities. Exterior slopes, grass, pavement, and ground constituted 78.33% of the response counts. The largest was “Exterior Ground” with 91 responses and second was “Exterior Slopes” with 87 responses The lowest was “Interior Hard Floor” at 7 responses. Features were rated for Dynamic Response feet were "Inversion-Eversion(Split Toe) Forefoot" with the largest rating average with 4.27. Second, with 4.13, was "Midfoot Rolling Mechanism". Third was "Integrated Shock Absorber" with 3.76 rating average. The lowest was "Cushion Foam Heel" at 2.20. When queried about “How long should a Dynamic Response foot last” there was a variety of answers. The largest number was 3 years at 35.4%, with 5 years second at 26.3%. 3-5 years included 82.9% of responses. 6-7 years constituted only 1.0%.

Values and clinical guidelines were briefly explored. When limited to a 4 of 8 of “Rules of Thumb, respondents chose "Reimbursement level greatly influences component choice" with 57 responses. The second was “The more proximal the Amputation, the softer the heel at 53 responses, third was "ISO Testing insures Durability and Performance" at 52. The lowest was "Heavier patients should have a less dynamic foot" at 7 response counts. Also when asked to choose 4 statements that correspond to the feet chosen from 8 statements "High Tech Design" was highest at 3.36 Rating average. The second highest rating average with 2.83 was "Physiologic Motion" and at 2.11 was "Past Positive Experience."

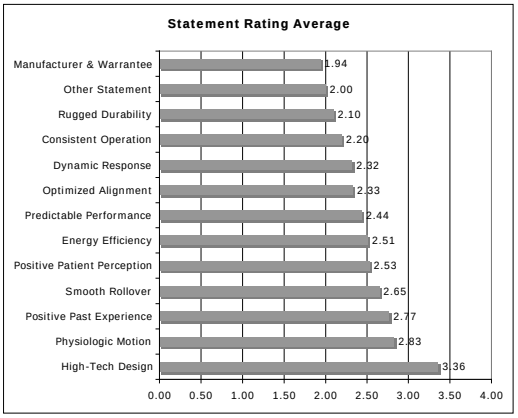


Figure2: Value Statement Rating

Discussion: Although the intention of the survey was to draw conclusions regarding values and beliefs when selecting prosthetic feet, more inquiry became apparent. It would be interesting to investigate the differences between more recent graduates and those with experience. This study was skewed to those with more than 20 years of experience. Somewhat surprising is that 17.2% of respondents said they chose between only three types of feet. Perhaps the option of two or even one should have been offered. A number of respondents indicated that “Evidence Based Quantitative Data” influenced their decision, but the survey did not ask what specific data they use or would use, when so little of it is readily available to the clinician. Outdoor terrain appears to be the biggest reason to pursue multiaxis feet while indoor activities are rated lower. This could imply, from the prosthetists perspective, that household ambulators are not typically indicated for multiaxis feet. One major criticism of the survey by one respondent was that the value statements were limiting in scope and did not solicit or factors offered by the participant. Admittedly this was done to facilitate efficacy the survey and improve overall consistency of answers for comparative purposes.

Conclusion: For the most part 75% of Prosthetists draw from a fairly exclusive group of only 3-6 foot designs (although 14% use 10 or more). Other than Amputation Level, prosthetists rate "Evidence Based Data" and the "Special Features" of feet quite highly. As expected "One Speed Walkers/Occasional Fast Speed Walkers" are the largest functional group. Outdoor activities appear to be the main reason prosthetist utilize to multiaxis designs. With respect to Dynamic Response feet, Inversion-Eversion, Rolling Motion, and Integrated shock are rated as most important. Prosthetists follow “Rules of Thumb” regarding Reimbursement, Stability Enhancement, and ISO testing when choosing feet. Most prosthetists feel feet should last 3-5 years, and look to "High Tech Designs" that provide "Physiologic Motion" that have prior "Past Positive Experiences" when making a foot choice.

References:

1. Michael, J., Clin Prosthet Orthot 11,154-168, 1987.
2. Hafner, B., JPO, 18-1S, 105-112, 2006.
3. Czerniekci, J., JPO 17-4S, 35-37, 2005.
4. Boone, D., Coleman, K., JPO, 18-1S, 68-79, 2006
5. Stark, G., JPO 17-4, 18-22, 2005.

FRIDAY, April 13th
1:15-2:15 PM

HECTOR KAY LECTURE

The Joys and Challenges of Providing Pediatric Orthopaedic Care in the Vast Area of the Pacific Basin

Ellen M. Raney, MD

Dr. Raney will discuss the joys and challenges of providing pediatric orthopaedic care in the vast area of the Pacific basin. There are numerous areas with little access to orthotists and prosthetists as well as orthopaedists. As we consider how best to make improvement in the lives of children we need to be mindful of many unique cultures.

Goals may be a varied as people. We are often accustomed to placing our highest emphasis on walking or earning a living. Certain societies place a higher emphasis on proper social etiquette such as being able to sit on the floor correctly. Conditions for which we consider flexibility and "braceability" to be ideal outcomes often require different treatment methods in an area where orthotics and prosthetics are not available. Treatment plans need to be sustainable. Local talent may be able to be recruited to create or recreate simple orthoses from models and local materials. The rewards of successful teamwork are immense.

FRIDAY, April 13th
2:15-3:15 PM

ORTHOPAEDIC REHABILITATION SYMPOSIUM

Lower Extremity Amputation Level Selection

Robin C. Crandall, MD
President, Orthopaedic Rehabilitation Association
Limb Deficiency Director, Shriners Hospital for Children
Minneapolis, Minnesota

Lower extremity amputations continue to represent a major and increasing cause of disability in the United States. The percentage of adult vascular amputees has increased to 82% of new amputees while congenital limb deficiency has remained steady at about 5%. Traumatic amputations have actually decreased due to improved limb salvage techniques. This symposium is a comprehensive look at how various lower extremity amputation levels are selected by the surgical team. This presentation includes statistics, discussion of traditional and new vascular techniques used in limb salvage, specifics of techniques both adult and pediatric with an emphasis on creating an ideal residual limb. Audience participation is encouraged with a question and answer session at the end of the presentation.

SESSION IV – LOWER EXTREMITY

FRIDAY, April 13th
4:00-4:10 PM
Paper 10

Comparison of Temporal-Spatial and Oxygen Consumption Data of Children with Lower Limb Deficiencies

Hank White, PT, PhD [1]
JJ Wallace, MS [1]
Sam Augsburger, MS [1]
Janet L. Walker, MD [1,2]
[1]Shriners Hospitals for Children and
[2]University of Kentucky Department of Orthopaedic Surgery,
Lexington, Kentucky, USA

Although a relative large amount of literature regarding walking speed and oxygen cost for adults is available, limited information is available regarding the typical walking speed, cadence, stride length and oxygen cost for children diagnosed with lower limb deficiencies. One reason for this could be the relatively small number of subjects with lower limb deficiencies evaluated in motion analysis laboratories. Therefore, we performed a retrospective review of 13 subjects (9 male; 4 female) who previously underwent three-dimensional motion study as part of clinical care to compare the temporal-spatial and energy cost when walking for children, and young adults with lower limb deficiencies. Subject age ranged from 11-20 years old. Subject's diagnoses were: AKA (n=3), fibular deficiency (symes/boyd amputation) (n=2), knee disarticulation (n=2), unilateral BKA (n=1), Pffd-symes conversion (n=3), bilateral BKA (n=2). For statistical comparison subjects place into three groups (AKA, BKA, bilateral BKA). Temporal-spatial data were calculated from kinematic data collected with motion analysis corporation system (8 eagle cameras) and post-processing were performed using Orthotrak software. Oxygen consumption data were collected using a Vmax metabolic cart (Carefusion, 2011) in dilution mode to measure oxygen consumption while subjects walked at a self-selected speed.

Statistical comparison between the three groups were performed (ANOVA test with post-hoc comparison) using SPSS 15.0 (Table 1). Statistically significant differences were noted for: oxygen cost, and step symmetry ($p<.05$). Subjects with AKA demonstrated higher oxygen cost, lower cadence and less time in stance compared to those subjects diagnosed with BKA (unilateral and bilateral)($p<.05$). Interestingly, no significant differences were noted between groups for speed, stride lengths and oxygen consumption when walking.

Seven of the 13 subjects demonstrated a vaulting gait pattern. Subjects that vaulted demonstrated a significant decrease in cadence and an increase in the percent of the gait cycle spent in single limb stance on the involved side ($p<.05$). Subjects that demonstrated a vaulting gait pattern also demonstrated a non-significant increase in oxygen cost and oxygen consumption when walking.

As clinicians we were surprised by the finding that approximately half of the subjects demonstrated a vaulting gait pattern. Most clinicians would agree that one important aspects of lower extremity prosthetic care is to optimize the symmetry of a child's gait pattern. For clinical care, a patient's walking speed, step symmetry; step width could be quickly and routinely calculated in a motion analysis laboratory, without performing a comprehensive evaluation.

Table 1 Mean, standard deviation, 95 % Confidence Intervals (CI), and ANOVA values

Variable	Diagnosis	Mean	Standard deviation	95 % CI Lower bound	95 % CI Upper bound	ANOVA
Velocity (% age match normal)	BKA AKA Bi BKA	96.3 96.5 101.0	9.7 12.6 2.8	72.2 86.0 75.6	120.5 107.0 126.4	F= .13 p = .88
Cadence (% age match normal)	BKA AKA Bi BKA	92.0 86.4* 103.5*	5.0 8.2 3.5	79.6 79.5 71.7	104.4 93.3 135.3	F= 4.5 p = .04
Stride Length (% age match normal)	BKA AKA Bi BKA	105.3 111.8 98.0	15.3 9.8 1.4	67.3 103.5 85.3	95.9 143.4 120.0	F= 1.5 p = .28
Involved side (% gait cycle in single limb stance)	BKA AKA	62.7* 59.0*	1.5 2.0	58.9 57.3	66.5 60.7	F= 10.3 p =.004
Oxygen cost (ml O_2/kg-meter)	BKA AKA	0.22* 0.30*	0.03 0.03	0.15 0.26	0.29 0.33	F= 6.1 p =.04
*denotes difference between groups						

FRIDAY, April 13th
4:10-4:20 PM
Paper 11

Radiographic Parameters Improve Lower Extremity Prosthetic Alignment

Ryan Mooney, PA-C*†
Patrick Carry, BA‡
Abby Schultz, BA
Bryan McNair**†, MS
Carol Page, PT§
Susan Biffl, MD§†
Travis Heare, MD*†
**Department of Orthopaedic Surgery, ‡Musculoskeletal Research Center, **Research Institute*
§Department of Physical Medicine and Rehabilitation, Children's Hospital Colorado
†The University of Colorado, Anschutz Medical Campus
Colorado, USA

Introduction: At our institution, standing AP long leg radiographs (LLR) are obtained from prostheses after they have been fit based on traditional methods (physical exam and observational gait analysis). The LLRs are used to assess alignment and guide adjustments as necessary. The purpose of this project was to determine whether this novel methodology improves prosthetic fit.

Methods: Following IRB approval, LLRs obtained between September 2009 and September 2011 were retrospectively reviewed. Each time a subject in the cohort received new prostheses due to growth and/or surgery, the patient was considered a new subject. Radiographs taken after the prosthesis had been fit based on traditional methods (baseline evaluation) were compared to LLRs obtained after adjustments had been made based on radiographic parameters (final post-adjustment evaluation). Lower extremity alignment was defined by mechanical axis angular deviation (MAAD), distal offset (DO) and leg length discrepancy (LLD). MAAD was measured by the optimal line, center of the femoral head through the center of the knee joint, and the deviation line, center of the femoral head to the center of the ankle joint. A neutral MAAD was defined as ≤ 1°. DO was defined as the horizontal distance (parallel the floor) between the optimal line and the deviation line. Ideal prosthetic alignment was defined as MAAD ≤ 1° and LLD ≤ 10 mm. The differences in these variables between the baseline and adjustment evaluations were analyzed using a generalized linear mixed model. The correlation between the limbs and the prostheses within a given subject were appropriately controlled for in the statistical model.

Results: A total of 24 subjects (10 female and 14 male) were included in our analysis. The average number of prostheses per patient was 1.75 (range 1 – 4). As a result, 50 unique prostheses were included in the analysis. Post-adjustment radiographs were obtained from 27 of these prostheses. Based on our definition of ideal alignment (MAAD ≤ 1° and LLD < 10 mm), only 13.16% of the prostheses were in ideal alignment during their baseline evaluation. After undergoing serial radiographic based adjustments, 44.44 % were in ideal alignment during their final, post-adjustment evaluation. The changes in alignment are displayed in table 1.

Table 1. Change in Alignment Between the Baseline and Final Post-Adjustment Radiograph

Outcome Measure	Parameter Estimate	95% CI	P value
Neutral Mechanical Axis Angular Deviation (≤ 1°)	3.353*	1.13-10.098	0.0324
Distal Displacement [mm]	12.8518†	1.75-23.96	0.0245
Leg Length Discrepancy [mm]	4.7582†	1.49-8.02	0.0054

*Odds ratio (Final vs Baseline)
†Difference in Mean (Final – Baseline)

Discussion: There was a significant [$p < 0.05$] improvement in all radiographic outcome parameters. The odds of a prosthesis being in ideal alignment during final post-adjustment evaluation was 3.344 [95% CI: 1.04-10.71] times the odds of the prosthesis being in ideal alignment during their baseline evaluation [$p=0.04$]. Although significant, the changes in length and displacement were less than 2 cm. Future research needs to determine whether these improvements translate into improved function.

Conclusion: The addition of LLRs to existing fitting methods significantly improves prosthetic alignment and length.

FRIDAY, April 13th
4:30-4:40 PM
Paper 12

Significant Differences Between Reported and Measured Wear-Rates in Clubfoot Bracing Via a Novel Pressure Sensor

Aaron Morgenstein, MD
Neeley Buhr, MS
Vishwas Talwalkar, MD
Henry Iwinski, MD
Janet L. Walker, MD
Todd Milbrandt, MD
Shriners Hospitals for Children
University of Kentucky Department of Orthopaedic Surgery
Lexington, Kentucky, USA

Purpose: Compliance with foot abduction orthosis (FAO) wear has been postulated to improve treatment outcomes in patients undergoing clubfoot treatment via the Ponseti method. Our hypothesis was that caregiver reported wear-rates were significantly less than actual wear-rates.

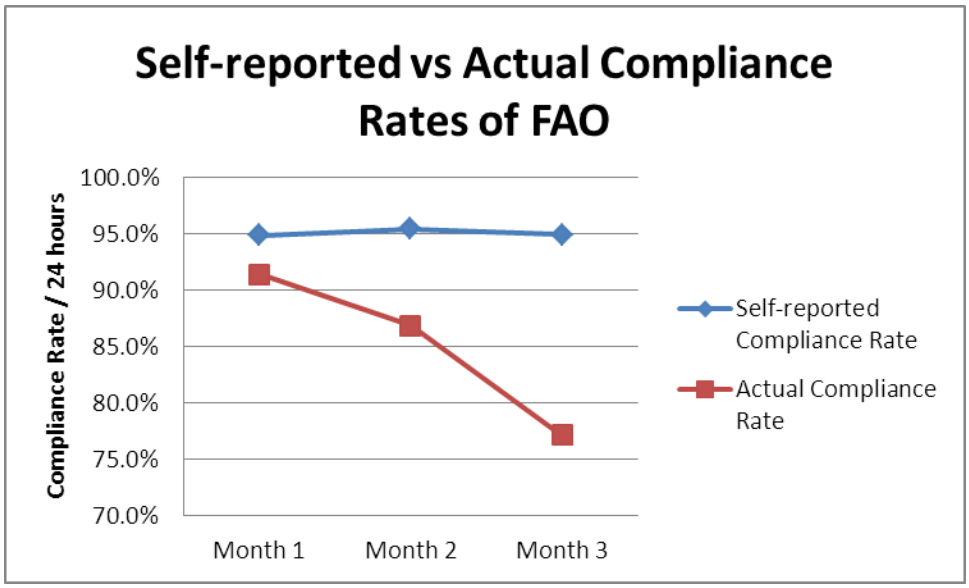
Methods: A randomized prospective study of 48 children, ages 0-3 years old with clubfoot, and who successfully underwent the Ponseti technique for idiopathic clubfoot, was undertaken following IRB approval. Participants were randomized into three groups; a functioning pressure-based sensor (group FPS) attached to the FAO (19 pts), a non-functioning sensor (NFPS group) attached to the FAO (15 pts), or no sensor (NS group) (14 pts). All care-givers filled out a diary of subjective wear time (journal). Reported and actual wear-rates were recorded as a percentage of the entire day and compared via statistical evaluation.

Results: In the FPS group, the average actual wear-rate for months 1, 2 and 3 was 91.4% (14 pts; 72.7-97.0%), 86.3% (9 pts; 60.5-96.3%), and 77.1% (7 pts; 57.5-95.8%) respectively. The average self-reported wear-rate in the FPS group in months 1, 2 and 3 was 94.8% (11 pts; 93.7-98.7%), 95.4% (8 pts; 92.3-99.4%), and 94.9% (9 pts; 82.8-99.6%) respectively (Figure 1). During the first month 2/11 pts reported a wear-rate that was significantly different than the actual wear-rate ($p<0.0001$). This changed dramatically for the second month (4/8 pts, $p<0.0001$) and the third month (4/6 pts, $p<0.0001$). The earliest predictive factor in determining a patient's decrease in wear-rate overall was a drop in the wear-rate between month 1 and 2 ($p<0.001$). The NS group showed a three month subjective wear-rate of 95.1% without statistical significance between months ($p<0.01$). The reported wear-rates were not statistically different between any of the three groups ($p<0.01$).

Conclusions: By using a novel method of pressure sensitive measurement, which documented FAO wear, we have shown a significant drop in wear-rates from month 1 to month 3, with some wear-rates as low as 52.5% of ideal per month. These actual FAO wear-rates did not match their reported rates, thus putting into question previous assumptions about brace compliance. The largest decrease in wear-rates occurred from month 2 to 3. The addition of a placebo sensor did not influence the reporting of wear-rates.

Significance: This study provides the first objective measurement of FAO brace wear in patients undergoing the Ponseti method of treatment. These results bring into question the utility of any clubfoot outcome studies using diary reported FAO wear-rates.

Figure 1: Comparison of self-reported to actual compliance rates of FAO wear.



FRIDAY, April 13th
4:40-4:50 PM
Paper 13

Verebelyi-Ogston Procedure for Management of Club Foot Deformity in Cerebral Palsy and Meningomyelocele

Vipal Shah, MD

Introduction: Conservatism is well recognized after Ponseti's method in the treatment of congenital clubfoot; however, this is not applicable to the complex and resistant club foot in hemiplegic cerebral palsy, dystonic cerebral palsy and meningomyeloce which challenge the orthopaedic surgeon. In such a type, soft tissue releases as fasciotomies, tenotomies, and capsulotomies, as well as osteotomies are insufficient and lead to scarring and joint fusions are not suitable in early childhood before skeletal maturity in addition they are fraught with failures,we evaluated Verebelyi-Ogston procedure in such difficult situations in combination with tendon transfers material and methods seventeen children (19 feet) with resistant clubfeet between 5-14 years of age were analysed clinically and radiographically. 10 of the cases received previous conservative treatment in their first year of life, 3 received conservative followed by soft tissue releases before treatment by decancellation of the cuboid, the calcaneus, and the talus to correct the complex adduction, supination, varus, and equinus deformities. 4 were virgin feet without any treatment whatsoever .tendon transfers were done wherever required. Pre-operative measurements of foot angles were compared with their corresponding postoperative values.

Results: A grading scheme for evaluation of the results using a point scoring system was suggested to evaluate accurately both clinical and radiographic results after a follow-up period of an average of 2.3 years. 40% had excellent, 40% good, 20% fair, and no poor (0%) outcome. There was no major complication. There was significant improvement in the result ($P > 0.035$).

Conclusions: Tarsal decancellation with tendon transfers is particularly useful to such complex cases at an early age. It shortens the period of disability, improves the range of foot motion, and does not interfere with the foot bone growth; flexible polypropylene orthosis and night splints are an important adjunct and will be discussed in the presentation

FRIDAY, April 13th
5:00-5:10 PM
Paper 14

Botulin Toxin for Management of Equinus in Children Less Than 5 Years with Cerebral Palsy (CP) – A Comprehensive Approach

Vipul Shah, MD

Introduction: Equinus is one of the commonest and usually the first evident deformity meriting treatment in CP ,in recent time there is an increased understanding of the natural history of CP hence most centers globally have shifted to surgical treatment at 5/6 years of age, botulin toxin is a very big tool in the armamentarium of the surgeon treating these children below 6 years, this paper looks at our experiences

Method and material: 60 children with CP < 5 years who had at least 1 shot of botulin toxin in the TA`s were randomly selected from data base as per protocol all children have serial videotaping, ashworth, Tardieu scales ,gmfcs along with static measurements . excluded- GMFCS grade 5 and children > 1 generalized seizure / month),leaving 48 children, all except 5 were concurrently given oral baclofen and all received home therapy programme, botulin was administered under anesthesia, in case of static deformities supplementary casting was done

Observations: Correction of equines was achieved in all, splints/baclofen and home therapy programme helped in maintenance, effect of a single shot was 6months- 3 years, 12 children lost to long term follow up (> 1 year) average - 9.3 months

Discussion: This research shows that botulin toxin is an important tool in the management of children with cerebral palsy and can be used to push the age of surgery till 6 years, an analysis on value of adjuncts especially splintage will be discussed in the presentation

FRIDAY, April 13th
5:10-5:20 PM
Case Study 6

Serial Casting 55 Degree PF Contracture, CP

Nancy M. Hylton, PT, CO
Dynamic Orthotic Systems
Children's Therapy Center of Kent
Kent, Washington, USA

We have used a specific protocol of Serial Casting very extensively to regain lost ROM over the past 30 years at our Center. Typically, we see children after a period of rapid long bone growth that have lost functional dorsiflexion ROM making orthotic fit, as well as, stable weight-bearing and balance more difficult. With and average of 2-3 weeks in serial cast and focus on active weight-bearing strength and training, DF ROM is regained.

In Spring of 2011 we were approached by a family regarding serial casting for their 15 year old son with Dystonic Tetraplegic CP, who lived 3-4 hour drive from our Center. He had had multiple orthopedic opinions, but the family wanted to avoid surgery if possible. He had a 55 deg PF contracture of the left ankle with strong supination and was unable to tolerate any type of orthosis for ankle-foot support. He used a hinged AFO with PF stop on the right side and was gradually loosing his independent ambulation.

The first serial cast was left on one week, gaining 10-15 degrees of DF. Due to the long drive for the family the second serial cast was left on for 2 weeks with enough gain in ROM with knee flexed to cast mold for new supra-malleolar Dynamic AFOs and then re-cast for 2.5 weeks to gain remain ROM into dorsiflexion with knee extended. He was encouraged to develop WB strength over the left side and walk as much as possible while in each cast. Even though he attained just neutral DF with knee straight by the end of the 3rd cast, we chose not to apply another cast, but ask him to continue to actively stretch in standing and walking.

Because the hamstrings were also quite tight, he also began to use a knee extension splint during this time. At re-check 3 months later, he had increased DF Rom by an additional 10 degrees and was walking 2-3 miles in a day for exercise.

FRIDAY, April 13th
5:20-5:30 PM
Case Study 7

Challenging Current Practices and Beliefs in Using AFOS to Pediatric Patients with Cerebral Palsy

Curt A. Bertram, CO, FAAOP
Hanger Prosthetics and Orthotics, Inc.
Hartland, Wisconsin, USA

For years we have managed our pediatric CP patients with standards of practice and beliefs that are being challenged by new paradigms and research. We have held to such beliefs and practices such as; the talocrural joint (TCJ) and subtalar joint (STJ) need be at neutral, the triceps surae must be strong if the child has a equinus deformity, “tone reducing modifications” in an afo reduce tone and spasticity, accommodating an equinus contracture and wedging under the heel can increase the contracture, AFOs have little effect on hip stability, it’s ok to force alignment in an AFO as long as you can obtain the alignment with your pressure, articulating AFOs help reduce plantarflexion contractures, AFOs prevent foot deformities, navicular redness is a sign of poor modification of the plaster mold and AFOs in and among themselves are poor at addressing the first rocker of gait. In addition to these beliefs, AFOs have a great track record on controlling the swing phase of gait (40%) but perform inefficiently for the stance phase (60%). The complexity of stance and the degrees of freedom have limited the success of solid AFOs and have demanded too much from the articulating AFO. As times have changed we have also overlooked the shoe AFO interface. Modifications to the shoe from SACH style heels and appropriately placed rockers can “tune” the AFOs function and enhance the outcome for the patient.

The goals and learning objectives will be to challenge these long standing practices and beliefs and present research to corroborate a new paradigm. The attendee will also gain an appreciation for the AFO shoe interface and learn how the proper modifications can improve outcomes and enhance performance by “tuning” the AFO shoe combination. The AFO used in conjunction with the properly modified shoe can be used as a form of therapeutic treatment for the equinus deformtiy and go beyond just being a gait aide.

SESSION V – LOWER EXTREMITY

SATURDAY, April 13th
8:00-8:10 AM
Paper 15

Non Operative Management of Pediatric Post Injection Nerve Palsy Lessons Learnt

Vipul Shah, MD

Introduction: Post injection sciatic nerve palsy is disabling, children are more prone because of poor muscular coverage and they fall ill repetitively. Management is a challenge specially if there is no recovery in the first 6 months, the tendoachilles becomes tight, strategies from neural decompression to tendon transfer have been explored and so has the use of splintage/physical therapy and muscle stimulation. This paper looks at these modalities in a small cohort.

Material and Methods: Five children aged 6-12 years ,inclusion criteria – at least 6 months post palsy (range 6 -15 average 10.2 months), documentable atrophy ,without clinical recovery since the last 6 months. On examination all children had tightness in tendoachilles with an equinus ranging from -10 degree to neutral with resultant foot drop gait. All children were first casted A/K for 6 weeks to correct equinus and post cast removal were given dynamic AFO`S , simultaneously supportive neurotrophic factors administered orally and parents were taught muscle stimulation -three times a day 15 min per session in the dorsiflexors, followed up with videotaped gait analysis and physical examination.

Results: All children on follow up video gait analysis showed reduced foot drop , active dorsiflexion from neutral to 10 degree , reduced their AFO`S wearing time. Time needed to achieve active neutral during gait averaged 9.7 months(range 8-11) ,children in long term follow up (1.2 years-3.5 yrs average 1.8 yrs fu) did not have major functional disabilities

Discussion: Small cohort with long term follow up shows that distal muscle stimulation/intensive therapy and splintage may obviate the need of surgery in cases of nerve injury, long term follow up in a larger population is needed, in addition use of splintage as adjuncts to prevent further formation of deformities.

SATURDAY, April 13th
8:10-8:20 AM
Paper 16

Long Term Correlates of Pediatric Hyperlax Flat Feet - Not So Benign Any More

Vipul Shah MD*
Prof A.N. Varma
Garima Singh

Introduction: Flat feet is a common condition in children and often reversible. There is scant literature in pediatric and adult world on the long term correlates of hyperlaxity. We at R.P. Shah Memorial Trust and Indian Cerebral Palsy Clinics take care of back ache and pediatric orthopedic conditions which provide us the unique opportunity to assess the long term correlates between hyperlaxity and other orthopedic conditions.

Methods and Material: All children above 6 years who demonstrated hyperlaxity by Breigton`s criteria in the data base were taken up. Telephonically parents were called for review, 67 parents out of 82 turned for review, parents were examined for hyperlaxity. In 45 cases either of the parents demonstrated hyperlaxity and were taken up for review – the data gathered was compared with data in the spine clinic. Their siblings were telephonically contacted and asked regarding orthopedic complaints and related documents were examined. All these parents also demonstrated mobile hyperlax flat feet. Children with hyperlax flat feet were also compared with a data base of normal school going children.

Observations: Comparative data showed that children with hyper laxity and hyperlax flat feet have more frequent incidence of back ache with early disc degeneration on MRI imaging, knock knees, knee hyperextension ,their parents statistically have increased incidence of backache ,their back problems have an extension bias with the facet joints more involved, their disc involvement is multilevel and the back ache started earlier in life, they also have increased incidence of migraine type headaches as associated non orthopedic findings, this cohort also had increased predilection to failed low back surgery syndrome.

Discussion: This paper will discuss findings and look at associations between these conditions, it will also make the adult orthopedic surgeon look at flat feet with a little more trepidation and care, the value of assistive orthosis will be discussed in the presentation.

SATURDAY, April 13th
8:20-8:30 AM
Paper 17

Physical Functioning In Children with Lower Limb Length Discrepancies: A Review of Current Outcomes Measures

Corinne Mercier, PT[1]
Noémi Dahan-Oliel[1]
Kathleen Montpetit[1]
Reggie Hamdy[1,2]
[1]*Shriners Hospital for Children*
Montreal, Quebec, Canada
[2] *McGill University*
Montreal, Quebec, Canada

Hypothesis: Pain, cosmesis, shoe wear and restrictions in daily activities and in sports are common concerns in children with lower limb length discrepancies. The use of outcome measures is indicated to measure baseline functional performance and to evaluate the impact of treatment. There is limited information as to which outcome measures should be used in this population and concern that functional outcome measures commonly used in pediatrics have a ceiling effect in this population. The objective of this systematic review was to identify the existence of a gold standard measurement to assess physical functioning in children with lower limb length discrepancies.

Methodology: A systematic search of the literature using PubMed, PEDro, CINAHL, Rehabdata and Web of Science using a combination of relevant keywords was conducted. Keywords utilized were “physical functioning”, “physical activity”, “mobility”, “motor activity”, “functional outcomes”, “functional mobility”, “limb length discrepancy”, “leg length discrepancy”, “lower limb discrepancy”, “lower extremity length inequality”, “lower limb inequality”, “limb length inequality”. The search and data extraction was conducted by two independent reviewers. Consensus was achieved through discussion between the reviewers.

Data Analysis: The search strategy yielded 205 articles. Outcome measures which were applicable to the entire population having a lower limb length discrepancy, measured physical functioning, and were validated in English were summarized in a table. Twelve physical functioning measures were included and appraised based on their purpose, administration, target population, items and domains included, scoring, and psychometric properties. The physical functioning measures identified in these studies were analyzed to determine whether they would be applicable to a pediatric population with limb length discrepancy based on the presence of ceiling effect and relevance to issues specific within this population.

Conclusions: Our findings indicate that no relevant outcome measures assessing physical functioning in the pediatric population of patients with lower limb discrepancies could be found in the literature. We recommend that an outcome measure for children with lower limb length discrepancies be developed to optimize objective assessment of physical functioning in this population. Assessments should be tailored to the individual needs of these children and also include client-centered methods. Other concepts such as quality of life, pain and psychosocial functioning should also be considered as these have also been identified as key issues in the literature.

SATURDAY, April 13th
8:45-9:45 AM
Symposium III

Clinical Experience of Designing, Aligning and Tuning AFO Footwear Combinations Based on Segment Kinematics

Donald T. McGovern CPO, FAAOP
Kenneth R. Boggs, CO
Corinne Jordan, DPT
Rehabilitation Institute of Chicago, Chicago, IL

This course aims to introduce participants to the importance of segment kinematics in understanding and classifying standing and gait as well as designing, aligning and tuning of Ankle Foot Orthosis Footwear Combinations (AFO-FC). The biomechanics of normal and pathologic gait will be reviewed with attention to segment kinematics and kinetics. We will also discuss the initial clinical assessment and medical interventions prior to gait analysis. This approach will be placed within the context of the International Classification of Functioning, Disability and Health.

The importance of segment kinematics in standing and gait, and their effect on joint kinematics and kinetics will be demonstrated. The use of shank kinematics for the designing, aligning and tuning of AFO-FC will be reviewed. The importance of Footwear design in AFO-FCs will be established. The difference between optimal Angle of the Ankle and the Shank to Vertical Angle in an AFO-FC will be clarified.

The experiences of utilizing these concepts will be included from the viewpoint of the Physician, Orthotist and Physical Therapist. The initial experiences of the RIC AFO Tuning Clinic will be shared. Orthotic and Physical Therapy assessment, treatment goals and strategies will be presented.

Goals:
Maximizing stability and mobility to improve function often includes the use of orthotics. This course presents a fresh approach to the analysis of normal and pathological standing and gait. Manipulation of lower extremity segment alignment as opposed to the common focus on joint position will be presented as an improved method for lower extremity orthotic alignment resulting in improved standing and gait. A more objective understanding of standing, gait and optimum orthotic intervention will be offered. Once the Orthosis is optimized the user has a new opportunity to improve control of their body, Physical Therapy can exploit this opportunity to improve function and address issues previously obscured by compensations. Strategies to take advantage of these opportunities will be explored.

Objectives:
1. Describe the kinematics and kinetics of normal and pathological gait and standing, with equal emphasis on the kinematics of the segments and the joints.
2. Discuss a clinical algorithm to determine the optimum sagittal Angle of the Ankle in an AFO.
3. Discuss the biomechanics of AFO and Footwear Combination designs and a clinical algorithm to design, align and tune AFO-FCs.
4. Discuss the influence of optimally designed and aligned orthotics within the ICF model.

SESSION VI-LOWER EXTREMITY AND GENERAL

SATURDAY, April 13th
10:30-10:40 AM
Paper 18

Impact of Fine-Tuning Hinged Ankle Foot Orthoses on Abnormal Knee Kinematics in Children with Gastrocnemius Spasticity

Andrea N. Dennis, PT [1]
Jennifer L. Hutchens, PT [1]
Adam Miller, Engineer [1]
Cathy Harro, PT [2]
[1]Mary Free Bed Rehabilitation Hospital
Grand Rapids, Michigan, USA
[2]Grand Valley State University
Grand Rapids, Michigan, USA

Introduction: Genu recurvatum, defined as full extension or hyperextension of the knee during stance phase, is a common gait dysfunction observed in children with lower extremity spasticity.[1] Genu recurvatum can lead to bony deformities, pain and posterior knee ligament damage .[2] Numerous causes of genu recurvatum have been identified including spasticity of the triceps surae, ankle plantarflexion contracture, hip extensor and quadriceps weakness.[3] When triceps surae spasticity is the culprit, hinged ankle foot orthoses (HAFO) are commonly prescribed; prescription of the optimal angle of plantarflexion stop to reduce recurvatum is inadequately examined in the research. The purpose of this study was to investigate the effects of fine-tuning the adjustable plantarflexion stop (APS) in HAFOs on knee kinematics in children ambulating with genu recurvatum secondary to spastic equinus gait.

Methods: To be included in the study, children had to be between 5 and 18 years of age; able to ambulate household distances or greater with an assistive device other than a walker; dorsiflexion passive range of motion to +12* with the knee flexed or extended; spasticity of the triceps surae greater than or equal to 1 on the Modified Ashworth Scale; and either excessive peak knee extension (PKE > 5*, n=7) or excessive peak knee extension velocity (PKEV > 1.2*/%GC, n =2) as determined by computerized gait analysis (CGA). Exclusion criteria included Botox within the past 4 months, orthopedic surgery within the past year, BMI >30, or less than antigravity strength of the knee extensors. Nine children (hemiplegic n=6, diplegic n=3) with a mean age of 6.5 years were included. Each participant was casted with a customized HAFO. CGA was performed on each child in 8 randomized conditions including barefoot, footwear alone (shod), and with HAFO set in -3 to 12 degrees of dorsiflexion in 3 degree increments (+/- 0.5* as determined by CGA). Children were allowed a 4 minute acclimation period in each condition. Mean PKE, PKEV and peak knee flexion moment (PKFM), in addition to temporal spatial gait measures were collected from each gait trial. Repeated measures analysis of variance was used to compare across conditions (p<. 05 level of significance); as well as graphical analysis of knee kinematics to identify trends in the data.

Results: All three kinematic variables demonstrated statistically significant differences across brace conditions: PKE (p = .000), PKEV (p = .001), and PKFM (p = .000). Due to a small sample size and number of conditions, post-hoc analysis was not appropriate and the data were analyzed using graphical analysis to examine trends. Trends were found for PKE and PKEV, as 70% of subjects demonstrated improved PKE in stance in the 9 and 12 degree APS conditions. Approximately 50% of subjects demonstrated improvements in PKEV in the 9 and 12 degree conditions. A similar trend was found in the PKFM measure, with increasing dorsiflexion resulting in a decrease in the PKFM.

Conclusions: The results of this study reflect that changing the APS angle can impact sagittal plane knee kinematics in stance phase; however a uniform optimal brace angle could not be determined. Data trends suggest that setting the APS in increased dorsiflexion may lead to improved kinematics at the knee, suggesting that brace angle selection is an individualized, multi-factorial process.

References:

1. Wren TAL, Rethlefsen S, & Kay RM. Prevalence of Specific Gait Abnormalities in Children with Cerebral Palsy. *J Pediatr Orthop*. 2004;25:79-83.
2. Simon SR et al. Genu recurvatum in spastic cerebral palsy: report on findings by gait analysis. *J Bone Jt Surg*. 1978;60:882-894.
3. Fish DM & Kosta CS. Genu recurvatum: identification of three distinct mechanical profiles. *JPO*. 1998;10:2:26

SATURDAY, April 13th
10:40-10:50 AM
Clinical Case 5

Use of Resistance in the Sagittal Plane at Ankle to Control Knee Crouch and Hyperextension

Keith M. Smith, CO, LO, FAAOP
Orthotic and Prosthetic Lab, Inc
St. Louis, Missouri, USA

Problem: Patients with crouch gait from knee flexor tightness as well as patients with knee hyperextension secondary to ankle tightness propose challenges to the practicing clinician as limited Range of Motion restricts orthotic design. Traditional approaches tend to cause the center of gravity (COG) to move outside the base of support (BOS), thereby causing patients to use compensatory strategies in an attempt to gain balance again by trying to get the COG back into the BOS. In other words, traditional approaches tend to attempt to achieve positions that are not attainable due to limited ROM. For example, the child with CP that crouches in stance due to tight hamstrings that is fit with a GRAFO attempting to increase the knee extension moment ends up leaning forward on the toes. Because the knee does not have the ROM, the result is that the COG is thrown posterior to the BOS. The patient has two choices- Fall backwards or lean forward on the toes to get the COG back into the BOS. Another example is the knee hyperextension control by attempting to dorsiflex the angle of the ankle and stopping plantarflexion. The result here is the sacrificing of the first and third rockers in this scenario and for the crouch gait pattern fit with the GRAFO the loss of all three rockers.

Solution: With these two scenarios, the solution in our clinic has become the use of resistence joints rather than stops. With the crouch gait pattern we resists dorsiflexion so that the patient can maintain the COG in the BOS while still getting support or resistance from crouching. The key here is that they will still crouch but it will be lessened and the resistance is increased as the ROM of the knee increases. For the Knee hyperextension patient, we are resisting plantarflexion rather than stopping it.

For both scenarios in the sagittal plane, the patient is controlled with the COG in the BOS without sacrificing rockers.

Outcome Measures: Functional Mobility Scale, PODCI, Observational Gait Analysis, Standing Balance, One Minute Walk Test, Passive ROM.

SATURDAY, April 13th
10:50-11:00 AM
Clinical Study 8

Comparison of 3D Gait and Balance Effects From an Adjustable Dynamic Response Versus Fixed Ankle Foot Orthosis in A Child with Hemiplegic Cerebral Palsy: How Did It Do and Can We Do Better?

Mark D. DeHarde [1]
Lindsey A. Curatalo, MS [2]
Katharine E. Alter, MD [2]
Diane L. Damiano, PhD, PT [2]
[1]Ultraflex Systems
[2]Functional and Applied Biomechanics Section, Rehabilitation Medicine Department
National Institutes of Health
Bethesda, MD, USA

Background: Ankle braces are commonly utilized in ambulatory children with cerebral palsy (CP) to restrict excessive ankle plantarflexion during gait so as to improve toe clearance in swing, foot strike at initial contact and tibial translation throughout stance. Some active plantarflexion is desirable in late stance for propulsion. However, current "passive" ankle bracing strategies tend to totally block plantarflexion beyond neutral with some including a hinge to allow some ankle dorsiflexion during stance. It is being increasingly recognized that traditional bracing approaches may be too restrictive by blocking wanted as well as unwanted motions and thereby limiting functional capabilities and potentially exacerbating weakness over time. These also do not provide dynamic assistance to desired motions, such as ankle dorsiflexion during swing, when the patient lacks strength or motor control to accomplish this without assistance. The Adjustable Dynamic Response (ADR) ankle orthosis was designed to address previous limitations by "actively" augmenting dorsiflexion as needed in swing while restricting plantarflexion through variable resistance rather than a mechanical block.

Objective: To comprehensively and objectively evaluate performance of the ADR ankle orthosis during gait and balance tasks compared to barefoot, shoe inserts, and locked brace conditions.

Methods: A 12 year old boy with right spastic hemiplegia participated in this pilot investigation. He was given a custom-designed ADR ankle orthosis for daytime use and a nighttime dynamic stretching device. 3D kinematic, kinetic and EMG analyses and the Limits of Stability Test on the Neurocom were performed after he had worn the brace for several weeks.

Results: His fast gait speed improved by 0.2-0.3 m/sec in all brace conditions compared to barefoot with no appreciable differences among brace conditions. Both the locked and ADR braces improved sagittal plane kinematics by improving toe clearance and foot positioning for contact but the ankle curve was notably "flatter" in the locked brace. By allowing more dorsiflexion in stance, the ADR brace allowed better tibial progression, leading to greater knee and hip extension at mid-stance. Increased dorsiflexion in swing further reduced compensatory ipsilateral hip flexion and contralateral hip abduction -circumduction. The first of two ankle peak moments in stance was markedly reduced with the ADR orthosis. However, the second peak did not increase as desired. Since plantarflexion resistance was set fairly high, no motion occurred at self-selected speed with slight motion at fast speed. Tibialis anterior EMG magnitude decreased during swing in the ADR brace, suggesting that assistance was more than was required. Instrumented balance parameters of reaction time, movement extent and velocity were best in the ADR compared to other conditions.

Conclusions: The ADR showed improvements over the traditional brace in this patient, consistent with design goals. Even though some adjustable parameters were not optimized here to encourage

greater active dorsiflexion in swing and plantarflexion in stance, the concept of actively versus passively restraining and segmenting muscle actions is a promising approach that warrants greater study, development and implementation. Quantitative evaluation techniques may prove increasingly valuable when evaluating and modifying more dynamic bracing strategies, especially for more subtle or invisible effects (such as muscle activation).

Acknowledgment: The ADR and stretching brace were provided to the patient by Ultraflex. This research was funded by the Intramural Research Program at the National Institutes of Health Clinical Center.

SATURDAY, April 13th
11:15-11:25 AM
Paper 19

Acceptability of a Functional Electrical Stimulation Device for Foot Drop in Children and Adolescents with Cerebral Palsy

Laura A. Prosser, PT, PhD
Lindsey A. Curatalo, MS
Katharine E. Alter, MD
Diane L. Damiano, PhD, PT
Functional and Applied Biomechanics Section, Rehabilitation Medicine Department
National Institutes of Health
Bethesda, Maryland, USA

Background: Inadequate ankle dorsiflexion during swing, or foot drop, is a common gait impairment in cerebral palsy (CP). Ankle orthoses are the standard of care for this impairment in CP, but these may overly constrain ankle movement and limit function in those with mild CP. Functional electrical stimulation (FES) devices may be a less restrictive and more effective treatment alternative, but have rarely been utilized in CP, in part because of the potential for discomfort in children.

Objective: The primary objective was to examine the acceptability of a novel commercially-available device that delivers FES to the common peroneal nerve in children and adolescents with CP who are able to ambulate independently.

Methods: After the initial setup and individual programming of the device, participants had one month to accommodate to the device before the start of a 3-month FES treatment phase, during which they were asked to wear the device 6 hours per day. At the end of the FES phase, they were given the option to continue to wear the FES device during a subsequent 3-month follow-up phase. Several strategies were employed to increase tolerance and acceptability, including provision of family support and ongoing modification of the stimulation settings. Acceptability was measured 3 ways: percentage of participants who enrolled who tolerated FES and continued to the FES phase, amount of daily use, and percentage of participants who chose to continue using FES after the treatment phase.

Results: Twenty-one participants, classified as Gross Motor Function Classification System (GMFCS) level I and II, enrolled in the study. Of these, one did not tolerate the stimulation and in another, it triggered dystonic posturing. The remaining 19 (90.5%) participants (9 female, 10 male; mean age 13.2 years) continued to the FES phase. On average, the participants used the FES device for 5.6 (± 2.3) hours per day and took an average of 2087 (± 1039) steps during that time with the more affected leg. Ten of nineteen used the FES for at least 6 hours per day. All but one of these participants chose to continue wearing the device after the treatment phase (94.7% of the participants who tolerated the device and 85.7% of the total participants). All participants had used orthoses in the past, but only 3 still used an AFO and 3 used a SMO at the start of the study. Two of the initial AFO users were no longer using the orthosis at all by the end of the study.

Conclusions: The FES device studied here was a well-accepted treatment for children and adolescents with CP and may be superior to positional bracing in those with mild gait impairments. Direct comparison to ankle orthoses, including effect on ankle kinematics and long term impact of each on muscle structure and function, is warranted.

SATURDAY, April 13th
11:25-11:35 AM
Clinical Study 9

Long-Term Use of Conservative Night Splinting to Manage Functional Knee Extension

Nancy Hylton, PT, CO
Dynamic Orthotic Systems
Children's Therapy Center of Kent
Kent, Washington, USA

Night splinting to maintain or increase muscle length in the presence of moderate to severe spasticity is commonly used for short and long-term stretching of muscles.

This case study follows functional impact of knee extension night splinting from 4.5 years of age to 27 years in a young man with moderate to severe Spastic Tetraplegia. The only surgical intervention was Selective Dorsal Rhisotomy at 4.5 years of age and long term use of supra-malleolar Dynamic AFOs from 2 years of age. Active assistive daily stretching program was also employed.

Significant active functional improvement was seen in the year after the Rhisotomy with initial independent ring sitting balance shortly after 5th birthday and continued gains in assisted upright for toileting, handwashing, etc. Independent dressing and undressing developed in long-sitting on the floor for sense of security by 7.5 to 8 years.

These skills have been preserved and gradually improved with short distance adult assisted ambulation in home, daily in home and community use of power wheelchair for independent mobility, balance assisted standing transfers, and 75 to 80 degree straight-leg ROM. Much easier stretch and ROM with knee splints on probably due to improved stability and sensory information. Knee extension splints worn all night during sleep from 4.5 years to present.

Poster 1

Prosthesis for a Patient with Proximal Femoral Focal Deficiency: A Case Report

Kristopher P. De Leon, MD
Gaerlan D. Inciong
College of Medicine and Philippine General Hospital,
Department of Rehabilitation Medicine,
University of the Philippines Manila

Proximal femoral focal deficiency is a rare birth defect that affects the hip bone and the proximal femur. The incidence is one case per 50,000 to 200,000 population. The disorder may be unilateral or bilateral, with the hip being deformed and the leg shortened. The goal of treatment is to provide optimal function during standing and ambulation. A 15-year-old male diagnosed with left proximal femoral focal deficiency was admitted for prosthetic rehabilitation. He presented with a very short left lower extremity, 38 cm leg length discrepancy, flail left hip and knee joints, and normal range of motion at the left ankle, and with muscles graded at 4/5. The patient was independent in transfer activities and ambulated with bilateral axilllary crutches. A combination of orthosis and prosthesis (henceforth “prosthosis”) was designed for the patient with a mechanical hinge joint to equalize the leg length and to improve lower extremity function during standing and ambulation. Upon discharge, the patient was independent in donning and doffing the prosthosis, was ambulatory using the prosthosis without gait aid but with minimal listing during the stance phase on the prosthesis side. During the patient’s two-year follow-up, adjustment of the prosthesis was done to accommodate growth; checking of the prosthesis for mechanical breakdown and anticipatory management of potential musculoskeletal complications and psychosocial concerns on the use of the prosthesis were also done.

Keywords
Proximal femoral focal deficiency, leg length discrepancy, prosthesis, “prosthosis”

Poster 2

Functional Outcomes of Van Nes Rotationplasty with Ipsilateral Partial Fibular Deficiency

Anna V. Cuomo, MD
Hugh Godfrey Watts, MD
Shriners Hospital for Children – Los Angeles
Los Angeles, California, USA

Background: Van Nes rotationplasty is a surgical treatment option for patients with femoral deficiencies. Preoperative ankle stability and adequate range of motion are considered prerequisites for a good outcome. More than half of patients with femoral deficiencies also have an ipsilateral fibular deficiency, which can lead to poor tibiotalar stability and motion. However, motion between the foot and ankle is also coupled to subtalar motion, which could, in theory, compensate for mild ankle deformity. This study reports the functional outcomes of patients with severe femoral and mild fibular deficiencies after a van Nes rotationplasty.

Methods: We identified 17 patients who were treated with a van Nes rotationplasty for a femoral deficiency at our hospital between 1980 and 2011. All preoperative scanograms and tibial radiographs were examined and 7 patients were identified with an ipsilateral partial longitudinal fibular deficiency. Their charts and radiographs were reviewed to report patient demographics, Aitken classification for femoral deficiency, Achterman and Kalamchi classification for fibular deficiency, surgical procedures performed, co-morbidities, and complications. At the final follow-up, the type of prosthesis used and an observational gait analysis performed by a single senior author is reported.

Results: Of the 7 patients identified, the average age at the index van Nes rotationplasty was 5.5 years (range 2.2-11.1). The average length of follow-up after the index procedure was 10.8 years (range 7.6-17.0) with an age at final follow-up of 16.2 years (range 10.5-19.1). According to the Aitken classification, 3 were type A, 3 were type C and one was type D. According to the Achterman and Kalamchi classification, all patients had Type 1a fibular deficiency. Two of the 7 patients were converted to a Syme amputation secondary to complications from postoperative compartment syndrome. All of the patients at time of follow-up were using an above-knee-type prosthesis that allowed for active knee control. Two of the prostheses were end bearing and 5 were ischial weight-bearing. All 5 of the 7 of the patients who were not converted to Syme amputation were deemed to have a functional swing-through gait with their prosthesis. Patients noted to have mild derotation and hindfoot valgus were able to compensate with their subtalar motion, allowing them to swing the lower limb of the prosthesis in the line of progression of gait.

Conclusions: Van Nes rotationplasty is a reasonable consideration in patients with femoral deficiency and ispilateral mild partial fibular deficiency. Ankle and subtalar motion can compensate for mild ankle deformity to provide functional swing-through gait patterns.

Poster 3

Treatment of Tibial Deficiency with Transposition of Fibula

Anthony A. Scaduto, MD
Nicholas M. Bernthal, MD
Hugh Watts, MD
Los Angeles Orthopaedic Hospital; Shriners Hospital for Children - Los Angeles
UCLA Department of Orthopaedic Surgery
Los Angeles, California, USA

Introduction: The role of reconstructive surgery in children with tibial deficiency is controversial, especially in patients with Jones Type II deficiency. The side-to-side fibular onlay technique and fibular centralization described by Brown have been found by many to yield less than satisfactory results. The purpose of this study is to report our 18-year experience with a novel alternative surgical technique in which a fibular segment is transferred and fused to the distal aspect of the residual tibia anlage, then fused distally to the cut surface of the calcaneus, after resection of the talus and forefoot.

Methods: We retrospectively reviewed 10 consecutive patients who underwent this modified fibular transfer for tibial deficiency between 1993 and 2010. We reviewed each patient's medical record for extremity status, secondary operations, and functional status.

Results: All 10 patients were ambulating with the use of a prosthesis at final follow up. 7 of 10 (70%) of patients required no additional surgery. 3 of 10 (30%) patients required further surgeries for "major" complications associated with this procedure. Of these, one required bone grafting and internal fixation for a non-union, one required a full thickness skin graft after debridement of a necrotic stump, and one required an osteotomy of the fusion mass to correct a varus deformity. One additional patient had a residual knee flexion contracture of 30 degrees, which was present pre-operatively.

Discussion: While the modified fibular transposition technique had a relatively high rate of secondary surgeries (30%), it significantly improves fit and function of the prosthesis and knee mechanics by preserving the native extensor mechanism and maximizing stump length. Varus deformity commonly seen with a side-side syndesmosis of the fibula to the tibial anlage was avoided with this technique.

Poster 4

Pilot Study to Determine Pediatric Subspecialists Education and Comfort in Prescribing Orthotics, Prosthetics, Wheelchairs and Durable Medical Equipment

Joshua A. Vova, MD
Children's Healthcare of Atlanta
Emory University Department of Physical Medicine and Rehabilitation
Atlanta, Georgia, USA

Introduction: Children with special needs often have complex medical needs, including medical equipment. Based on location, region, availability, and medical needs often different medical professionals will attend to all the needs of these children. However, traditional educational programs often do not prepare physicians for these responsibilities. The goal of this study was to determine which specialties are prescribing medical equipment and their preparedness.

Method: A questionnaire was emailed to members of the list serve of the American Academy of Pediatrics counsel of children with disabilities. The questionnaire was designed to determine which specialties prescribed orthotics, prosthetics, durable medical equipment and wheelchairs. It was also designed to determine the level of education and confidence that these practitioners had in prescribing these devices.

Results: Fifty-three physicians responded to the questionnaire. Of the physicians that responded, 8 were pediatric physiatrists, 20 were developmental pediatricians, 7 were general pediatricians, 5 orthopedic surgeons, 4 pediatric neurologists and 9 special needs pediatricians. Of the physicians surveyed, 75% indicated that they wrote Rx for Orthotics, DME and wheelchairs. Only the pediatric physiatrists indicated that they prescribed and had education in prosthetics. Of those surveyed, 85% felt confident in their ability to prescribe orthotics, 75% in wheelchair prescriptions and 87.5% felt comfortable with DME. However, the majority of those physicians had received very little formal education. Of those who physicians surveyed who felt comfortable in their prescriptions, 47.5% had orthotic education, 35% had durable medical education and 37.5% had education on wheelchairs. However, if you eliminate the pediatric physiatrists, all of whom indicated that they had formal education, the percentage of physicians who received formal education was reduced to 34%, 18.8% and 22%.

Conclusion: The results of the study indicate a lack of specific training in orthotics, wheelchairs and durable medical equipment in physicians who take care of children with special needs and write prescriptions for their medial equipment. However, despite training, physicians appear to be very confident in their clinical decision making abilities. Although this is a pilot study, it does indicate the need to determine competencies in physician prescribing practices.

Poster 5

Measuring Outcomes in Children and Youth with Osteogenesis Imperfecta: Top Picks

Marie-Elaine Lafrance, BSc, OT
Kathleen Montpetit MSc. OT
Shriners Hospital for Children – Montreal
Montreal, Quebec, Canada

Objectives: Outcome measures are used in clinical practice to compare an individual's performance to that of typically developing peers and to set goals for treatment. In research, outcome measures serve to describe abilities and evaluate change over time or following an intervention. As treatment in Osteogenesis Imperfecta (OI) is multi-modal and tailored to individual needs, it is imperative to determine the success of different treatments. Our objective was to describe the spectrum of outcome measures that have been used in clinical practice for baseline assessments and/or to evaluate treatment interventions in children and youth with OI. As well, recommendations are provided as to which measures are most appropriate for this population.

Methods: A literature search of relevant electronic databases; Pubmed, MedLine, Rehabdata, CINAHL and Embase was performed using key words to search for validated measures that have been used with the OI population. These measures were evaluated and classified according to the International Classification of Functioning, Disability and Health-Children and Youth version (ICF-CY) framework. Expert opinion on the clinical utility of these measures contributed to the final recommendations.

Results: Fifteen standardized outcome measures are recommended for use with the OI population. Only 2 measures were specifically validated for use with the OI population; the Gross Motor Function Measure (GMFM) and the Brief Assessment of Motor Function (BAMF). The recommended outcome measures map to the ICF-CY's domains as follows; 4 relate to body function and structure, 6 relate to activity and 5 relate to participation.

Conclusion: Select outcome measures are recommended for use with children and youth with OI in order to address all aspects of the health condition, as defined by the ICF-CY domains. Using outcome measures in clinical practice and in research will facilitate the implementation of goals, contribute to evidence-based practice and identify the effectiveness of interventions. These findings should encourage health professionals and researchers following individuals with OI to use outcome measures prospectively and longitudinally. Future studies should focus on determining the validity of these measures in the OI population. The use of validated and clinically useful measures provides an important link between clinical practice and research.

Disclosure Information:
There are no conflicts of interest to disclose.

Key Words: *Outcome Measures, Osteogenesis Imperfecta, International Classification of Functioning, Disability and Health –Children and Youth*

Poster 6

Teddy Bear Splint: How a Comforting Toy can achieve Orthotic Goals of a Volar Resting Splint

Jordan D. Raugust, MD
Department of Clinical Neurosciences, Division of Physical Medicine and Rehabilitation, University of Calgary

Setting: Inpatient pediatric hospital.

Patient: A 9---year---old female with a severe anoxic brain injury due to cardiac arrest, with flexion---supination dystonias in her arms, and paroxysmal exacerbations of her dystonias associated with agitation.

Case Description: On our assessment at one---month post injury, the patient had persistent upper limb flexion--- supination posturing, and maintained full passive ROM. As she became more alert, she began to have episodes of agitation, which exacerbated her dystonic posturing.
In addition to distressing the patient, her postured fists bruised her chest. In order to maintain functional positioning while active movement was limited, we applied volar resting splints. Unfortunately, the patient did not tolerate them, as she became more agitated when they were applied and had evidence of skin breakdown after one night of wear. We noticed that the patient often held a teddy bear in each hand when posturing at rest, which appeared to giver her comfort. The possibility of using a teddy bear to achieve orthotic goals was raised.

Intervention: Orthotic goals were as follows:

1. passive positioning with slight finger flexion and wrist extension at rest;
2. protect chest from fist during dystonic paroxysms;
3. limit skin breakdown due to straps or splint pressure during dystonic paroxysms; and
4. Provide emotional comfort to the patient with the goal of attenuating dystonic paroxysms.

Because the conventional resting splint was not tolerated, it did not achieve these goals, while her unmodified teddy bear satisfied these criteria. Modifications were made to a teddy bear to further enhance its ability to meet these orthotic goals. The orthotists utilized the nose of the bear to passively position the patient's hand and wrist in slight extension. The forearm was secured in position by the teddy bear's arms, which were held together with a buckle away from the patient's skin. The stuffing was removed and replaced with a soft foam insert that had a forearm trough angled to direct the patient's hand on the far side of the nose, allowing the nose and head to protect her chest from her fist when flexion and supination occurred during the dystonic posturing. Finally, the leg closest to the patient's body tucked in the antecubital fossa, providing mild resistance to terminal elbow flexion that occurred during posturing.

Results: The use of the modified teddy bear enhanced the ability to meet our orthotic goals.
The patient tolerated the orthosis well, with no skin breakdown, and seemed to be comforted by it's application. Between dystonic paroxysms, the bear passively positioned the wrist and hand in our desired position. During dystonic episodes it provided minimal resistance to posturing, but did protect her chest from contact with her dystonic fist.

Conclusions: This case demonstrates how subtle modifications to a comforting teddy bear can effectively achieve orthotic goals of a volar resting splint.

Disclosure Statement

The presenting authors on papers and posters are printed in boldface. All authors are required to fill out and sign a financial disclosure statement disclosing whether or not he or she has received something of from a commercial company or institution, which related directly or indirectly to the subject of their presentation. The Academy has identified the options to disclose as follows:

(n) = Respondent answered 'No' to all items indicating no conflicts.
1= Royalties from a company or supplier;
2= Speakers bureau/paid presentations for a company or supplier;
3A= Paid employee for a company or supplier;
3B= Paid consultant for a company or supplier;
3C= Unpaid consultant for a company or supplier;
4= Stock or stock options in a company or supplier;
5= Research support from a company or supplier as a PI;
6= Other financial or material support from a company or supplier;
7= Royalties, financial or material support from publishers;
8= Medical/Orthopaedic publications editorial/governing board;
9= Board member/committee appointments for a society.

ACPOC does not view the existence of these disclosed interests or commitments as necessarily implying bias or decreasing the value of the author(s) participation in the course.

An indication of the participants' disclosures appear in parentheses after each individual name, in the program schedule, as well as the name of institution or company that provided the support.

The Program Committee has disclosed the following:
Janet Walker, MD (Lexington, KY): *9 (Association of Children's Prosthetic and Orthotic Clinics); Submitted on: 09/30/2011.* *
Jorge A Fabregas, MD (Roswell, GA): (n) Submitted on: 08/11/2011. *

The ACPOC Staff has disclosed the following:
Angela Schnepf, MBA (Rosemont, IL): *(n) Submitted on: 01/26/2012.* *
Jennifer Wolff Jones (Rosemont, IL): *(n) Submitted on: 10/17/2011.* *
Elizabeth Frale (Rosemont, IL): *(n) Submitted on: 12/22/2011.* *
Lynett Wilson (Rosemont, IL): *(n) Submitted on: 11/23/2011.* *

NOTES

NOTES

NOTES

NOTES