HIGH-TECH HANDS

How advances in design and manufacturing are enabling a new paradigm for digit amputation care

Technological advances have given orthotic and prosthetic professionals a wealth of new options for helping patients with limb loss to regain function.[1] However, O&P practices have had far fewer options for patients who have experienced amputation of one or more fingers. Although digit loss is common, prosthetic solutions for this population have until recently been restricted largely to cosmetic devices with limited functionality.[2,3]

Finger and thumb amputations carry physiological, lifestyle and psychological effects, but anatomical and production challenges have impeded development of functional prostheses for these patients. Fortunately, advances in prosthetic technology, computer-aided design and manufacturing are bringing new options to this underserved population, equipping clinicians with effective solutions to help patients re-engage fully in their lives.[2,3,4]

PREVALENCE AND ETIOLOGY

In 2005, 1.6 million Americans were living with limb loss, with 35% of cases involving the upper limbs. Although lower-limb loss is heavily associated with chronic disease and old age, upper-limb loss most commonly afflicts working-age men, and it is almost exclusively secondary to trauma. Ninety-two percent of these traumatic upper-limb amputations involve loss of a finger or thumb. Altogether, 45,000 traumatic finger amputations are believed to occur in the US each year.[2,5]

Many of these injuries occur in the workplace, often involving machinery or powered hand tools. More than half of digit or partial-hand amputees are unable to continue their previous careers and may go on to become unemployed. Those whose work requires manual labor are particularly likely to leave their jobs after an injury. These changes carry lifestyle and psychosocial consequences for patients themselves as well as economic implications for society. [3,6,7,8]

Balaji Ram

A PATIENT'S VIEW

When Matthew Finney developed an infection after surgery to treat blood clots in his right arm, the loss of his thumb and portions of three other fingers was devastating. Facing major physiological changes as well as the psychological blow, Finney says he felt he had to start over in many areas of his life. And the amputations also severely restricted the cement mason's ability to work.

Finney underwent physical therapy and was fitted for a prosthesis, custom made by his clinician in an attempt to restore opposition. He tried returning to work with the device but found it bulky and ineffective. In the meantime, Finney says his injured hand and the response it got from strangers left him self-conscious and sometimes he avoided people.

A year after his surgeries, Finney's clinician obtained Naked Prosthetics devices for him, including an R1 MCPThumb, R2 MCPDriver, and an R4 PIPDriver. Within a month, Finney was fully back to work using both hands, continuing to regain strength and working toward being able to shake hands again. Adapting to the device was easy. "It works so well that I actually wear it pretty much all the time," Finney said. "I was amazed at what I could do. The more I do, the more I count on this like it's my real hand."

Finney says his hand still attracts attention, but the attention is positive. "It's done so much more for me than I thought it would — not just because of how I can use it, but the way it makes me feel about myself," Finney said.

UNDERSTANDING IMPAIRMENT

The physiological impairments associated with digit amputation are believed to have an impact on nearly every aspect of daily life. Even a relatively small partial amputation of a digit results in lower pinch and grip force and difficulty with everyday tasks, and these post-injury functional changes are an important factor in patient outcomes.[7,8]

Practitioners who work with amputees need to be able to assess and quantify the effects of impairment as part of patient care and documentation for payers. The American Medical Association's Guides to the Evaluation of Permanent Impairment is a commonly cited source that uses the percentage of digit loss to quantify impairment of the hand, upper limb function and whole body. The AMA Guides framework is an important, widely accepted tool for clinicians, who can use it to assess and convey the physiological magnitude of impairment to payers as part of efforts to secure reimbursement.

While the AMA Guides provide a straightforward, easy to calculate quantification of impairment based on anatomic loss, it should be noted that the guidelines underestimate the true impact of digit amputations. It is generally recognized that a combination of self-report functional and mental health measures best capture impact and recovery when it comes to upper limb amputation. Giladi et al. show that when this broad approach to health-related quality of life is applied, it shows greater levels of disability than the AMA approach can estimate.[5,8,9,10]

THE PROSTHETIC PARADIGM OF THE PAST

The variable anatomical and functional presentations of hand injuries as well as the small size of digits relative to their motor and sensory complexity pose a number of prosthetic design, engineering and production challenges. As a result, practical prosthetic solutions for patients with finger or thumb amputations have for many years been largely limited to cosmeses.[3]

Made of viscoelastic materials and designed to mimic the appearance of the missing portion of the digit or hand, cosmeses can yield tangible psychological benefits, such as reduced self-

consciousness and improved comfort with interactions involving hands. Cosmeses also can provide limited functional support, such as moderate stabilization when grasping. However, these functional benefits are minimal, and not all patients experience them. For the most part, cosmeses serve psychological purposes, but they are not a practical solution for most people who need restoration of function for work or other pursuits.[3,11,12]

EMERGING FUNCTIONAL DEVICES

Recent technological advances have enabled manufacturers to address some of the challenges of prosthetic design for digit amputees. A number of options are available for patients who want a more functional result, and the most robust devices even allow patients to return to work of virtually any type without worry that they will damage the device.

Battery-powered prostheses have advanced significantly in recent decades and have become available clinically. These motorized devices interact with signals from the user's residual limb to enable the patient to regain functional movement. However, extensive training is needed to help patients learn to use battery-powered devices. In addition, their high cost coupled with their lack of durability for practical use in a variety of environments limits their utility for some patients.[3,12]

Body-powered devices for partial hand amputation also allow users to regain functional movement through cable-, wrist- or finger-driven mechanisms, and these devices can be a more practical option.

Balaji Ram

CLINICAL PERSPECTIVES

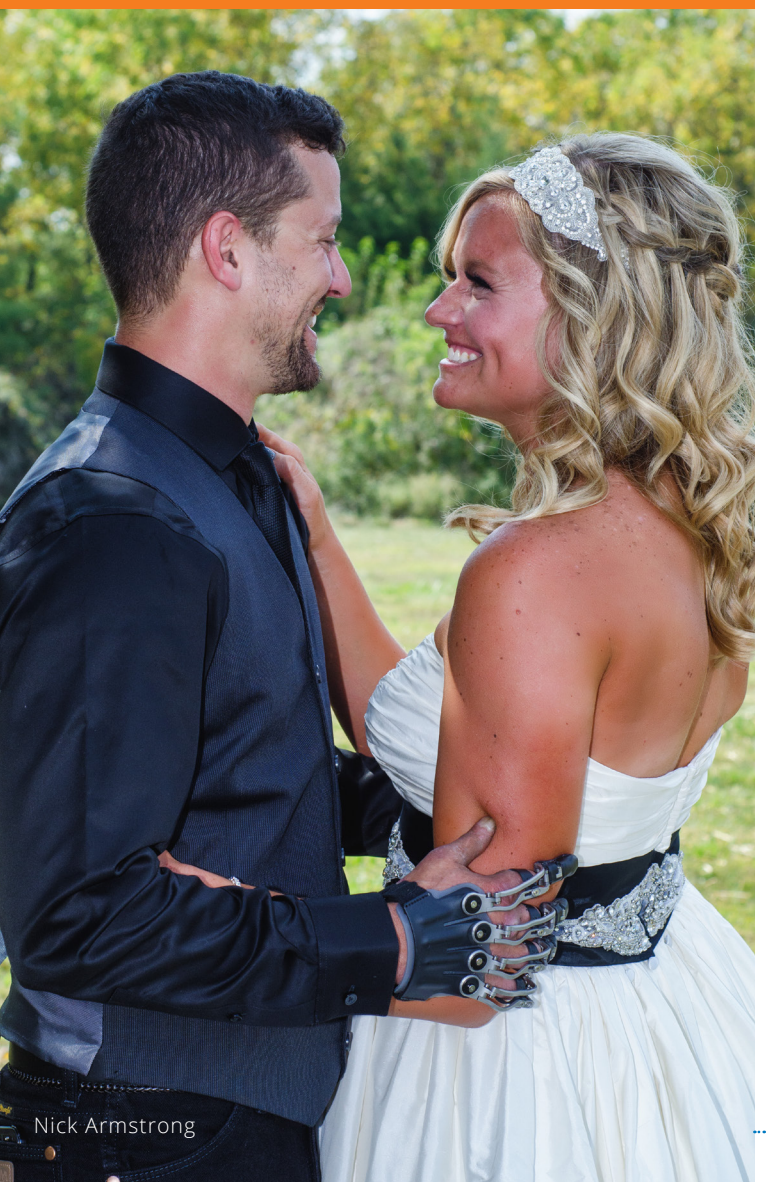
Aaron Sorenson, CPO, LPO, of Restorative Health Services says he spends most of his time working with lower-limb amputees, but he's handled enough finger and thumb cases to see that the impact of even relatively small amputations is significant. In addition to the clear physiological challenges of an amputation, Mo Kenney, CPO, LPO, FAAOP, of Kenney Orthopedics says he has seen patients struggling with feelings of shame, despair and in some cases unwillingness to spend time in public.

When Kenney approaches patients with partial-hand amputations who are candidates for a prosthesis, he looks at their history, career plans and lifestyle. "Our job as prosthetists is to try and return our patients to normalcy. That includes every aspect of life," Kenney said. "The impact of being able to grasp a fork or a soda or your phone — we take that for granted as able-bodied people."

After years of being able to offer only silicone and latex prostheses with limited function, Sorenson says access to body-powered functional prostheses has proved a game changer. Although variables including scar tissue, percentage of residual digit and neurological damage are important predictors of outcomes, Sorenson has seen patients regain what he called a surprising level of function with the newer devices. Kenney says the psychological benefits of a functional prosthesis are palpable the first time a patient begins to use it. "There are tears," he said. "Patients get their lives back when they get their prosthesis."

Sorenson has fitted a handful of Naked Prosthetics devices, a process he said was straightforward with a short learning curve. He secured reimbursement in each case, one through Tennessee's Medicaid program and the rest through workers' compensation plans. The Medicaid case was toughest to navigate, but Sorenson said a committed care team — including therapist, physician and prosthetist — plus resources and support from the manufacturer yielded success. Kenney also has had difficulty with third-party payers, but he says persistence usually pays off. "If you care about your patients, you really need to go the extra mile for them, and that includes not just clinical but also the financial as well," Kenney said.

> “There is no need for specialized training, and users report that with time, the prostheses begin to feel like an endogenous extension of the body.”



Nick Armstrong

Operated by the user through intuitive movement and powered by intact PIP or MCP joints, finger-driven prostheses can restore active grip and pinch force in many clinical scenarios. There is no need for specialized training, and users report that with time, the prostheses begin to feel like an endogenous extension of the body.[3,4,12,13]

The newest generation of high-durability, body-powered prostheses allows these devices to be used in welding, auto and woodworking shops, on farms and in other settings that place high physical demands on the prosthesis, helping working-age amputees return to their previous careers and hobbies. And advances in manufacturing technology have made these custom prostheses practical for use on a wide scale.

Research has validated the promise of this newest generation of durable body-powered prostheses, documenting improvements in fine motor dexterity and grip strength using the Minnesota Manual Dexterity Test and Jamar Hand Function Test as well as qualitative improvements, including reduced sensitivity and phantom pain, and increased confidence and ease associated with grasping.[4]

Case studies developed by manufacturer Naked Prosthetics yield additional quantitative as well as qualitative insights from users of the company’s body-powered prosthetic devices, including the psychological benefits that come with being able to return to work, regaining comfort in social settings and the ability to complete everyday tasks such as cutting food and tying shoelaces without help.

A BETTER APPROACH TO PATIENT CARE

The prevalence of finger and thumb amputation and the significance of these impairments in the lives of patients who experience such injuries warrant a better standard of care. Development of prostheses for this population has been impeded by technical and anatomical challenges, but a new generation of practical, durable, body-powered prosthetic digits can enable O&P practitioners to address an unmet need and transform the lives of people who have undergone finger amputation. ■

Joseph Yeske

LITERATURE CITED

1. Harvey, Z. T., Potter, B. K., Vandersea, J., Wolf, E. (2012) Prosthetic advances. Journal of Surgical Orthopaedic Advances. 21: 58-64.

2. Ziegler-Graham, K., MacKenzie, E. J., Ephraim, P. L., Travison, T. G., and Brookmeyer, R. (2008) Estimating the prevalence of limb loss in the United States: 2005 to 2050. Archives of Physical Medicine and Rehabilitation. 89: 422-429.

3. Imbinto, I., Peccia, C., Controzzi, M., Cutti, A. G., et al. (2016) Treatment of the partial hand amputation. IEEE Reviews in Biomedical Engineering. 9: 32-48.

4. Denham, S., Hawkins, T., Johnson, K., Rhoads, J., and Sims, S. (2017) The functionality of the biomechanical prosthetic finger when compared to standardized and nonstandardized assessments. American Occupational Therapy Association poster presentation.

5. Giladi, A. M., McGlinn, E., Shauvner, M. J., Voice, T. P., and Chung, K. C. (2014) Measuring outcomes and determining long-term disability after revision amputation for treatment of traumatic finger and thumb amputation injuries. Plastic and Reconstructive Surgery. 134: 746e-755e.

6. Chung, K. C., Kowalski, C. P., and Walters, M. R. (2000) Finger replantation in the United States: Rates and resources use from the 1996 Healthcare Cost and Utilization Project. Journal of Hand Surgery. 25: 1038-1042.

7. Burger, H., Mayer, T., and Marincek, C. (2007) Partial hand amputation and work. Disability and Rehabilitation. 29: 1317-1321.

8. Sagiv, P., Shabat S., Mann, M., Ashur, H., and Nyska M. (2002) Rehabilitation process and functional results of patients with amputated fingers. Plastic and Reconstructive Surgery. 110: 497-503.

9. Grunert, B. K., Smith, C. J., Devine, C. A., Fehring, B. A., Matloub, H. S., et al. (1988) Early psychological aspects of severe hand injury. Journal of Hand Surgery. 13: 177-180.

10. Shanmuganathan, N, Maheswari, M. U., Anandkumar, V., Padmanabhan, T. V., Swarup, S. et al. (2011) Aesthetic finger prosthesis. Journal of Indian Prosthodontic Society. 11: 232-237.

11. Pilley, M. J. and Quinton, D. N. (2016) Digital prostheses for single finger amputations. Journal of Hand Surgery. 24: 539-541.

12. Lake, C. (2004) Partial hand amputation: Prosthetic management. pp. 209-217 in Atlas of Amputations and Limb Deficiencies – Surgical, Prosthetic and Rehabilitation Principles.

13. Naked Prosthetics. (2017) Prosthetist/Therapist. Retrieved October 9, 2017 from http://www.npdevices.com/prosthetisttherapist

“Patients get their lives back when they get their prosthesis.”

IT’S ALL ABOUT FUNCTION.

Naked Prosthetics, located in Olympia, Washington designs and manufactures custom prosthetic devices specifically for finger loss or amputation. Our mission is to assist people with finger amputation(s) and to positively impact their lives with functional high-quality finger prostheses. Our devices aim to restore the user’s ability to perform most daily tasks, supporting job retention and an active lifestyle.

sponsored by

NAKED PROSTHETICS

Learn more:
www.npdevices.com