Special Pull-Out Section
Evidence Note
Outcomes Associated with the Use of Microprocessor- and Non-Microprocessor-Controlled Prosthetic Knees after Unilateral Transfemoral Limb Loss

Feature
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Indicates continuing education opportunity on the Online Learning Center at www.oandp.org

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Message from the President

As a physical therapy undergraduate student, I was instructed in how to set appropriate goals. However, it was a memorable event early in my career as a prosthetist that drove this concept home for me.

An elderly gentleman was referred to me for a facial prosthesis. His nose had recently been amputated due to cancer, leaving a large hole in the center of his face. Prior to his visit, I researched options and was well prepared to take an alginate impression that could be utilized along with pre-surgery photos to give us the best chance of creating a realistic match. Three weeks later, he returned for fitting. The silicone prosthesis was carefully applied with medical-grade adhesive in such a way that the feathered edges attached seamlessly to his skin. Because the skin’s natural oils would tend to interfere with the adhesion properties, the prosthesis would need to be removed twice a day for cleaning and reapplication—a rather minor detail when considering that his family felt that the prosthesis very accurately restored his facial features. He returned to the nursing home wearing the prosthesis and in possession of the fancy maintenance/application kit.

I was feeling pretty good about how things had turned out until I got a call from the nursing home to report that my patient was not happy with the prosthesis because it was too complicated to deal with. So I had him come back to the office to talk about what sort of changes we needed to make to improve the outcome. Ultimately, I cut a small piece of flesh-toned zote, heat-formed it over my thumb, feathered the edges, and then secured it to his eyeglasses with thread. He loved it. Specifically, it was very easy for him to manage, meaning he could quickly put it on to “cover up” before having meals with other residents. Of course, I was initially surprised and a bit chagrined by this course of events. Eventually, it became obvious to me that I had failed to discuss what he wanted, and instead I had substituted my own priorities. By simply asking at the first visit, “What are your goals with a prosthesis?” I could have avoided this fiasco.

The patient’s needs often seem so straightforward and so obvious that we might be inclined to skip asking what it is that they want. Most would probably agree that, aside from price, we can list comfort, function, and cosmesis as the “big three” when it comes to patient priorities. What we can’t predict is the order in which the patient would arrange this list. This fact becomes very important when we consider that our treatment options usually require compromise, or a tradeoff of sorts, between these priorities.

Over the years, I have come to the conclusion that it is best if the patient determines the priorities by stating his/her goal(s). The practitioner can then utilize this information to develop the most appropriate treatment plan, in effect providing the best chance that the patient will be satisfied with the outcome. Identifying the long-term goal(s) and then establishing short-term goals that act as stepping-stones, puts all concerned on the same page and gives the patient some tangible successes along the way.

Career coaches have been preaching for years that individuals should write down what they want to accomplish and their priorities. Businesses do the same thing when developing a business plan.

Many associations carry out a similar process when they engage in strategic planning.

The American Academy of Orthotists and Prosthetists (the Academy) has long embraced the concept that to advance the profession, we must support our members as they strive to improve patient care—short-term and long-term. Hence, every three years the Academy Board of Directors convenes a strategic-planning meeting to anticipate developing trends affecting the profession and thereby identify future needs of our members. Over the course of a two-day meeting, the Board engages in a series of activities designed to recognize and ultimately prioritize Academy actions that will address these needs. This process allows us to be proactive when considering such factors as the economy, technological advancements, healthcare developments, business philosophies, changes in learning strategies, etc. The Board then meets each year to review and update the plan as necessary.

The Academy’s strategic-planning process allows us to be more concerned on the same page and gives the patient some tangible successes along the way.

The Board of Directors is a diverse group that represents the interests of the 3,000 Academy members and acts on your behalf. But to do so, we need to know what you think.

We would like to hear from you, either directly or through our Chapters. I encourage you to exchange ideas with Academy Board members who are in attendance at Chapter meetings, or contact me or any Board member to share your thoughts. You can find a complete list of Board members and their contact information on our website at www.oandp.org/about/bod.

Through regular communication, the Academy will be in the best position to effectively meet the needs of our members now and in the future.
Qualitative Understandings of the Lower Limb in Children with Bilateral Cerebral Palsy

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Part 1

Foot and Ankle Deformities

Figure 1 illustrates a common presentation in children with bilateral cerebral palsy, characterized by (1) equinoplaanovalgus; (2) persistent flexion contracture at the knees; and (3) posturing of the hips into adduction, flexion, and internal rotation. This article, the first in a two-part series, is intended to present a qualitative understanding of how and why these deformities are so frequently encountered and strategies for their successful orthotic management. This first installment will focus on the more distal joint segments of the foot and ankle, with the more proximal joint deformities reserved for a second article, which will appear in the November 2011 issue of The Academy TODAY.

Figure 2 illustrates the foot and ankle irregularities most commonly encountered in this patient population. These include hindfoot valgus, pes planus, forefoot varus, and equinus at the talar-tibial joint. These tendencies begin as flexible deformities that are passively correctable. However, dependent upon the amount of spasticity present, if left untreated they will often become structural deficits, characterized by both muscular contracture and bony malalignment. Thus, a primary goal in the foot and ankle management of this maturing population is to discourage the development and progression of these deformities from flexible to structural phenomena, particularly during periods of rapid physical growth.

The mechanism underlying the development of these deformities is partially illustrated in Figure 3. During stance, most of the weight bearing forces are normally divided between two distinct areas of the foot: the calcaneus and the metatarsal heads (Figure 3A).

However, when the muscles of the triceps surae are overactive, the hindfoot is pulled upward out of contact with the floor (Figure 3B) and the forefoot must take most of the weight. The body’s center of gravity is shifted forward to maintain stability, creating a greater challenge for the child to maintain balance within a smaller base of support. In addition, because of inherent weakness of the posterior tibialis, which normally acts to support the longitudinal arch of the foot, the subtalar joint collapses and the joints of the midfoot are “unlocked.” The soft tissues that would normally maintain the longitudinal arch are progressively stretched. If these conditions persist, subtalar valgus becomes structural and the longitudinal arch continues to flatten. With growth and time, the long arch can actually be reversed, creating the “rocker bottom” foot deformity seen in Figure 3C.

Figure 4 diagrams this deformity in the frontal plane. Because of the comparative weakness of the inverters of the foot and ankle (most notably the posterior tibialis), they are ultimately overpowered, allowing the subtalar joint to collapse into valgus. Once this alignment event has occurred, both the weight bearing loads and the Achilles tendon tension become valgus deforming...
forces. Figure 5 is an example of the consequences for a particular ten-year-old.

Once this has occurred, the dorsiflexion required for ambulation occurs through collapse of the subtalar and midfoot joints rather than the tibio-talar articulation. For this reason, attempts to stretch the heel cord should not be applied to the forefoot alone as this will exaggerate the collapse of the subtalar joint (Figure 6). A skilled therapist will grasp the calcaneus to correct and control the subtalar joint to make sure it does not collapse into valgus as the ankle is passively dorsiflexed (Figure 7). These principles apply in orthotic design as well. An orthosis that is intended to resist plantarflexion must be designed to simultaneously control the subtalar joint and support the arch. If not, the orthosis will be needlessly contributing to the development of a foot deformity.

Such an example is shown in Figure 8, which illustrates classic, rigid, post-adolescent equinoplnanovalgus “rocker bottom” feet. For many years, this patient wore conventional double upright-type AFOs attached to a shoe such as that shown in Figure 9. The medial “T” strap was unable to effectively prevent the subtalar joint from collapsing into valgus.

In current orthotic practice, almost all lower-limb orthoses utilize the polypropylene shell design, enabling a very supportive fit at both the hindfoot and midfoot. In a well-designed AFO, an instep strap is installed as necessary to consistently position the child’s heel down and back in the corrective confines of the orthosis (Figure 10).

Unfortunately, there is a common misconception that a neutral subtalar alignment can be maintained solely by supporting the longitudinal arch of these developing children. This is rarely the case. In the absence of a normally functioning posterior tibialis, arch support alone requires ligaments, most notably the spring ligament, (Figure 11) to transmit that support back to the subtalar joint. Over time and with growth and development, these ligaments will be progressively stretched, allowing the subtalar joint to collapse into a valgus alignment in spite of support to the arch area.

Figures 12 and 13 show the primary areas of medial stabilizing pressure, and Figure 14 indicates the aggressive sculpting necessary to adequately grip the calcaneus and support the subtalar joint. This configuration of support is much more directly applied to the sustentaculum tali and calcaneus and reduces the deforming forces acting upon the midfoot, partially simulating the function of the compromised posterior tibialis.

With adequate support provided at the hindfoot, sagittal range of motion at the ankle can be fully assessed and managed. However, there are practical limits of orthotic treatment. When the heel cord of an ambulatory child is too tight to permit passive dorsiflexion to neutral with moderate force, even the most skillfully rendered orthotic treatment will fail to achieve a plantargrade foot. Such situations may call for surgical or pharmaceutical interventions. Alternately, the calf section of an AFO in relative plantarflexion can be brought to the desired anterior-posterior (A-P) alignment by means of a compensating posterior wedge added to the AFO or shoe.

Clinical experience strongly suggests that the application of these principles can greatly assist in the orthotic management of this commonly encountered and often challenging patient population.

Reference

Title: The Identification and Treatment of Gait Problems in Cerebral Palsy
Editors: James R. Gage, MD; Michael H. Schwartz, MD; Steven E. Koop, MD; Tom F. Novacheck, MD
Publisher: Mac Keith Press; Number of pages: 625
Reviewed by: Phil Stevens, MEd, CPO, FAAOP

Cerebral palsy is one of the most frequently encountered and, frankly, more challenging patient populations in the field of orthotics. As such, any efforts to enhance one’s ability to manage this population will lead to the provision of greater overall clinical care. Of the available resources for increasing your understanding of this presentation, there are none more comprehensive than this recent publication from Mac Keith Press. With a team of editors lead by the prolific James Gage, MD, 36 individual authors contributed to the body of the text.

The specific treatment of bracing is rather limited, comprising only a single 20-page chapter in a text of more than 600 pages. The authors of this section, including George Gent, CO, and Gary Kroll, CO, from Gillette Children’s Specialty Healthcare, Minneapolis, Minnesota, provide a thorough review of the different AFO designs that might be utilized in this population, as well as when one might be chosen over another.

The strength of this text lies in its comprehensive discussions of elements outside of the bracing process. The book begins with an overview of normal neural control, musculoskeletal growth and development, and the resultant “normal” gait. This is followed by a broad discussion of the pathologic gait patterns and presentations observed in cerebral palsy, including the underlying causative mechanisms, the associated pathophysiologies, and their various impacts on musculoskeletal development and function. The third section is devoted to patient assessment techniques and considerations including manual muscle testing, range of motion measurement, neuroimaging, radiographic evaluation, and gait analysis.

The text then transitions from assessment to treatment, including individual chapters on such non-operative modalities as physical therapy, orthoses, and pharmacologic interventions. These are followed by thorough discussions of various operative approaches, such as intrathecal baclofen, selective dorsal rhizotomy, and a host of orthopedic procedures, including both soft tissue releases and bony restructuring procedures. The text concludes with a section on outcomes assessment.

In summary: This textbook is unlikely to serve as a cover-to-cover read for most busy practitioners; however, it may serve as a valuable reference resource for those practitioners interested in expanding their understanding of the current management of this complex patient population.

Title: Paediatric Orthotics: Orthotic Management of Children
Editors: Christopher Morris, PhD, Luciano Dias, MD
Publisher: Mac Keith Press; Number of pages: 171
Reviewed by: Phil Stevens, MEd, CPO, FAAOP

Information on the orthotic management of pediatric populations is typically difficult to locate, due either to being broadly distributed in individual journal articles or buried among competing topics in thick atlases and textbooks. This recent offering from Mac Keith Press fills this gap, providing fairly succinct overviews of the most commonly encountered pediatric populations in a relatively concise, focused text.

The editors of this textbook include Christopher Morris, PhD, a clinical orthotist and research fellow at the University of Oxford, England; and Luciano Dias, MD, of Children’s Memorial Hospital, Chicago, Illinois. The book begins with introductory chapters on biomechanics, general patient assessment, and material science. While these are not specific to pediatric populations, they add to the comprehensive nature of the text. The next two chapters introduce the various device types that will be covered in the remaining chapters. An abundance of illustrative device photographs are included.

Following these introductory chapters, the editors begin their treatment of specific pediatric populations. The first such chapter treats the broad category of “congenital deformities” with brief discussions on foot deformities such as metatarsus adductus and talipes equinovarus (clubfoot), as well as developmental dysplasia of the hip (DDH) and more systemic disorders such as arthrogryposis, osteogenesis imperfecta, Down syndrome, and Marfan syndrome. The treatment of these presentations focuses on the most practical considerations associated with the orthotic management of each patient type.

This is followed by a similar section of disorders that arise in childhood such as pes planovalgus, toe-walking, Blount’s disease, Legg-Calve-Perthes disease, and leg-length discrepancy. Like the previous section, the treatment of each presentation is brief and focused on orthotic considerations.

Several chapters are then devoted to those patient populations seen with the greatest frequency in the pediatric setting, including individual chapters on cerebral palsy, the muscular dystrophies (including spinal muscular atrophy), and myelomeningocele. These are followed by separate chapters on idiopathic scoliosis and protective and corrective cranial orthoses.

In summary: The text will be of greatest value to the orthotist student who is unfamiliar with the patient populations cited above and their orthotic management, and the more seasoned clinician with limited pediatric experience. One of the strengths of the text is its brevity, providing concise overviews of many populations, with practical guidelines for patient management.

These publications are available via the Academy’s Recommended Reading list. Visit www.oandp.org/reading.asp to purchase these and other recommended publications.
Evidence Note

Key Points

- At this time, there is evidence to suggest that microprocessor-controlled prosthetic knees (MPKs) provide greater ambulatory safety and improve environmental obstacle negotiation when compared to non-microprocessor-controlled prosthetic knees (NMPKs) among individuals with unilateral transfemoral limb loss.
- There is also some evidence to suggest that MPKs provide improvements in patient-reported activity, cognitive demand, quality of life, preference, and satisfaction. Similar evidence suggests that although the initial acquisition cost associated with MPKs is greater than that for NMPKs, the total costs of prosthetic rehabilitation are similar between MPKs and NMPKs. There is limited evidence to suggest MPKs reduce metabolic energy expenditure and improve gait mechanics. No evidence was found to indicate that NMPKs improve clinical outcomes when compared to MPKs.
- Additional quality research is required to confirm and expand upon the currently available evidence for the prescription and use of MPKs.

Scope of Review

The purpose of this Evidence Note is to provide a summary of the outcomes related to the use of microprocessor-controlled prosthetic knees (MPKs) compared to non-microprocessor-controlled prosthetic knees (NMPKs) among individuals with unilateral transfemoral limb loss. This synopsis of the existing evidence is intended to complement other sources of available knowledge, such as experiential evidence, physiological rationale, and patient values and goals, in order to facilitate an evidence-based approach to the prescription of MPKs and NMPKs. Peer-reviewed publications that compared the use of any type of MPK to any type of NMPK among individuals with unilateral transfemoral or knee disarticulation limb loss contributed to the development of this Evidence Note.

Etiology and Functional Limitations

There are currently more than 1.6 million individuals with limb loss in the United States. Of these cases, more than 600,000 are considered major amputations (the loss of a limb other than the toes). Based upon the reported incidence of transfemoral limb loss (TFLL) in this population, an estimated 160,000 cases of TFLL are now present in the United States. Limb loss greatly impacts overall health, functional activities, and involvement in life situations. For example, TFLL is associated with secondary disabilities, lower return-to-work rates, decreased capacity for ambulation, reduced safety, and decreased quality of life.

Description and History of Microprocessor-Controlled Prosthetic Knees

The selection of an appropriate prosthetic knee is considered to be fundamental to a successful outcome for individuals with TFLL. Currently, more than 220 different prosthetic knees are available to the clinical prosthetist. Among these are models that incorporate a microprocessor control system. MPKs acquire and use position, load, and velocity information to regulate the knee’s resistance to flexion and/or extension during the swing and/or stance phases of gait. MPKs have been commercially available since 1990 although developmental efforts related to electronic control of prosthetic knees date back to the 1970s. Initial commercial designs focused on microprocessor control during swing phase (swing-only MPK), while more recent models have incorporated microprocessor stance-phase control (stance-only MPK or swing-and-stance MPK). In all cases, integration of the microprocessor control system into the prosthetic knee unit is aimed at addressing functional limitations experienced by the user.

Summary of Evidence

The findings presented in this Evidence Note were derived from a systematic evaluation of 27 peer-reviewed publications published between 1996 and 2009. These publications were identified through a subject-specific search of several common healthcare and biomedicine databases, including PUBMED, CINHAL, RECAL Legacy, and the Cochrane Library.

Outcomes comparing MPKs to NMPKs among individuals with unilateral TFLL were extracted from the 27 reviewed publications and grouped into nine topic areas. These included environmental obstacle negotiation, ambulatory safety, activity, cognitive demand while walking, quality of life, economics, patient preference and satisfaction, metabolic energy expenditure, and gait mechanics. Outcomes related to each topic area and the strength of the evidence (high, moderate, low, or insufficient) associated with these outcomes were examined by the Evidence Note authors. The strength of the evidence assigned to the reviewed outcomes was based upon three principles: quality, the methodological quality of the individual studies that contributed to the findings; quantity, the number of studies that contributed to the findings; and consistency, the extent to which the reported findings were in agreement.
There are multiple outcomes that indicate the potential for MPKs to improve environmental obstacle negotiation and enhance ambulatory safety. There is moderate evidence that swing and stance MPKs increase self-selected walking speed on uneven terrain\(^{24-27}\) and improve gait patterns during stair descent.\(^{24-26}\) There is some preliminary, but not yet substantiated, evidence to indicate that they improve gait patterns during hill descent.\(^{24,25}\) There is moderate evidence that the number of reported falls is decreased\(^{24-26,28}\) and that patient confidence is increased\(^{24,25,29,30}\) when using swing and stance MPKs as compared to NMPKs. Initial evidence also suggests that MPKs decrease reported frustration with falling, but further research is needed to confirm this finding.\(^{24,25}\) These environmental obstacle negotiation and ambulatory safety outcomes appear to be related to the stability features offered by swing and stance MPKs. This is notable, as MPKs are traditionally classified as fluid-controlled knees and therefore prescription criteria generally pertain to features of mobility (such as variable cadence). The findings reported in the literature suggest that indications for MPKs that offer microprocessor stance control should also include individuals who might require the inherent stability provided by these knees.

Outcomes related to activity and cognitive demand while walking appear to vary by the method used to measure the outcome. For example, there is moderate evidence to suggest that swing and stance MPKs increase self-reported mobility,\(^{24-26,31-34}\) but do not change the amount of activity performed.\(^{25,35}\) This may indicate a potential change in type of activity or ease with which it is performed rather than the quantity of activity (number of steps) performed. Similarly, there is moderate evidence to suggest that patient-reported cognitive demand while walking is reduced with the use of swing and stance MPKs,\(^{24,25,36}\) although this perceived difference has not been confirmed through quantitative measurement of cognitive burden.\(^{24,25,36,37}\) For both activity and cognitive demand, the reported disparity between patient-reported and physiologically measured outcomes may be related to the selected instruments’ sensitivity (the ability to detect change) to those differences noted by subjects. This finding could also be attributed to a placebo effect, as neither study subjects nor investigators are typically blinded to the interventions in these studies.

There is moderate evidence to indicate that swing and stance MPKs improve quality of life, as defined by patient-reported well-being,\(^{24,25,33}\) but that they do not change self-reported general health.\(^{25,34}\) This finding is likely due to the focus of the instrument used to assess each outcome. Those studies that assessed well-being did so with a population-specific instrument, the Prosthesis Evaluation Questionnaire (PEQ), designed for use with individuals with lower-limb loss.\(^{38}\) Those that assessed general health used a generic instrument (the Short Form 36 or SF-36).\(^{39}\) The questions included in the PEQ call specific attention to use of the prosthesis, while SF-36 questions are directed at sickness and health. Thus, the SF-36 may not be as sensitive to changes resulting from a prosthetic intervention (like an MPK) as would the PEQ.

There is moderate and low evidence to suggest that the prescription and use of swing and stance MPKs is associated with greater patient preference\(^{25,26,28,40}\) and satisfaction,\(^{3,25,26}\) respectively. There is also low evidence to suggest that swing-only MPKs are associated with increased patient preference compared to NMPKs.\(^{31,41}\) Interestingly, preference was not always associated with performance. In one study, performance-related outcomes were noted to improve with the use of the MPK, yet certain subjects still preferred the NMPK.\(^{26}\) This raises interesting questions regarding optimal user candidacy and prescription criteria for MPKs and indicates that further investigation is warranted so as to better understand the social, physical, and psychological characteristics associated with prosthetic knee use.

Economic outcomes have been used to assess the relative costs associated with the different prosthetic knee interventions. Despite significantly higher acquisition costs associated with MPK interventions,\(^{32,34,42}\) there is moderate evidence to suggest that overall costs of prosthetic rehabilitation (from a societal perspective) are equivalent between swing and stance MPKs and NMPKs.\(^{32,34}\) Overall costs in this context include not only the original acquisition costs, but also other long-term costs such as the loss of productivity, home adaptations, and housekeeping assistance.

There is limited evidence to suggest that the use of MPKs affects change in metabolic energy expenditure or gait mechanics when compared to the use of NMPKs among individuals with unilateral TFLL. There is low evidence to suggest that swing and stance MPKs decrease oxygen (O\(_2\)) rate at self-selected walking speed (SSWS)\(^{27,43,44}\) and that swing-only MPKs do not change O\(_2\) rate across a range of walking speeds.\(^{41,45,46}\) There is moderate evidence to suggest that swing and stance MPKs and NMPKs require similar O\(_2\) costs across a range of walking speeds.\(^{27,33,40}\) Oxygen cost is generally a preferred measure of metabolic energy expenditure as it accounts for changes in walking speed, while O\(_2\) rate does not. This is important as individuals with TFLL are reported to adjust walking speed to maintain an O\(_2\) rate that is equivalent to that of ambulating, able-bodied individuals.\(^{47}\) Therefore, O\(_2\) rate alone may not adequately explain the change in metabolic energy expenditure induced by the intervention.

Although well researched, few changes to gait mechanics outcomes were associated with different types of prosthetic knees. There is low evidence to suggest that swing and stance MPKs increase SSWS.\(^{26,40,43,48}\) However, moderate evidence indicates that SSWS is not influenced by swing-only MPKs.\(^{41,49}\) Spatial gait asymmetry appears to be unaffected by either swing and stance MPKs,\(^{25,28,48}\) or swing-only MPKs\(^{41,49}\) based upon moderate and low evidence, respectively. Mixed findings related to temporal gait symmetry,\(^{28,43}\) peak prosthetic stance-phase knee flexion angle in early stance,\(^{48,50,51}\) and...
prosthetic side hip power in late stance suggest that these outcomes are equivalent between swing and stance MPKs and NMPKs. Finally, an increased prosthetic knee moment in early stance phase with the use of swing and stance MPKs is supported by low evidence. It is worth noting that these gait mechanics outcomes were obtained in controlled laboratory environments that may not represent individuals’ free-living environments.

A number of methodological issues were identified upon review of this body of literature. Many of these issues were not addressed by the publications’ authors, which limited the overall strength of evidence reported in this Evidence Note. Those that were identified and perceived to be relevant to the outcomes presented include selecting a suitable control/comparison condition, defining appropriate inclusion/exclusion criteria for study subjects, blinding subjects and/or researchers to the intervention, addressing fatigue and/or learning effects during subject testing, explaining and/or addressing subject attrition over the study period, recruiting an appropriate sample size, defining meaningful changes in measured outcomes, and recruiting subjects representative of a targeted population. Many of these issues pertain as much to the description of the studies (the publications) as to the studies themselves, and may be easily addressed in the future.

Future Research

As indicated by the lack of “high” evidence, additional research with strong methodological quality is required to confirm, build upon, and expand the currently available evidence for the prescription and use of MPKs. Areas of future interest may include, but are not limited to, differences between Medicare Functional Classification Levels, time to acclimation with a new component, testing in free-living environments, and the role of technology versus therapy. The importance of these (and related) issues will continue to grow as advanced technology, like microprocessor control, becomes more common in prosthetic and orthotic solutions.

Acknowledgments

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Suggested Citation


References


Evidence Note
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The Orthotic and Prosthetic Education and Research Foundation (OPERF) Begins Its Third Year

The Orthotic and Prosthetic Education and Research Foundation (OPERF), the O&P field’s first research and education foundation, began as a dream by members of the American Academy of Orthotists and Prosthetists (the Academy) Board of Directors, educators, and researchers across the O&P community nearly a half-decade ago. Their goal was to create an independent organization to serve the needs of the O&P profession and industry by promoting and providing support for meritorious undergraduate students, residents, graduate students, practitioners, faculty members, and researchers. With the support of the Academy, Academy Chapters, individual members, and O&P businesses, OPERF has disseminated more than $100,000 in competitive, merit-based education and research awards through 2010. An additional $50,000 has already been pledged by the OPERF Board of Directors to continue these awards in 2011.

Attendees of the Academy’s 37th Annual Meeting and Scientific Symposium (March 16–19, 2011, Orlando, Florida) will have the opportunity to learn about research that has been sponsored by OPERF awards and grants on Saturday, March 19, from 10:40 a.m.–12:10 p.m. This special session, titled “OPERF Showcase,” will highlight special presentations by OPERF award recipients and will include the following:

- **How Does Socket Volume Affect Limb Volume in Transtibial Amputee Patients?**  
  Joan Sanders, PhD, OPERF 2009 Small Grant Award Recipient

- **Estimation of the Center of Rotation Position in Non-Articulated Energy Storage and Return Prosthetic Foot-Ankle Mechanisms**  
  Andrew Sawers, MSPO, CPO, OPERF 2009 Fellowship Award Recipient

- **A Review of Current Literature Studying the Use of Functional Electrical Stimulation for Foot Drop**  
  Richard Hunsaker, OPERF 2010 Resident Travel Award Recipient

### OPERF Awards Second Tamarack Prize

Through a generous endowment from Tamarack Habilitation Technologies, OPERF recently announced the 2011 Tamarack Prize for outstanding contributions to orthotic science and practice. This prize recognizes individuals who have made a significant contribution to the practice and understanding of orthotic science within the last five years. This second of the Tamarack Prizes will be presented during the opening session of the Academy’s Annual Meeting on Thursday, March 17, 2011, at 8 a.m.

### OPERF Awards for Educators and Students

In 2010, OPERF announced two new funding mechanisms intended to support O&P faculty and students. More than $5,000 in educator and student awards were offered and awarded to exceptional individuals who are pursuing their education in orthotics, prosthetics, and related disciplines. These new education awards complement the OPERF research awards already available to residents, graduate students, and investigators, and demonstrate OPERF’s commitment to promoting and supporting O&P research and education.

### New Awards in 2011

The OPERF Board of Directors has reaffirmed its commitment to research and education by making at least $50,000 available for research and education awards in 2011. Award announcements will be made throughout the year and will appear on the OPERF website (www.OPERF.org).

### Donate to OPERF

You or your company can help promote O&P research and education through a donation to OPERF. Donations of any amount may be made to OPERF to support new research and education awards. Larger donations or endowments may be designated and named after an individual or a company that you want to honor. Please contact OPERF for more information if you wish to create a designated or named award.

Companies or businesses may also partner with OPERF to develop and sponsor specific awards that target research or education in focused areas. Targeted awards allow independent researchers and educators to compete for awards in specific sponsor-designated areas. OPERF can help facilitate these awards and provide the means for quality independent research to be conducted in areas of importance to the sponsor.

Please consider making a contribution to OPERF this year. OPERF has come a long way with the help of many generous individuals and organizations in O&P that have supported its efforts to grow the base of scientific research and quality education in our profession. OPERF is a non-profit, 501(c)(3) independent organization, and all contributions made to OPERF are tax deductible to the full extent allowed by law.

For more information about OPERF, current awards, past award recipients, or to make a contribution, visit www.OPERF.org or contact Brian J. Hafner, PhD, OPERF Board member and Research Committee chair, at brian.hafner@operf.org
Adjustable Dynamic Orthoses for the Child with Spastic Cerebral Palsy

Exciting New Tools for Our Treatment Armamentarium

Keith M. Smith CO, LO, FAAOP
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Adjustable Dynamic Orthoses for the Child with Spastic Cerebral Palsy

Comprehensive treatment of the child with cerebral palsy (CP) includes selective use of surgery (orthopedic and neurological); pharmacology (systemic and focal); physical and occupational therapy (traditional and fitness training programs); and orthotic management (functional and therapeutic) practiced in a multidisciplinary team approach. Due to the growing evidence of brain plasticity in the developing child with CP, releasing the full potential of each child can be pursued with more vigor and hope than ever before in order to raise the long-term trajectory of function and quality of life.

Times are equally exciting for orthotists and research and development (R&D) efforts supporting these teams because new tools such as adjustable dynamic orthoses can play a vital role in leveraging emerging science.

What are the four basic goals of conventional orthoses for the child with spastic CP?  
1. To correct alignment of rearfoot, midfoot, and forefoot flexible deformities to protect the foot.
2. To provide a solid base of support with maximum contact area for improved stability.
3. To position the foot-ankle complex for swing clearance.
4. To help maintain current ankle range of motion (ROM).

What are the three additional goals of these children implied by the emerging science that are driving R&D efforts for adjustable dynamic approaches?  
5. To increase muscle length, strength, and balance as the child grows.
6. To improve proper biomechanical alignment of the trunk and lower limb without restricting motion.
7. To improve sensory-motor and proprioceptive feedback to the brain to learn motor control and function.

Basic Goals #1–4

Basic Goal #1 can be achieved with proper casting, mold modification, and fabrication of the AFO design. Basic Goal #2 is often difficult if ROM is inadequate or if the design overly restricts ankle motion. Basic Goal #3 can often be achieved assuming the hip and knee do not restrict terminal swing. Basic Goal #4 is doubtful at best and lacks any evidence to the authors' knowledge.

Current designs routinely prescribed for goals 1–4 are an articulated AFO with plantarflexion (PF) stop or a DAFO®-style AFO to address equinus or crouch without heel contact. If the patient is cast and corrected to a neutral (90°) ankle position but has a dynamic or static limitation of the posterior muscles (gastrocnemius-soleus, or GS), the GS may actually be tensioned by donning the AFO, as shown, for instance, if the heel is trying to pop out. This contributes to GS adverse firing during initial contact, when the tibialis anterior (TA) muscles should actually be firing eccentrically for shock absorption and controlled tibial progression. Without plantarflexion, the first and third rockers of walking are lost. These limitations have led the quest to more fully address the basic goals of conventional AFOs and additional patient needs (goals 5–7) demanded by patient brain plasticity and functional potential.

Each child's needs for ongoing comprehensive orthotic management are nearly constant throughout childhood, particularly during the child’s growth periods, before the age of eight, and again during adolescence. Throughout these times, rapid changes in body mass and long-bone length may degrade the child’s ability to walk. Therefore, his or her Gross Motor...
Function Classification System for Cerebral Palsy (GMFCS) level may change. GMFCS is the system by which levels of motor function are determined based on self-initiated movement (the scale uses Levels I–V, with Level V being the most involved). The functional level attained by puberty will likely be the peak function achieved and a key predictor of morbidity and mortality.

By replacing older static approaches with adjustable dynamic approaches, orthotists have a conservative and potentially longer-lasting intervention, thereby increasing the opportunity to make a difference in each child’s potential.

Summary Comparison of Adjustable Dynamic versus Older Static Approaches

Goal #5: Muscle/Strength Length

**Static:** Solid daytime AFOs block some or all of the eccentric muscle work at the ankle. Static “night braces” are intended only to accommodate current ROM.

**Adjustable dynamic:** Adjusted Dynamic Response™ (ADR™) AFOs augment muscle function, assist eccentric muscle work, and lengthen muscle with each step. The three rockers of walking are allowed rather than sacrificed. ADR AFOs also have been shown to improve average daily activity level by 47 percent over a traditional AFO in a single-patient case study. Ultraflex therapeutic orthoses worn at rest and/or at night lengthen muscle and improve range, making daytime ADR™ AFOs more effective.

Goal #6: Biomechanical Alignment

**Static:** Solid daytime PF-stop AFOs restrict ankle motion, dynamic balance, and stability.

**Adjustable dynamic:** ADR AFOs position the foot for swing clearance and weight acceptance to the extent of available range, allowing for potentially greater dynamic balance and stability, and allow for the ability to also fine-tune first (heel), second (ankle), and third (toe) rocker to the extent feasible. Dynamic and static limitations to ankle range can be addressed with dynamic therapeutic orthoses at rest or at night. Heel lifts/post are also used within the ADR AFO during daytime walking to maximize ankle motion and eccentric muscle action of the TA in early stance and GS in mid to late stance without contributing to adverse firing patterns that the 90° or PF-stop AFO may exacerbate.

Goal #7: Feedback to the Brain

**Static:** Solid and PF-stop AFOs restrict motion and therefore limit sensory motor and proprioceptive feedback necessary to improve motor function and dynamic stability and balance.

**Adjustable dynamic:** ADR AFOs seek to maximize motion with stability and to fine-tune first, second, and third rocker to the extent feasible so the gait pattern learned by the brain is potentially more optimal. This potential is exciting and demands further research.

The following patient summary demonstrates adjustable dynamic principles.

Our patient is an eight-year-old boy born with GMFCS Level III. He presents with significant spasticity in his lower limbs causing ROM deficits, gross weakness of the lower limbs, and significant crouch during gait. He began with a -35° popliteal angle and resultant crouch. Past orthotic management consisted of primarily ground-reaction AFOs, either solid-ankle designs set at 90° or hinged designs allowing the angle to be locked or set in a fixed position to accommodate his hamstring tightness. Problems with ambulation began when our patient began losing ROM in the sagittal plane to the hamstrings. We quickly implemented a program of therapeutic night-stretching Ultraflex knee orthoses to increase ROM and also incorporated Ultraflex ADR functional orthoses during the day for ambulation. ROM increased to -20° with the use of the night orthoses.

The key for ambulation with the ADR for our patient is that we are not stopping motion anymore but rather resisting it. The AFOs allow our patient to have full tibial progression through PF and dorsiflexion (DF). The focus of the AFOs is now on resistance of tibia DF or resultant crouch gait pattern. We are no longer stopping motion but utilizing the gains in ROM achieved with Ultraflex therapeutic orthoses and allowing controlled motion with the ADR resistance settings.

Many exciting research studies involving comparison effectiveness of static versus adjustable dynamic approaches are now under way, but more need to be initiated. Interested researchers are invited to contact the authors.

References

The Academy’s Scientific Societies Growing Strong

The Academy’s eight scientific societies are growing. Publications, educational programming, and professional networking websites where members can dialog with other experts in specialized areas are some of the resources put forth by the Academy’s societies to expand knowledge-based tools available to the profession. Recent progress includes the addition of two sub-groups of the Lower-Limb Prosthetics Society (LLPS): Pediatrics, Post-Operative Treatment after Lower-Limb Amputation (LLA); and, currently in development, a Sub-Atmospheric Socket group.

For more details, see the specific information below for each Society. Visit the Academy’s Society page (www.oandp.org/membership/societies) for a complete list of Society officers. Academy Society officers may be contacted directly and are happy to answer any questions.

CAD/CAM Society

The CAD/CAM Society is an emerging resource for individuals interested in cutting-edge technologies revolving around computer-aided design and manufacturing. “Due to its relevance in multiple disciplines, including upper- and lower-limb prosthetics and orthotics, craniofacial, and fabrication services, the CAD/CAM Society is uniquely positioned to interact with all of the scientific societies of the Academy,” Michael Nunnery, CPO, society chair, points out. “By joining the CAD/CAM Society, you can be at the center of the discussion of technology advancement regarding digital assessment and capture, modification and alignment, as well as fabrication and finishing of prosthetic and orthotic systems.”

He adds, “As a CAD/CAM Society member, you can help drive technology development through manufacturer interaction, education and assistance with reimbursement documentation, and supportive research via the CAD/CAM Society’s developing L-Code project.”

Nunnery invites interested persons to meet with him during the Academy’s 37th Annual Meeting and Scientific Symposium March 16–19, 2011, in Orlando, Florida, to discuss the society.

The society encourages practitioners using cutting-edge CAD/CAM techniques within their clinical practice to share their experiences through short papers, technical sheets, and at conferences such as the Annual Meeting and local Chapter or international meetings, Nunnery says. “Showcasing unusual clinical case studies and creative techniques with the use of CAD/CAM in O&P highlights the creative and innovative side of CAD/CAM that is often overlooked. More importantly, it can showcase the multidisciplinary aspect of CAD innovation….”

Interested persons can visit the new CAD/CAM Society professional networking website (http://cad-cam-society.ning.com). To register on the site, you must be a member of the CAD/CAM Society. This website provides forums and the ability to split off into specific topic areas as well as image- and video-hosting opportunities.

Craniofacial Society

The Craniofacial Society continued its focus on the treatment of infants with plagiocephaly, brachycephaly, scaphocephaly, and craniosynostosis. The society’s most recent newsletter is available on its networking website (http://craniofacial.ning.com). “We encourage more people to ask and answer questions, to post cases, and to help let others know about important events and developments in the specialty,” Society Chair Barbara Ziegler, CPO, FAAOP, says. The site contains newsletters, articles, photos, and discussions. All are encouraged to comment and add to the material, which currently includes “Custom Protective Helmets” and “CAD Modifications.” Non-members are welcome to browse the new site for a free two-week trial before being required to join the society to continue access.

Fabrication Sciences Society

The Fabrication Sciences Society is dedicated to the development of and education in fabrication methods and standards for both orthotics and prosthetics. “In order to meet the goals of the society, we would like to invite you to join and participate in our growth,” Chair Glenn F. Hutnick, CPO, CTP, FAAOP, says. “Our society has numerous lectures and articles already scheduled during 2011 including presentations at this year’s Academy Meeting. The society has many plans in the works, so get involved at our new networking website, http://aaop-fabrication.ning.com. Your membership will help us continue to grow and educate the profession.
“There are many ways to get involved and help our programs grow,” Hutnick continues. He lists the following opportunities:
- Volunteer to work as a Fabrication Society Board member.
- Submit your fabrication techniques for the library.
- Prepare a fabrication presentation.
- Help us develop and maintain the website.
- Help develop the “standards of fabrication guideline” document.

Any professional with an interest in fabrication and its advancement is encouraged. “We invite your participation and seek your knowledge and experience, but we also would like to hear from students and newly certified individuals who are interested in affecting the future of fabrication,” says Hutnick.

**Gait Society**

The Gait Society promotes gait analysis education for its members to improve functional abilities of physically challenged individuals. “We welcome you to join in the journal club discussions on our networking website (http://gait-society.ning.com),” Chair Sue Ewers Spaulding, MS, CPO, says. “We also encourage you to share clinical cases that you have seen and describe the interventions that were applied to alter the gait.”

The Gait Society’s newsletter, The Bipedal Exchange, is available on the Gait Society’s webpage: www.oandp.org/membership/societies/gait

“Please contact us if you are interested in membership, have ideas for guest speakers or topics, or are interested in becoming involved in the leadership or committees of the Society,” Spaulding says.

**Lower-Limb Orthotics Society**

The Lower-Limb Orthotics Society (LLOS) is developing its professional networking website and is currently recruiting participants to help manage the site as well as to manage committees in the society. Chair Bridget Lawler, CPO, says, “The society has been concentrating on growing its leadership and would like to talk to people interested in participating in publishing and program development focused on lower-limb orthotics. It’s a great opportunity and a minimal investment of time.” The society is poised to bring lower-limb orthotics outcomes to the forefront by centralizing member research, presentations, and publications. It will work through its networking website (in development) to dialog with members, through education programming at the Academy’s Annual Meetings and regional Chapter meetings, as well as publishing opportunities. Contact information to get involved is available at the LLOS website, www.oandp.org/membership/societies/lo

**Lower-Limb Prosthetics Society**

The Lower-Limb Prosthetics Society (LLPS) continues to grow, and new content, such as case studies and discussion forums, is often being added to its website. “We are adding new member benefits and would like you to join us as we focus on improving patient care and professional development,” Kevin Carroll, MS, CP, FAAOP, society chair, says. The society is dedicated to sharing information and knowledge, engaging in research, and presenting and publishing to advance the profession. “All prosthetists who provide lower-limb devices are encouraged to join the Lower-Limb Prosthetics Society,” Carroll says.

Some of the ways members can participate include:
- Help manage the LLPS networking website, http://aap-llps.ning.com. Interested persons can sign up for a two-week trial or join the society for full-time access.
- Publish in a future issue of *The Academy TODAY*. “Our next issue will focus on amputation wound care,” Carroll notes.
- Create an LLPS subgroup to serve as a forum for information sharing. Current groups include Pediatrics and Post-Operative Treatment.
- Plan programming for upcoming Academy Annual Meetings.
- Build communication with physicians and members of the rehabilitation community.
- Participate in LLPS programming at the Academy Annual Meeting in Orlando.

**Upper-Limb Prosthetics Society**

The Upper-Limb Prosthetics Society recently organized a symposium for the Academy’s Annual Meeting in Orlando titled, “Beyond the Prosthetist.” According to Society Chair Christopher Lake, CPO, FAAOP, this program highlights successful prosthetic cases that involved input or influence from other professions outside the walls of the prosthetic office. “The purpose of this symposium is to present a variety of case studies where insightful cooperation between the prosthetist and other rehabilitation team members had a positive influence on the patient’s case. Cases highlight the involvement of the prosthetist with occupational and physical therapists, social workers, psychologists, chiropractors, radiologists, and rehabilitation technologists as well as the spectrum of physicians from physiatrists to hand surgeons to pain management specialists. Persons outside the medical arena such as machinists, artists, and prosthetic component manufacturers are also enlisted from time to time to make patient-specific modifications that provided the overall tipping point to successful outcomes,” Lake adds.

Note: An update from the Spinal Orthotics Society (www.oandp.org/membership/societies/spi/) was unavailable at press time.
Ultraflex addresses the multiple treatment goals involved with crouch. Jacob wears an Ultraflex dynamic assist stretching KO (at rest/nighttime) to maintain and increase ROM. Ultraflex Adjustable Dynamic Response™ (ADR™) AFOs (daytime) are worn bilaterally to control dorsiflexion, provide normal range, increase stability, and improve balance. The Ultraflex stretching KO worn at night/at rest is easily connected/disconnected to and from the ADR™ AFO with the Ultraflex UltraQuick Release™. The stretching KO/AFO ADR™ combination is billable as one brace. The family reports that Jacob is getting the stretching he needs, has improved balance and stability, and is more upright—all of which give Jacob greater function.

For education for you and your referrals, please call: 800-220-6670

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