ADDRESSING PARTIAL-HAND AMPUTATION

Most upper-limb amputations are traumatic in origin, and 94 percent of them occur at the fingers and metacarpals.[1,2] In fact, for every traumatic transradial amputation, there are 31 amputations distal to the wrist.[2] Given that the hand itself accounts for a full 90 percent of the function of the arm,[3] it's no wonder that people with partial-hand amputations experience similar rates of loss of work to those reported for levels above the wrist.[4] So why is reimbursement for partial-hand prosthetic intervention routinely and unceremoniously denied as a matter of written policy? This strict denial carries the implication that payers either do not believe this population is sufficiently impaired to warrant coverage or that there are no effective functional interventions. This article will make the case for changing this outdated approach to providing coverage by describing the impact of this type of injury. It will also describe the groundbreaking solutions that Naked Prosthetics provides to help get those affected back to work and their lives.

The average American takes around 6,000 steps in a day and makes about 7,200 hand grasps.[5] Damage or pain in a foot would almost certainly disrupt your life, and this is even more true for your hands. Our motor system's control over the 27 bones and 23 degrees of freedom that make up our hands is so finely tuned that we often don't notice how extensively we rely on its exquisite coordination until we no longer have it. One small loss of part of a finger can forever alter your ability to sort your mail, play an instrument, do your job, or even dress yourself and cut your food. A seemingly minor anatomic loss results in both psychological and functional impairment that can be quite devastating. The impact increases with the involvement of more digits or more proximal amputations.[4,7,8]

In the world of Labor & Industries Workers' Compensation insurance, disability and compensation after amputation are rated based on the American Medical Association *Guides to the Evaluation of Permanent Impairment.*[3] This rating system, based simply on anatomic loss, is straightforward to use. A clinician can easily calculate hand, upper-limb, and whole person impairment in a letter of medical necessity to support a prosthesis. Giladi et al. found that the *Guides* correlate well with validated outcome measures concerning function and anatomic loss. However, they also found that the *Guides* fall short in capturing mental health and psychosocial impacts after a disfiguring hand injury,[7] and therefore tend to underestimate true impairment levels.

When we are in good health, we rarely consider the contribution of our hands to our body image. Our hands and faces are what we present to the world to be seen, and our hands serve an important role as communication tools. Disfigurement of the hands can cause profound changes to an individual's sense of well-being in the world. It can lead to social ostracization, agoraphobia, problems with routine interactions, and a psychological conflict between body image and what the ego maintains as ideal.[6] Up to 94 percent of individuals with mutilating hand injuries experience symptoms associated with stress and anxiety disorders, major depression, pain syndromes, and adjustment problems,[6] and these problems often do not resolve with time. In addressing disfigurement and loss in the partial-hand population, appearance and restoration of body-image confidence are paramount.

While a silicone cosmesis can go the distance in restoring body image, these prostheses do little in the line of providing function. The majority of partial-hand amputations occur in workplaces where manual labor is performed. These injuries are caused by machinery, power tools, crushing, and stab wounds.[9,10] Burger found that 75 percent of heavy manual laborers with partial-hand or finger amputations were unable to return to their jobs,

with 26 percent of them leaving the workforce entirely.[4] Given that the population of people with partial-hand amputations is mostly working-age men whose jobs entail manual labor, the ideal intervention would provide relief both functionally for return to the workforce and psychosocially to resume a healthy emotional life. Imbinto asserts that restoring opposition, while providing enough grasping force and aperture width, is the most important functional target for partial-hand interventions.[9] To address the substantial psychological impact,[6] any intervention for the hands also must be appealing and enhancing to the appearance.

Finding a Solution

Although fingers are the primary site for amputation injuries, technology has struggled to provide relevant solutions. The combination of a small envelope, high dexterity, and high strength makes designing replacement digits a tremendous challenge. The advent of advanced manufacturing has shifted the paradigm and broken open this age-old problem. Finally, there are robust functional solutions on the market.

Naked Prosthetics provides mechanical, body-powered fingers that are custom-designed for each impacted digit's specific anatomy. The fingers restore natural motion, dexterity, and strength to people with amputations who have a small amount of phalanx remaining to drive them. While 3D printing has democratized design in many ways and led to rapid turnaround on virtually any design, ultimately there is no replacing classical engineering for end-use products. Naked Prosthetics is unique in that it has brought together experienced mechanical and biomechanical engineers from backgrounds as diverse as aerospace, robotics, prosthetics engineering, and product development to collaborate with clinicians and patients on developing the most effective technical solutions possible. Because of our engineering strength, our solutions are kinematically and kinetically optimized to take maximum advantage of the capabilities of the patient's driving joints and the mechanisms used to transfer force from existing anatomy to artificial.

Engineered for Strength

Naked Prosthetics currently provides three products: the PIPDriver, the MCPDriver, and the ThumbDriver. The ThumbDriver is unique in that it is anchored to and driven from both the carpometacarpal (CMC) and the metacarpophalangeal (MCP) joints, with the thenar eminence tracking capability providing the most function. As with any anatomical joint, there are angular ranges throughout flexion/extension in which each joint experiences its maximum moment-generating capability. The factors influencing this peak force range include pretension on the tendons, muscle body engagement, and, for the hand, the posture of the surrounding anatomy. The combination of the hand joints with four-bar linkages, which is what we use in our devices, provides a powerful opportunity for engineering optimization. A four-bar has an interesting property: Its kinematics change throughout its trajectory. Sometimes its "throw" is very fast, and sometimes it is very slow. Given that speed and force are inversely related in force systems, it becomes imperative to consider peak joint moment generation ranges alongside four-bar kinematics. Done correctly, this allows a patient to have maximum four-bar leverage at his or her maximum joint moment-generation capability. The evolution/design of our anatomic hands ensures that this range lines up perfectly with our most common hand grasps. Our devices are thoroughly optimized for the anato-mechanical combination that they are. This is why a Naked Prosthetics user can get up to two-thirds input force (~10–12 lb. for the MCPDriver) out at the fingertips of our devices, and why our devices are often used for 12–16 hours per day on hard-labor jobs.

Naked Prosthetics' goal is to change the harsh reality facing individuals after these all too common injuries and ensure that no one loses his or her vocation as a result. Our team works daily to innovate in a space where much innovation is needed and where technology has not yet lived up to its promise. We deliver solutions than can handle the load.

References are available at www.oandp.org/page/ATcurrent.

KT Treadwell
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NAKED PROSTHETICS

It's all about *function.*

Fully Custom *— Each device is custom designed to within millimeters of a patient's unique amputation and hand structure.*

We offer three functional custom designed prostheses.

MCPDriver™ | Gen 2

The **MCP**Driver is a functional finger prosthesis custom designed for amputees who have suffered a finger amputation in their proximal phalanx.

CANDIDATE SPECIFICATIONS

This device is driven by an intact MCP joint with enough residuum to engage the ring. Output is dependent on patient range of motion and strength.

6 week lead time once all documention is received.

PIPDriver™ | Gen 2

These unique devices articulate freely and progressively with the residual finger.

CANDIDATE SPECIFICATIONS

This device is driven by an intact PIP joint with enough residuum to engage the ring. Output is independent on patient range of motion and strength.

4-6 week lead time once all documention is received.

ThumbDriver™

This prosthesis is designed to restore length, articulation, and function to persons with a partial thumb amputation distal to the MCP joint.

CANDIDATE SPECIFICATIONS

This device is driven by intact MCP and CMC joints in the thumb. However, patients with more proximal amputations will still benefit from the device as long as their stump can enage the suspension. Output is dependent on patient range of motion.

6 week lead time once all documention is received.

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