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The ACADEMY TODAY

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Upper-Limb Prosthetics:

Using Evidence-Based Practice to Enhance Patient Care Experiences

Overuse Syndrome(s) in Upper-Limb Loss:

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Message from the President

As I begin my term as president of the American Academy of Orthotists and Prosthetists (the Academy), I want to take a moment to reflect on how I got to this point. So many people have been influential in my professional growth. The professors who taught me as an undergraduate while studying engineering, the practitioners with whom I volunteered to gain my first exposure to O&P, and my instructors at Northwestern University, Chicago, Illinois, all showed me that O&P is more than a job—it is a profession. As a young professional, I received guidance and encouragement from the clinicians and patients at Southern California O&P, San Diego, California. And just when I thought I was starting to really understand what it meant to be a practitioner, my perception of the field widened when I joined Össur, Foothill Ranch, California, where I interacted with colleagues and clients from all over the country and the world. I learned that the problems we face in one part of the country may differ from other areas, and those differences may appear great. But throughout the profession, every clinician I have encountered asks himself or herself the same question to guide his or her approach to problems large and small: "What can I do to help make someone else's life better?"

Within our profession, each of us finds our own way to improve lives. It may be through our interactions with the patients we see every day, or maybe it is by volunteering within the field or by mentoring someone who wants to know more about O&P. After 20 years of learning, watching, communicating, and developing relationships, I believe that the best way I can repay all of my mentors and teachers is to nurture the next generation of practitioners. I will do my best to build upon my past experiences to help shape the future of our profession as an educator and in my role on the Academy's Board of Directors.

I am truly excited to begin my term as president. During my seven years as a member, the Academy Board has strived to help the profession grow. While we sometimes struggled to make the hard decisions, we always worked together to achieve our goals. Our prevailing principle was, "Do what is best for the membership and in turn for those patients who seek our services." With each new idea, issue, situation, and decision, the Board never said, "We can't do that," but rather worked diligently to make it happen.

Academy's Accomplishments

The Academy's accomplishments over the past few years have been profound. The list of these accomplishments is long: the creation of the Online Learning Center (OLC), which now has more than 150 education modules; the development of the Research Council's guide to conducting research, literature updates, Evidence Notes, and the Recommended Reading section on the Academy website; the kickoff of the Women in O&P Committee mentoring program; the establishment of the Student-Resident Committee; the production of the Licensure Tool Kit; and the enhancement of the Fellow program and the one-day certificate programs. With the assistance of our federal grant, we now have completed ten State-of-the-Science Conferences, with more to come. I am proud of all the work the Academy has done to help professionals promote care through knowledge.

Mark D. Muller, MS, CPO, FAAOP
2011-2012 President

Strategic Plan for the Next Three Years

As the Academy moves forward, we will continue to build on these accomplishments to advance our profession. We will achieve this by planning carefully for the future. This past June, the Board of Directors held its planning meeting and developed a strategic plan for the next three years.

The plan was designed from the ground up with direct input from our membership, our eight Scientific Societies, and our three Councils. The plan is lofty and ambitious and will take everyone involved with the Academy working together to realize its goals. In the short term, we will continue to focus on building an education and knowledge base that our professional members can use within their everyday practice. But our long-term goals are directed toward collaboration, unification, research, mentorship, licensure, and the legislative needs of our individual membership.

It is important to remember that the work of the Academy is done by volunteers who work with a dedicated staff to carry out the policies of the Board. Albert Einstein (1879–1955) once said, "The value of a man resides in what he gives and not in what he is capable of receiving." I think of these words as I look back at past Academy presidents, and I am in awe of their accomplishments. I am inspired by what they have done and their sustained commitment to our profession. These amazing individuals continue to serve the profession long after their term as president has ended.

I look forward to the exciting year ahead and want to hear from you often. Feel free to contact me anytime either through the Academy or at mmuller@csudh.edu. I welcome your ideas on how to improve and strengthen our profession and the Academy.

Upper-Limb Prosthetics: Using Evidence-Based Practice to Enhance Patient Care Experiences

■ Chris Lake, BS, CPO, FAAOP

Introduction

Evidence-based practice strikes at the core of ethical, conscientious, and proficient prosthetic care. From Sackett et al.'s, original definition comes the analogy of evidence-based practice as a three-legged stool on which our patient sits. These legs draw their stability from searching for and integrating the current best research evidence, respecting and integrating the patient's values, and building the clinical expertise to address the patient's needs.[1] The strength of these factors provides a stable platform for improved patient outcomes. Conversely, a weakened or missing leg compromises the prosthetic outcome (Figure 1). As we strive to improve our patients' prosthetic outcomes, the evidence-based practice model provides an approach to increase the likelihood of patient success.

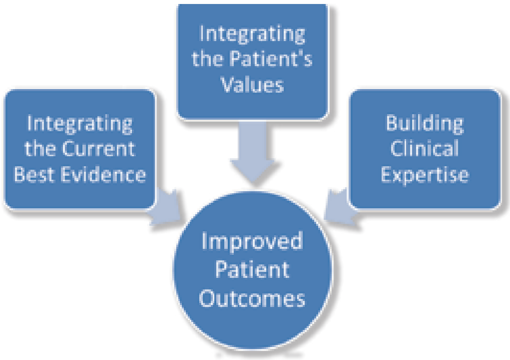

Figure 1: The three core factors of evidence-based practice help to improve patient outcomes.

When it comes to the strength of our clinical foundation, a review of the evidence tells us the following:

- Subscribing to and using the best evidence allows the prosthetist to incorporate sound clinical and technical proficiency in everyday practice.
- Patient-oriented care provides a platform for favorable outcomes by making the patient the center of the prosthetic rehabilitation team.
- The prosthetist needs enough experience with clinical cases to base, compare, and analyze the literature. The purpose of this article is to discuss some of the recent literature and trends that highlight the importance of integrating evidence-based practice concepts into upper-limb prosthetic care.

Background

We use our hands in almost every activity of daily living (ADL). Our hands help us communicate, learn, show emotion, and support our families. Upper-limb injury is consistently one of the most common injuries requiring medical care.[2–3] A loss of even a part of the upper limb results in significant challenges to the patient. When a person loses his or her fingers and thumb, an overall 90 percent upper-limb impairment and 54 percent whole person impairment exists[4] (Table 1).

Furthermore, the prosthetic replacement of upper-limb function can be a daunting task for the rehabilitation team. A substantially larger amount of neurological area within the human brain is dedicated to the motor and sensory functions of the upper limb than the lower limb.[5,6] This creates an engineering hurdle for manufacturers and a noticeable gap in our technical ability to replace the functions of the human hand.

Individuals with upper-limb loss present very differently than those with lower-limb loss, and it is important to appreciate those differences. The prevailing cause of upper-limb loss is trauma (92 percent) in contrast to the vascular complications (78 percent) found in the lower-limb-loss population.[7] Individuals with upper-limb loss are generally between the ages of 16 and 44 at the time of amputation, whereas lower-limb loss is associated with individuals who are in their 60s or older.[8–10] Upper-limb amputees are usually healthier individuals at the time of amputation and can generally expect to live full lives.[10,11] In contrast, many lower-limb amputees may experience other complications that lead to poor survival rates at five- and ten-year post-amputation intervals.[8,12] Many times,

Table 1: Significant upper-limb impairment exists with loss of just the hand and increases as amputation levels move more proximal.

Level of Amputation	Whole Person Impairment	Upper-Limb Impairment
Transhumeral—Proximal Third	60%	100%
Transradial—Proximal Third	57%	95%
Partial Hand—Metacarpal Phalangeal Level	54%	90%

Adapted from Guides to the Evaluation of Permanent Impairment, *American Medical Association. 6th ed. American Medical Association: 2008.*[4]

lower-limb amputees are aware of an impending amputation secondary to the gradual disease process. Upper-limb patients have little or no warning of impending loss. As a result, upper-limb patients must immediately cope with the pain of the traumatic injury and amputation while at the same time facing the psychological blow of feeling less capable and independent in a world that often measures self-worth by what individuals can do.[13] Unlike individuals with lower-limb amputation, who may choose to cover their affected leg under long pants and shoes until they feel more comfortable discussing their loss, upper-limb patients find themselves more exposed from the very beginning.[14] Failing to recognize the psychological impact and post-traumatic stress associated with upper-limb amputation can negatively affect successful prosthetic use and coping.[14–16]

Review of Recent Literature

Integrating the Current Best Evidence

The turn of the century has brought a renewed investigation of what variables influence upper-limb prosthetic success.[17–21] Time to fit has always been a common variable associated with prosthetic acceptance. In the early 1980s, Malone et al., found that the greatest prosthetic success was achieved when an individual was fit within 30 days of amputation.[22] More recently, Biddiss and Chau found that this "time-to-fit" window might indeed be larger. Within their study population, "individuals fitted within two years of birth (congenital) or six months of amputation (acquired) were 16-times more likely to continue prosthesis use."[19] This new study provides current numbers and methods to expand on the highly quoted Malone et al., study. When examining consumer priorities for upper-limb prosthetics, comfort-related design issues were the primary concern of prosthesis users across all genres. These issues include the need for increased heat dissipation, improved socket-interface fitting, and reduction of prosthesis weight.[18]

The patients' perception of their prosthetist's skills can influence acceptance as well. Pezzin et al. found that patients with transradial- and humeral-level amputations tend to be less satisfied than transtibial-level individuals with the information their prosthetist provides. Contributing variables of this finding were the usefulness of the information offered, the prosthetist's ability to answer questions effectively, and the degree of confidence the patient had in the prosthetist's expertise and dependability.[23] A possible explanation for this finding surfaces when one considers the most common amputation levels seen today. There are approximately 65,000 new lower-limb amputations (Symes level and proximal) in contrast to approximately 2,000 new upper-limb amputations (wrist disarticulation and proximal).[24] This 30:1 ratio provides the prosthetist with many opportunities to sharpen his or her lower-limb skills and far fewer opportunities when it comes to upper-limb experiences. In 2007, Biddiss and Chau[19] found statistically significant results when comparing prosthesis rejecters to frequent users. Prosthetic rejecters reported less satisfaction with many aspects of their prosthetic care, as shown in Table 2. These various aspects, ranging from prosthesis fitting, follow-up, and repair to information provided with respect to prosthesis technology and use of multiple prostheses, speaks to the level of attention necessary to support the upper-limb patient.

Integrating the Patient's Values

When we integrate the patient's values, we make a conscious effort to put the patient at the center of the care model, from planning and implementation to service delivery and follow-up.[25] Patient-oriented care represents a fundamentally different medical philosophy from the traditional parental model. The prosthetics and orthotics field has not exclusively studied patient-oriented care, though the research discussed in the previous section highlights the poor results and experiences found when a patient feels less attended to and informed. The benefits of patient-oriented care are becoming more widely studied across the medical field. Two recent studies from the fields of pharmacology and hand surgery rehabilitation describe benefits in efficacy and cost savings when a patient-centered approach exists.

In the field of pharmacology, an investigation of medication decisions and management found fewer hospital admissions due to medicine mismanagement in the patient-centered model. One conclusion the authors made was, "No matter how sophisticated our medication technology becomes, ultimately, their success depends on the client's motivation and behavior."[26] A study from the University of Heidelberg, Germany, looked at the effectiveness of a patient-oriented hand rehabilitation program. The patient-oriented approach led to reports of reduced pain and greater patient satisfaction as well as an increased likelihood of returning to former occupations and less sick time taken from work.[27]

Table 2: Prosthetic Rejection Rates

Prosthetic rejecters reported less satisfaction with:

- Fitting of the prosthesis ($p<0.001$)
- Follow-up ($p<0.001$)
- Repair ($p<0.001$)
- Training ($p<0.007$)
- Information provision ($p<0.009$)
- Information provided with respect to prosthesis technology ($p<0.001$)
- Sources of funding ($p=0.01$)
- Use of multiple prostheses ($p=0.001$)
- Level of expectations set ($p<0.001$)
- Overall knowledge and experience of healthcare providers ($p<0.001$)

Source: Biddiss E, Chau T. Upper-limb prosthetics: critical factors in device abandonment: Am J Phys Med Rehabil. 2007;997–987.19

Clinically, there is a greater likelihood of patient success when patients take an active role in the decision process. Meier and Esquenazi recommend a standard education program as "a means of empowerment so that the amputee can make the best possible decisions for his life and future needs."[28] Van Dorsten states, "In every situation, healthcare providers have a responsibility to be knowledgeable about the forces affecting an individual at any given time and to proactively cooperate in facilitating the amputee's involvement in development and achieving goals that have meaning. Self-determination is fueled by challenge, fostered by supportive, significant others, or extinguished by provincial paradigms of professional control. Successful outcomes are truly a team endeavor."[29]

Clinically, the upper-limb preparatory fitting protocol embodies a patient-oriented care approach by allowing for the verification of appropriate components based on patient feedback. The preparatory fitting became critical in the evaluation of a patient's candidacy for the externally powered prosthetic technology emerging in the early 1980s.[30] This type of fitting provides the foundation for expeditious changes to any prosthetic element such as accommodation of residual-limb volume fluctuation. In its purest form, a preparatory fitting empowers the patient to make an informed decision regarding the direction of the prosthetic course (Figure 2). This mutual discovery process between the patient and the clinical team further allows the patient to influence the decision-making process and to help develop a prosthetic care plan and device that better meets the patient's expectations. Considerations for the length and level of amputation, as well as exploration of prosthetic options, have a real impact on patient outcome. Brenner and Brenner highlight the use of trial fittings that plot and change course based on patient feedback and technical assessment. The dynamic nature of the preparatory fitting helps the prosthetist develop case-specific evidence for definitive prosthetic management.[31]

Figure 2: The use of disconnect wrist and myo/body-powered wrist adaptors allow for the evaluation of myoelectric, body-powered, and activity-specific options in one preparatory fitting.

Building Clinical Expertise

Building expertise in upper-limb prosthetics requires the prosthetist to make a direct decision to specialize. Even with a significant level of commitment, it is difficult to gain the necessary experience. The increasing prevalence of vascular-related lower-limb amputations[7] will lead most prosthetists to find themselves in high-volume lower-limb practices. This increasing lower-limb population sets the stage to challenge access to specialized upper-limb care.[32] Furthermore, past trends have shown that traumatic amputation is decreasing,[11] which will further limit upper-limb patient exposure for the treating prosthetist. This is due to improvements in both occupational safety and surgical techniques. The aforementioned challenges are then complicated by the numbers of new patients versus prosthetists. The annual rate of 2,000 new upper-limb amputees (with limb loss between the wrist and shoulder region) per year potentially treated by one of the 3,300 prosthetists or prosthetist/orthotists certified by the American Board for Certification in Orthotics, Prosthetics, and Pedorthics (ABC), substantiates what is known as the "upper-limb dilemma."[13, 33]

Medicine generally accepts the role of specialized care in treating rare and complex conditions, with specialty care dating back into the early 20th century.[34] The emergence of upper-limb specialty care is much more recent and fosters a partnership with occupational therapy to attain optimal patient outcomes.[35] In the O&P profession, specialization is also noted in the areas of pediatric prosthetics and orthotics, as well as the management of spinal deformities, fractures, and cranial-facial deformities.[36]

In medicine, those who focus on specific patient populations exhibited greater command of the medical knowledge and were more up-to-date in the use of progressive diagnostic and treatment modalities. These observations led to the assumption that the practice pattern of the specialist can produce better outcomes. In general, the treatment of common conditions had similar outcomes regardless of the specialty of the provider. The true differences come when looking at conditions that are more complex and/or rare. In these situations, specialists tended to have shorter hospital stays, lower readmission rates, and lower mortality rates for their patients.[37]

Discussion

Appreciating the elements of evidence-based practice helps the prosthetist to incorporate sound clinical and technical proficiency in everyday practice. This proficiency, as observed by the patient, can encompass the patient's perception of the prosthetist's expertise and quality of fitting, follow-up, repair, training, provision of information, discussion of prosthetic options, and recognition of the need for peer support. Proficiency in these areas echoes that of a practitioner who specializes—having a command of the latest diagnostic and therapeutic modalities and the experience to execute a progressive care plan.

Various authors suspect the rate of upper-limb amputations is decreasing secondary to improvements in limb salvage and reconstruction as well as occupational safety. What is striking is the effect that emerging technology may have on the available population that could benefit from upper-limb treatment. Five to ten years ago, the levels most commonly fit with a functional prosthesis were proximal to the wrist. As both electric and body-powered digital technology advances, a previously underserved population will have a functional prosthetic option to consider. This influx of upper-limb patients will bring the need for enhanced educational, technical, and clinical expertise.

Recent research suggests that greater prosthetist expertise and awareness of patient values can reduce rejection rates. Research further validates the clinical reality that the patient will often abandon the prosthesis when a fitting does not meet the patient's needs, whether in the areas of function, comfort, or aesthetics. It is imperative that we do everything in our power to continually raise the standard of upper-limb patient care.

Recommended Reading

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Overuse Syndrome(s) in Upper-Limb Loss: Recognizing Problems and Implementing Change

■ Sandy Fletchall, OTR/L, CHT, MPA, FAOTA

Upper-limb loss acute pain lasting for fewer than three months may be directly associated with the trauma, wounds, or surgery that resulted in the amputation. Acute pain resolves as the medical condition improves and does not interfere with participation in activities. Chronic pain, present for more than three months, can contribute to limitations in activities of daily living (ADL). An individual without a limb loss will minimize use of the limb with chronic pain by placing the muscle/tendon and nerve tissue on rest. However, for those with an upper-limb loss, placing the non-amputated limb at rest significantly limits independence in ADL and interferes with their ability to participate in work and leisure activities.

The term "overuse syndrome" is synonymous with cumulative trauma disorder (CTD) or repetitive stress injury (RSI). These terms refer to injuries that develop over a period of weeks, months, or years when repetitive use results in micro-trauma or tears at the microscopic or molecular level of musculotendinous structures, nerves, vascular bundles, or bones.[15] Without time to repair, the microscopic damage creates excessive pressure on nerves and tendons, with internal cellular edema limiting tendon gliding and blood flow and increasing fibrotic scar-tissue development. The angle of muscle pull can be changed, adding to further irritation at the muscle/tendon insertion of the bone. If the pain from the overuse syndrome is not resolved, the individual has a potential to develop additional problems such as limited motion and decreased muscle strength and endurance, which can result in decreased sensation in the hand, poor posture, and limited ability to grasp or obtain adequate prehension strength for the performance of self care.

Incidence

Several articles have identified that 33 to 57 percent of individuals with an upper-limb loss experience non-amputated limb pain.[2,6,7,8,13] Ephraim et al., noted the time from the amputation increased the potential of developing non-amputated limb pain, with an increase of 1.7 times at two–five years post-amputation and 3.0 times at 10 years or more post-amputation.[2] Work completed by Sato et al. identified an overuse syndrome of carpal tunnel syndrome (CTS) in individuals who had sustained a stroke.[11] They found CTS in the nonparetic hand at 31.1 percent if the involved hand had limited function; however, this increased to 57.7 percent when the hand was not functional. The amputated upper limb could be seen as synonymous with the involved limb in stroke patients, with the non-amputated limb exhibiting potential to develop one of the overuse syndromes due to the need to perform several tasks. Jones' and Davidson's work identified that the use of an upper-limb prosthesis did not "save" the non-amputated limb from overuse syndrome problems.[8]

Overuse syndromes can include neck pain, back pain, rotator cuff injuries, or tendinitis and tears, shoulder impingement and bursitis, lateral and medical epicondylitis [Term ok, or should it be "medial epicondylitis"?], CTS, tendinitis of the forearm flexors or extensors, De Quervain's syndrome, and trigger finger.[14]

Reviewing work performed with the general population of working-age individuals and individuals with upper-limb loss and comparing the percentages of overuse syndrome and back and neck pain in each group will determine if there is a difference between the groups. Ziegler-Graham identified that traumatic amputations occur among those below the age of 45 years, fostering a comparison to the working-age group of the general population.[15]

Dillingham and Hanley et al., found 62.3 percent and 52 percent, respectively, of those with upper-limb loss report back pain.[1,7] Ephraim et al., found that the upper-limb-loss population reported back pain 2.2 times more than the general population in the United States.[2] The Panel on Musculoskeletal Disorders and the Workplace found the prevalence of back pain in the general population to be 17.6 percent.[10] Regardless, the upper-limb-loss population reports a higher occurrence of back pain than the general population (Table 1).

Neck pain is reported by 14 percent of the United States population, while Hanley et al. reported that 43 percent of the upper-limb-loss population experience significant neck pain that interferes with activity performance.[7]

Hanley et al. and Ephraim et al. found that 33–36 percent of individuals with upper-limb loss report non-amputated limb

Table 1

Type(s) of Non-Amputated Limb Pain with Traumatic Upper-Limb Loss, N=26[5]	
Shoulder pain	61.5%
Back, cervical pain	53.8%
Lateral epicondylitis	42.3%
Carpal tunnel syndrome (CTS)	34.5%
Hand cramping*	30.7%

*Includes intrinsic muscle fatigue, trigger finger, tenosynovitis, and cubital tunnel syndrome.

Table 2

Incidence of Overuse Syndromes (CTD): Comparison of General Population and Upper-Limb-Loss Population		
	General Population	Upper-Limb-Loss
Back pain	17.6–28%[10,2]	52–62.3%[1,7]
Neck pain	14%[7]	43%[7]
CTD of the upper limb	20%[10]	33–36%[2,7]

pain, overuse syndrome, or CTD pain.[7,2] Morse, as identified in the report by the Panel on Musculoskeletal Disorders and the Workplace, found that more than 20 percent of the population were diagnosed with some form of CTD.[10] Fletchall's presentations included a retrospective review of more than 15 years and found 100 percent of the upper-limb-loss individuals indicated at least one CTD within a four-week period, with 60 percent reporting a minimum of two CTD issues (Figure 2).[3,4,5]

Other factors identified as contributing to pain intensity are depressive disorder and decreased socioeconomic status. Ephraim et al. found those with limb loss who had depressive symptoms ranged from 35–51 percent, which is three to five times higher than the general population.[2]

Program Development

Knowing that upper-limb-loss population surveys identify a higher incidence of back, neck, and upper-limb pain related to CTD or overuse than the general population, the amputee-care team should develop guidelines to minimize its occurrence.

It has been recommended that educating or counseling the individual on overuse or CTD while undergoing rehabilitation may decrease the intensity or incidence.[6,7,12] Taking this a step further, education should be ongoing throughout the individual's life. During the early rehabilitation phase involving prosthetic training by the occupational therapist (OT), an assessment of posture, muscle function, strength, and motion is made, with a program developed to minimize limitations and improve mobility and performance. This early phase of the program should include education and training related to hand/arm mechanics and trunk and head positioning to minimize CTD. Also during the early phase of rehabilitation, placing the client into a program of total-body conditioning, similar to randomized training for athletics, can encourage lifelong participation in conditioning.[9] A conditioned body can experience fewer muscle imbalances and pain issues.

Following completion of the early rehabilitation program, the client would be reassessed at follow-up appointments with the amputee-care team, or at least the OT and prosthetist, regarding any pain issues, overall body performance, and prosthetic function issues. The maturity process finds individuals participating in different activities or work duties than he or she did during the early rehabilitation phase. The maturity process also involves the normal physiological changes one experiences, which can influence participation in activities. The OT, knowledgeable in body function, body mechanics, task analysis, and prosthetic use, can assist the individual to minimize or eliminate pain issues for return to participation in activities. The OT can make recommendations to stabilize or minimize movement through custom or non-custom splinting. These devices can assist in providing rest to the area with pain, allowing the opportunity for healing and repair to occur. The OT can make recommendations for adaptive techniques to complete tasks, thus decreasing the frequency of placing the body part in pain in motion. The OT may recommend the use of adaptive equipment to minimize pain issues in the non-amputated limb.

When non-amputated limb pain does occur, the OT and other amputee-care team members must document to the funding source the need for the individual with upper-limb loss to have an additional therapy session for further education, assessment regarding adaptive techniques and equipment, a change of prosthetic styles or components, a change of medication, additional tests, or referrals to other specialists.

Case Presentation

Case 1: A 32-year-old female sustained an avulsion injury resulting in a short transradial amputation of the dominant limb. During her early-phase rehabilitation program, she underwent total body conditioning and prosthetic training. She received education related to hand/arm mechanics to minimize development of CTD. Becoming independent in bilateral upper-limb use with her prosthesis, she returned to the work environment and resumed home activities and duties. She was followed twice a year in the amputee clinic. Three years after completing the early rehabilitation phase, during her scheduled appointment in the amputee clinic, she identified pain issues in the non-amputated limb, diagnosed as lateral epicondylitis. The OT provided a counterbrace band for the forearm for daytime use and a wrist-support splint for nighttime use. She was educated in alternative use of the non-amputated limb when performing the activity that resulted in the development of the pain. She also was placed onto an eccentric strengthening program for the extensor carpi radialis brevis. Pain was decreased from a level eight to a level two on a pain scale of one to ten within one week. The patient continues to implement appropriate devices or techniques when participating in repetitive activities and remains pain free six years later.

Case 2: Eight years after an electrical injury resulting in a left shoulder disarticulation, loss of the right axillary nerve, and loss of significant soft tissue of the posterior neck, this 38-year-old male began experiencing numbness in digits four and five, decreased strength of the intrinsics, and an inability to sleep, secondary to pain occurring in the hand. After failing a trial of conservative techniques for cubital tunnel irritation, the amputee-care team's recommendation was referral to a surgeon. The OT was identified as the consult to the surgeon to provide information related to the client's level of function and his need to return to independence as soon as possible. Following the consultation, the surgeon chose a less involved procedure to transposition the ulnar nerve. Following less than six OT treatment sessions, this client returned to work full time and remains pain free four years later.

Summary

Individuals with upper-limb loss are frequently younger than those with lower-limb loss, resulting in more time using muscles, tendons, and nerves. The amputee-care team, knowledgeable regarding upper-limb-loss issues, can assist the individual in remaining functional through education of overuse syndromes during the early rehabilitation phase and with continued reassessment. For funding sources and life care planning, information should be included to anticipate development of overuse syndrome or CTD.

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The Pocket Podiatry Guide: Footwear & Foot Orthoses

Authors: Anita Williams, PhD, BSc (Hons); Chris Nester, PhD, BSc (Hons)
Series Editor: Ian Mathieson
Reviewed by: Seamus Kennedy, BEng (Mech), CPed

Publisher: Churchill Livingstone, Elsevier Health Sciences Division
Number of pages: 164

The Pocket Podiatry Guide: *Footwear & Foot Orthoses* lives up to its title in that it is a slim and compact volume that fits neatly into a standard lab coat pocket. It is divided into nine chapters that cover much of the essential information on foot orthoses and shoes. Chapter topics include a review of foot biomechanics and gait, foot orthoses, general shoe design and wear assessment, and a review of systemic diseases of the foot and related patient management.

The stated goal of the book is to aid in the "understanding of the true role of footwear in the maintenance of foot health and the management of foot pathology." The authors' intention is to cover all three aspects of foot health, treating them as equally important contributors to patient well-being: biomechanics, orthoses, and footwear.

The first chapter on biomechanics covers standard terminology and gives a brief summary of the gait cycle. From there, the book considers the impact of some common diseases that practitioners encounter such as diabetes, rheumatoid arthritis, and neuropathy. This information is accompanied by some good photographs that illustrate end-stage examples of various conditions.

The chapter on foot orthoses is almost 30 pages. It looks at both prefabricated and custom orthoses from initial design considerations and materials to the goals of reducing pronation, pressure, and shear. It also discusses how to protect the "at-risk" foot.

The heart of the book focuses on footwear. This begins with an interesting history of shoe evolution and design. The "Modern Footwear" chapter is a good reference for shoe nomenclature. Chapter 6 is devoted to "Footwear Assessment," evaluating worn shoes and wear patterns as an aid to diagnosis and treatment. It takes an in-depth look at the distortions and wear marks that appear on shoes and insoles and how to interpret them. The next chapter covers footwear options and the different ways that shoes can be designed, custom made, or altered in order to achieve optimal fit and function. *The Guide* then goes on to look at footwear options for the pathological and vulnerable foot, offering suggestions for the best shoe types and styles for selected diagnoses. Finally, there is a general discussion about the methods of managing patients' attitudes and acceptance of therapeutic shoes and orthoses.

In Summary: *Footwear & Foot Orthoses* is a marvelous and compact book that serves as a good reference for the language and concepts of pedorthics. It is a good book for practitioners such as orthotists, prosthetists, and podiatrists who want to quickly access pedorthics. Each chapter in the book comes with its own in-depth "References" and "Further Reading" sections. These are excellent sources to begin research for more advanced study. The book is a good general guide, and it provides a gateway to further explore specific aspects of interest.

Gait Analysis: Normal and Pathological Function, 2nd Edition

Editors: Jacquelin Perry, MD; Judith Burnfield, PhD, PT
Reviewed by: Bryan Malas, MHPE, CO

Publisher: SLACK Incorporated
Number of pages: 576

The second edition of *Gait Analysis: Normal and Pathological Function* is now available. Gait analysis pioneer Jacquelin Perry, MD, teamed with co-author Judith Burnfield, PhD, PT, and several contributing authors to update and expand the original 1992 work, adding seven new content areas. The greatest strength of the new edition lies in its logical, reorganized content presentation, which interweaves the old and new into a single comprehensive text. Since the initial publication of *Gait Analysis,* the field has witnessed an increase in the development and use of sophisticated measuring tools. The reader will see the fruits of this technology throughout the new edition, including numeric value updates specific to particular gait subdomains (e.g., functional range of motion, kinematic and kinetic data, normative joint-motion data, and peak electromyography activity).

The second edition opens in lockstep with its predecessor, describing the fundamental elements of gait, normal gait, and pathological gait. Important changes in the original text add clarification and emphasis to key ideas. Especially noteworthy are the deeper discussions on propulsion, heel transient, selective motor control, the addition of "the fourth rocker," and the new thinking on the "determinants of gait."

The greatest reorganizational changes occur in the sections on normal and pathological gait. The material in these sections is expanded and re-sequenced to improve clarity. Pre-swing accelerated progression and floor-contact deviations benefit from greater in-depth discussion, as do the expanded discussions about power in the chapters pertaining to normal gait.

The second edition largely retains the format of the original. The new material complements the original with sections on running, stair negotiation, pediatric gait, new gait-analysis methods and technologies, and bilateral synergies of the lower limbs. The addition of gait-specific clinical examples and cases are especially welcomed.

The treatment of bilateral synergies, pediatric gait, and running form the core of the new material. The section on bilateral synergies clarifies the interplay between the two lower limbs during walking better than the former edition. The chapters on pediatric gait and running are equally valuable. The former includes a discussion on developmental gait, the Gross Motor Function Classification System (GMFCS), and clinical examples. The chapter on running includes relevant definitions and concepts easily accessible and assimilated by readers already knowledgeable in normal and pathological gait.

One content area that would benefit from greater discussion is the section on "observational gait." An expanded treatment on the advantages and limitations of observational gait would have been a nice complement to the textbook.

In Summary: This textbook will remain a staple in the educational setting for both student and teacher alike. If an O&P student needed one book on gait, this would be that book. For practitioners, the textbook is a ready reference that can augment existing knowledge and inform clinical practice.

Multi-Articulated Hands Take an Exciting New Step

The launch of the newest size and version of the *bebionic* hand signifies the latest step of an exciting development of multi-articulated hands. The new *bebionic* hand is truly appropriate for routine prescriptions as an alternative to simpler hand styles.

Cable-operated hands with articulated fingers have been available as far back as the Civil War, with ratchet-locked hands being described in Medieval times.[1] Steeper, Leeds, England, has a legacy in upper-limb prosthetics dating back to World War I and has collaborated in developing multi-joint prostheses since the 1960s, including the D.W. Collins hand[2] (Figure 1) and the SVEN hand[3] developed in collaboration with the Swedish Handicap Institute.

Figure 1: Patient Bob Daish uses a cable-operated, multi-articulated hand in the 1960s.

Since then, many attempts have been made to build complex articulating hands and full-arm prostheses with multiple freedoms of motion. It is, however, only relatively recently that multi-articulated hands, of which *bebionic* is one option, have been available commercially as alternatives for myoelectric hands with simpler geometry.

Design Features

When determining how to provide stable grip patterns in prosthetic hand design, it is essential to consider the force to be applied to the gripped object and the geometry to allow a compliant grip. In order to reduce grip force, the geometry must maximize the surface area of the hand contacting the gripped object.

Individual-digit motor drives in the *bebionic* hand allow compliant grip patterns. The combination of individual actuators with advanced onboard electronics has allowed further elements to be incorporated into the design of the *bebionic v2* hand:

- Up to 14 user-selectable grip patterns are available, ten of which are accessible by direct selection and four that can be substituted wirelessly using *bebalance* programming software. These include grips never before available in a prosthetic hand, such as a mouse grip to operate a computer mouse (Figure 2) and a trigger grip to operate a trigger-activated device such as a spray bottle (Figure 3). Two additional grip patterns, finger adduction and precision open grip, are shown in Figures 4 and 5, respectively.
- New motor technology allows the hand to react very quickly under smooth, fast, proportional control for true two-handed activity.
- Onboard microprocessors that continually monitor the motion of individual digits allow the creation of grip patterns that can be reliably repeated and also allow automatic grasp stability and stall detection.
- Weight distribution has been optimized by positioning the mass of the motors more proximally, enabling the hand to be perceived as lighter than devices with weight positioned more distally.
- *bebalance* programming software allows wireless programming to fine-tune the operation of the hand to the abilities and requirements of each individual user.

Design Testing

Initial tests during development were conducted on two patients by a prosthetist, *bebionic* design engineers, and an upper-limb occupational therapist. The tests compared the pre-production *bebionic v1* hand with standard myoelectric hands—Steeper Select and Otto Bock DMC. The Southampton Hand Assessment Procedure (SHAP)—a clinically validated hand function test—was employed to objectively compare the hands. Semi-structured interviews were conducted to obtain subjective patient feedback. Video footage was recorded to document the procedure and compare body movements. The objective data revealed that both standard myo-hands could perform the tasks quicker than the *bebionic* hand; however, it is important to note that the *bebionic v2* hand operates at twice the speed of the original version. Users soon become adept at selecting a grip for a given task. As *bebionic* hands provide the appropriate grip pattern for different tasks, rather than a single tripod

Figure 2: Mouse Grip: The thumb and little finger close to hold the side of the mouse, with middle and ring fingers providing stability. The index finger can then be moved up and down to operate the mouse button.

Figure 3: Trigger Grip: The hand grasps the handle of an object with the middle, ring, and little finger, and secures the grip with the thumb. The index finger will be positioned over the trigger of the device with the index finger opening and closing to operate the trigger.

Figure 4: Finger Adduction: The fingers move together naturally as they close, allowing the user to grip thin objects, such as cutlery or a toothbrush, between the fingers to achieve function in a different plane.

Figure 5: Precision Open Grip: The index finger meets the static thumb, allowing the user to pick up and manipulate small objects quickly and accurately.

(three-jaw chuck) grip, users exhibited a marked reduction in compensatory body movements. The requirement for less gross body positioning while using a multi-articulated hand is likely to be beneficial for improved overall function and preserving the longer-term condition of proximal joints. Both trial patients reported preference for the *bebionic* hand compared to the standard myoelectric hands, even following years of proficient experience with the conventional designs. The reasons stated for preferring the *bebionic* hand included the stability afforded by the compliant grips, the additional grip-pattern possibilities, and the reduction in gross body motion.

Cosmetic Appearance

Besides optimizing the function of the hand, the designers gave much consideration to cosmetic appearance. To achieve a functional and aesthetic hand, the articulations of the digits and the position of the joints in *bebionic* hands are optimized to naturally reflect the human anatomy. The silicone glove with enhanced surface detail works harmoniously with the hand, permitting full, unrestricted function. The result is a prosthetic hand that more closely resembles the natural form in both movement and appearance. A custom silicone glove is available, which incorporates fabrication techniques that layer different shades of silicone to give a natural translucent finish, similar to real human skin tissue. Skin pigmentation, freckles, and veins can be incorporated for an authentic finish.

Affordability

The *bebionic* project has been developed by a team that understands today's constrained financial healthcare environment. Great care has been taken to evaluate the financial needs of the market, both in the United States and globally, to deliver a product that may be supplied as part of regular clinical practice within existing reimbursement systems.

bebionic hands strike the perfect balance of innovative technology with lifelike appearance. An unprecedented range of

Figure 6: Custom Silicone: The silicone is colored before sculpting, as opposed to surface painting, to provide a natural, translucent finish, similar to real human skin tissue.

compliant grip patterns enables users to perform a greater number of everyday tasks quickly, repeatedly, and reliably. Affordability ensures *bebionic* hands can be available to as many potential users across the world as possible, not just a fortunate few.

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The Academy's Scientific Societies

Opportunities to Contribute Expertise and Get Involved

The Academy's scientific societies continue to grow, develop new programs and groups, and expand educational initiatives and knowledge-sharing. Opportunities abound in many different areas in which both new and long-standing members can contribute to and benefit from each Society. Besides sharing research and clinical knowledge, members with website and networking skills can put their expertise to work to develop and enhance the societies' websites and networking sites. For more details, see the specific information below for each Society. Visit the Academy's Society page for a complete list of Society officers. Academy Society officers may be contacted directly and are happy to answer any questions.

Fabrication Sciences Society

"We welcome input from clinicians, technicians, educators, manufacturers, and researchers," says Chair Glenn F. Hutnick, CPO, CTP, FAAOP. "Any professional with an interest in fabrication and its advancement is invited to join." Members can get involved by volunteering as an officer or committee member, submitting their fabrication techniques, preparing a fabrication presentation, helping to maintain the Fabrication Society website, or contributing to the development of standards of fabrication guidelines.

Society goals for 2012 include creation of regional technical continuing-education workshops, preparation of abstracts for the Academy meeting, submission of abstracts for presentation at Academy chapters, and development of a networking website.

Craniofacial Society

Although the main focus of the Craniofacial Society has been to improve communication among practitioners who treat infants with plagiocephaly, brachycephaly, and scaphocephaly with cranial remolding orthoses (CROs), one of its recent goals has been to expand into related craniofacial topics.

The Society recently sent out surveys on modifying techniques for producing a CRO to help gather information for its joint efforts with the CAD/CAM Society in developing guidelines for computerized modification.

Additionally, Society members are currently preparing an article covering fabrication techniques, materials, and treatment protocols for using custom facemasks in treating burns and traumatic injuries.

Other opportunities for involvement include working to boost communication on the Craniofacial networking website and blogging.

Gait Society

The Gait Society networking website has been very active with Journal Club and Discussion Forum posting at http://gait-society.ning.com/

The Gait Society offers opportunities for clinicians to become part of groups involved in the following projects: using a formal gait analysis form in evaluating a specific number of patients per week, reading and discussing a gait analysis textbook, integrating an outcome-measurement protocol into their practice, and developing case studies to be published on the Society's networking site.

The Gait Society is also pleased to announce its new slate of officers who are listed at www.oandp.org/membership/societies/gait. In addition to the officers listed, the new position of Academic Committee chair has been created. Justina Shipley, MEd, CO, BOCPO, FAAOP, will be filling this role, which will help to recruit speakers, generate ideas, and develop materials for publication.

Spinal Orthotics Society

The Spinal Orthotics Society aims to enhance spine-related learning opportunities and to share expertise among practitioners with a special interest in spinal orthotic management, explains Chair Catherine Voss, CO. "Whatever your strengths or interests, there is room for you to be more active." She adds that the society would like to develop its professional networking website as well as expand member research, presentations, and publications.

Lower-Limb Prosthetics Society

The Lower-Limb Prosthetics Society (LLPS) has added a new group, led by Michael Leach, CPO, focusing on elevated vacuum technology. The society encourages anyone with interest in the advancement of this technology to join in monthly discussions.

Sarah Thomas, CPO, is continuing to develop the pediatric program under the LLPS umbrella and recently published an article in *The O&P EDGE* with Deborah Wilde, MS, CPO, FAAOP, (www.oandp.com/articles/2011-04_03.asp), which focuses on working with children. Thomas is also the go-to person to submit articles for internal review before sending them to various publications for potential publication, thus increasing the possibility of publication, according to the LLPS.

2011–2012 Board of Directors

PRESIDENT
Mark D. Muller, MS, CPO, FAAOP, graduated from Stony Brook University, New York, with a bachelor's degree in material science and engineering. He completed his master's degree in instructional design and technology and is currently an instructor of prosthetic education with the California State University Dominguez Hills (CSUDH) Prosthetics and Orthotics program.

PRESIDENT-ELECT
Bruce "Mac" McClellan, CPO, LPO, FISPO, holds degrees in prosthetics, orthotics, and health administration. He received his prosthetic training at the Northwestern University Prosthetics-Orthotics Center (NUPOC), Chicago, Illinois. He is in private practice as president and owner of Prosthetic-Orthotic Associates of Texas, Tyler.

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Michelle J. Hall, CPO, FAAOP, received her bachelor's degree in biomedical engineering from the University of Iowa, Iowa City. She currently works at Gillette Lifetime Specialty Healthcare, St. Paul, Minnesota.

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Phil Stevens, MEd, CPO, FAAOP, graduated from the University of Washington (UW), Seattle, and received his master's degree in allied health education and administration from the University of Houston, Texas. He specializes in pediatric orthotics, lower-limb orthotics, and cranial remolding.

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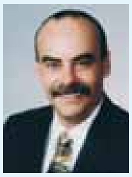
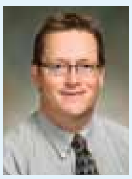
Scott D. Cummings, PT, CPO, FAAOP, graduated from Northeastern University, Boston, Massachusetts, with a bachelor of science degree in physical therapy. He completed his orthotic and prosthetic education at the University of California, Los Angeles (UCLA). He is currently employed by Next Step O&P, Manchester, New Hampshire, where he provides patient care in a private-practice setting.

DIRECTORS



Michael Allen, CPO, FAAOP, graduated from the New York University (NYU) O&P bachelor's degree program. He completed his clinical residency in orthotics in San Antonio, Texas, and his prosthetics residency in Ft. Smith, Arkansas. He is a second-generation practitioner and the clinical director of Allen O&P, Midland, Texas.

Kevin Carroll, MS, CP, FAAOP, has worked for more than 30 years as a practicing prosthetist, researcher, and educator. He is vice president of prosthetics for Hanger Prosthetics & Orthotics, a division of Hanger Orthopedic Group, Austin, Texas. He travels extensively, treating patients and managing clinics for unique and challenging prosthetics cases.



Don Cummings, CP, LP, is a graduate of the O&P education program at the University of Texas Southwestern Medical Center at Dallas, and also has a bachelor of science degree in generic special education from the University of Texas at Dallas. He has been the director of prosthetics at Texas Scottish Rite Hospital for Children, Dallas, since 1987.

Alicia J. Davis, MPA, CPO, FAAOP, earned her bachelor of science degree in healthcare administration and master's degree in public administration, healthcare administration, from the University of Michigan, Ann Arbor. She received her orthotics and prosthetics education at the Northwestern University Prosthetics-Orthotics Center (NUPOC), Chicago, Illinois. She is the residency program director at the University of Michigan Orthotic and Prosthetic Center (UMOPC), Ann Arbor, and maintains a full-time clinical practice.

David M. Gerecke, CPO, FAAOP, graduated from the bachelor's degree program at the University of Washington (UW), Seattle, in 1989. He is president and owner of Active Prosthetics and Orthotics, San Antonio, Texas.

M. Jason Highsmith, DPT, CP, FAAOP, completed the prosthetics program at the Northwestern University Prosthetics-Orthotics Center (NUPOC), Chicago, Illinois, in 2004. He is also a physical therapist in Tampa, Florida. He is jointly appointed as an assistant professor at the University of South Florida (USF), Tampa, and a prosthetic/amputee rehabilitation researcher at the Department of Veterans Affairs (VA) James Haley Patient Safety Center, Tampa.

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Hook Grip

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