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Prosthetic Limbs: A New Hope of Life by Robotic

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Abstract - *In today's society, over one million limbs are amputated each year due to accidents, war casualties, cardiovascular disease, tumors, or congenital anomalies. Robotic prosthetic limb is a well-established research area that combines advanced mechatronics, intelligent sensing, and control to achieve higher order lost sensorimotor functions while preserving the physical appearance of the amputated limb. Robotic prosthetic limbs are expected to replace an amputee's missing limbs, restoring lost functions and providing an aesthetic appearance. The main benefits are improved social interaction, a more comfortable amputee life, and a more productive amputee in society. Significant contributions have been made in this area in recent decades as sensor technology has advanced. Much of the work is still in the research stage, and more research and development work is expected in the coming years, with the ultimate goal of producing a device capable of producing human-like motions.*

1.INTRODUCTION*)*

Upper limb absence (ULA) can occur as a result of surgery, trauma, disease, or as a congenital condition. Regardless of the cause, it is common for the physiatrist to lead a multidisciplinary team of practitioners in the care of people with ULA. While the primary goal of care is to help patients understand and access prosthetic options, there are frequently other health factors and issues to consider. The rehabilitation process starts with educating the individual with ULA and their caregivers and encouraging them to actively participate and collaborate with team members to establish goals, research prosthetic options, and make decisions [1].

Prevalence and Incidence

Amputation is the surgical removal of all or part of a limb or extremity, resulting in the amputation of a limb. Some people are born with congenital limb absence or difference, so not all limb absence is acquired. As a result, the population can be referred to as "individuals with limb absence" (LA). There are approximately 2 million Americans with LA (1:200 people); an additional 28,000,000 people are at risk of amputation. Every year in the United States, approximately 185,000 people are amputated. The number of people living with limb loss is expected to more than double by 2050, owing primarily to the rise in vascular disorders [3,4, 5]. Lower limb absence (LLA) outnumbers upper limb absence (ULA) by a factor of four. Upper extremity amputation affects approximately 41,000 people, or 3% of the Los Angeles population. Increased workplace safety awareness and changes in workforce patterns may both contribute to lower rates. for traumatic amputations of the upper extremity According to current data, trauma-acquired upper limb loss occurs at a rate of 3.8 per 100,000 people. The most common type of trauma-related upper limb amputation (2.8 per 100,000) is loss of digits, particularly a single finger [6, 7]. Following this, acquired loss at the trans-radial (47%) and trans-humeral (25%) levels is the next most common level of upper limb amputation, with elbow disarticulations being the least common (2.1 percent) [7]. Congenital upper limb difference affects about 1500 (4 out of 10,000) infants in the United States and can cause longitudinal and/or transverse deficiencies [8, 9]. Longitudinal deficiency is characterised by the absence or shortening of a bone, such as the radial clubhand. Transverse deficiency manifests as the total or partial absence of bony segments; a common example is a trans-radial congenital difference, which lacks the forearm, wrist, and hand. Congenital absence accounts for approximately 90% of the paediatric population; acquired loss accounts for approximately 10% of the paediatric population. As the congenitally involved population ages, this ratio shifts so that only 10% of upper extremity absences are congenital by adulthood. Unfortunately, there is a paucity of research that follows these children into adulthood, particularly in terms of prosthesis use, satisfaction, and challenges to optimal function [5, 6, 10]. This is an excellent example of how physiatrists who are familiar with human development might use a life course health development model to influence the plan of care.

Care Challenges

According to national and global health initiatives, specific attention from health care and public health professionals is required to address population needs and prevent further disparities [11, 12, 13]. Members of this group face specific issues such as loss, pain, and isolation, as well as understanding prosthetic technology and its control, and accessing technology.

Specialized Treatment

It is critical that people with ULA receive specialised care for the multifaceted challenges they face. Unfortunately, many people with ULA find it difficult to obtain specialised care. Individuals with ULA frequently require specialised training that most generalist clinicians do not have. Individual needs dictate the course of intervention and outcomes for people with ULA. Regardless of the unique patient/client factors, optimal outcomes necessitate the expertise of a specialised collaborative inter professional team: individuals from various disciplines who collaborate, contribute knowledge, skills, and experiences to provide optimal care. Communication and collaboration must extend beyond the various institutions for which practitioners work. A collaborative inter professional team for ULA often includes surgeons, physiatrists, nurses, prosthetics, occupational therapists, physical therapists, vocational rehabilitation counsellors, social work- ers, case managers, and, in some cases, life care planners [14, 15, 16, 17]. A physiatrist, specializing in physical medicine and rehabilitation, is knowledgeable about the developmental, physical, and psychosocial processes and the resources needed for optimal outcomes. Sheehan and Gondo reported on the effect of limb loss in the USA, stating that each well-trained member of the specialized amputee rehabilitation team has a specific and important role in the care and recovery of people with limb loss.

The Effects of Loss

Regardless of the level of loss, the presentation, or the aetiology, the impact on social and physical function can be devastating to the individual and/or family [18, 19, 20, 21, 22, 23]. David Crandell, MD, Medical Director for the Amputee Program at Spaulding Rehabilitation Hospital in Boston, stated recently that it is critical for practitioners to remember that "limb loss does include loss." Even with the best technology, we must include psychological support for those who have suffered a loss. We need to shift the momentum in order to help people and their families see limb loss as a new beginning rather than an end point. I tell people that an amputation shapes you but doesn't define you."

Pain

Individuals with ULA are more likely to experience pain from a variety of causes. Overuse syndrome, phantom pain, neuromas, and heterotopic ossification are examples of these. Individuals with ULA, whether congenital or acquired, are at risk of experiencing sound side overuse. Pain and deteriorated musculoskeletal function of the sound arm have been well documented in individuals with unilateral or bilateral ULA [18]. Gambrell documented the importance of preventing overuse syndrome and advocated for a team approach, with practitioners responsible for educating patients about the possibility of overuse and methods that impede development. Secondary conditions have an impact on both physical and mental health; standard medical treatments frequently exclude psychosocial interventions [28].

Advancements

Recent advances in various forms of technology and techniques have aided in addressing the challenges faced by this population, thereby improving patient/client care and outcome.

Management of Pain

Individuals suffering from ULA may suffer from a variety of pain issues, including neuromas and phantom pain. Phantom pain affects 80 present of people who have lost a limb. It is common for a person to experience pain in the phantom limb shortly after a loss, which gradually fades [3]. In the acute postoperative phase, intervention for phantom sensation and pain is implemented [2, 7, 29]. Active participation in functional tasks, gentle massage, prosthetic wear, transcutaneous electric nerve stimulation (TENS), and mirror therapy are examples of interventions .

Targeted muscle re- innervation and osseointegration are surgical techniques that may reduce pain and improve prosthetic control and function. These procedures have the potential to influence the future course of intervention, outcomes, and prognosis, and are commonly thought to achieve better functional outcomes [22, 33, 34, 35].

A severed or injured nerve attempts to regenerate, which can result in a painful neuroma. TMR (targeted muscle re-innervation) is a procedure performed during or after amputation to provide nerve endings with a new host muscle to innervate in a way that does not cause a neuroma or phantom limb pain. TMR can improve a person's ability to use and control some prosthetic technology by employing a pattern recognition concept .

Osseo integration is a significant advancement in amputation surgery in which an artificial implant is surgically anchored and integrated into the bone, which then grows into the implant. The procedure provides a direct skeletal connection between natural bony anatomy and prosthesis extension. Osseo integration improves mobility and proprioception (Osseo perception), reduces nerve pain, and eliminates common problems associated with fitting the residual limb into a socket, according to research [35].

Technology

In numerous ways, technology has advanced care for people with ULA.

1.Materials and components for prosthetics

New materials, such as silicone, and processes, such as additive manufacturing, have influenced prosthetic user options at every level. Passive functional aesthetic devices are static prostheses that resemble a hand and serve various functions such as stabilising, supporting, and improving cosmesis. Advances have resulted in more lifelike appearances, allowing users to blend in more easily and often improving self-esteem and

quality of life. More durable materials have aided in the development of activity-specific devices that can withstand more strenuous activities or harsh environments. Similarly, the use of softer silicones, air bladders, and temperature control systems results in more comfortable sockets for various types of prostheses. The control of the body-powered prosthesis has been improved with newer harnessing materials, and even the harness has been eliminated through the use of adhesives. Pattern recognition has improved externally powered prosthesis control, requiring a set of myoelectric signals corresponding to possible prosthesis movement to be recorded and used to calibrate the control system . It has also been enhanced by radio-frequency identification (RFID), a wireless communication system that typically consists of an RFID reader and a tag. The tag has information stored in its memory, which the reader (via an antenna) can read.Additive manufacturing, or 3-D printing, is another option for prosthesis users. This is a three-dimensional device that replicates a prosthesis. It is made using computer-aided manufacturing (CAM). Such devices are less expensive and typically less durable, necessitating more frequent replacement, and are not covered by health insurance[36,37] .

3- DATA

Outcome measures that accurately assess areas of concern to key stakeholders are critical for determining efficacy and facilitating access to specialised healthcare, technology, and reimbursement for such services. With the ability to create and collect data, technology has influenced patient care by interpreting function, frequency of use, satisfaction, and quality of life. Data collection to various repositories, such as search engines and even the "cloud," provides practitioners with evidence on which to make informed decisions to guide care and justify it for insurance authorization and reimbursement. This technological advancement also allows individuals with ULA to access more than one type of prosthesis because data on functional outcomes, prosthesis use, and satisfaction are more readily available. People's lives are complicated, with multiple roles and responsibilities, and no single prosthesis can accommodate the multiple functions of the natural body hand. Different prosthetic technologies can enable the user to live fully while protecting the remaining anatomy from overuse. According to Blair Lock, CEO of Coapt Engineering, there are now various types of data collection and computing analysis. This is important because the "cloud" can crunch the data and distribute it to practitioners for patient care. The data explains "what we need to know, why we need to know it, and how we can use it for better patient outcomes, incorporation into daily life, and product development." The data becomes more authentic, valuable, and reliable.

4-Telehealth

Individuals with ULA frequently report receiving little to no information about preventing secondary conditions from medical professionals [3]. These people are frequently invited to peer support groups for education, engagement, and empowerment; however, because the groups are frequently dominated by people with LLA, they do not return[38]. This results in even more isolation and a lack of information. Telehealth provides a remote pathway for practitioners to collaborate and consult with one another, as well as access to specialized practitioners and peers for individuals with ULA . Hewitt et al. recently discussed how COVID-19 has catalyzed virtual health care for people who have lost limbs. Among the topics mentioned are surgical decision-making, wound monitoring and peripheral vascular disease, and postoperative care. Among the topics mentioned are surgical decision-making, wound and peripheral vascular disease monitoring, postoperative care, prosthetic training, residual limb care, pain management, and psychosocial needs. Natural disasters, wars, conflicts, and even pandemics have all resulted in technological advancement and utilisation in the past.

Conclusion

Managing a person's health with ULA is a strategic and complex task. In addition to understanding the missing limb(s), the provider must be aware of the impact on other anatomy, both in its current state and projected for the future over the life course. The rehabilitation team should be aware of and understand the

individual's reaction to limb absence, as well as the psychosocial aspects, which may include changes in self-image and body image, acceptance of the residual limb, and feeling comfortable in society as a person with limb absence. Health care providers should facilitate and reinforce good communication with the client centred health care team, allowing the individual patient to be an active stakeholder in the plan of care's development. Health care practitioners cannot be expected to know everything, but working with an inter professional team will help providers become more aware of resources and advancements, as well as make appropriate referrals to improve patient health, function, satisfaction, and quality of life.

References

1.Melton DH. Physiatrist perspective on upper-limb prosthetic options: using practice guidelines to promote patient education in the selection and the prescription process. Journal of Prosthet- ics and Orthotics. 2017;29(4S):P40–4.
2.Amputee Coalition of America (ACA). Resources [Internet]. Amputee coalition. Available from: https://www.amputee-coali tion.org/resources
3.Atkins DJ, Heard DCY, Donovan WH. Epidemiologic overview of individuals with upper-limb loss and their reported research priorities. Journal of Prosthetics and Orthotics. 1996;8(1).
4.Varma P, Stineman MG, Dillingham TR. Epidemiology of limb loss. Physical Medicine & Rehabilitation Clin N Am. 2014;25(1):1–8.
5.Ziegler-Graham K, MacKenzie EJ, Ephraim PL, Travison TG, Brookmeyer R. Estimating the prevalence of limb loss in the United States: 2005 to 2005. Arch Phys Med Rehabil. 2008;89(3):422–9. Available from: https://www.sciencedirect. com/science/article/pii/S0003999307017480
6.Braza DW, Yacub Martin JN. Upper Limb Amputations. In: Essentials of physical medicine and rehabilitation: musculoskel- etal disorders, pain, and rehabilitation. Philadelphia, Pa: Elsevier Saunders; 2015.
7.Centers for Disease Control and Prevention. Facts about upper and lower limb reduction defects [Internet]. Centers for Disease Control and Prevention. 2020. Available from: https://www.cdc. gov/ncbddd/birthdefects/ul-limbreductiondefects.html
8.Le JT, Scott-Wyard PR. Pediatric limb differences and amputa- tions. Phys Med Rehabil Clin N Am. 2015;26(1):95–108.
9.Home of the Office of Disease Prevention and Health Promotion-health.gov [Internet]. Health.gov. 2019. Available from: https:// health.gov/
10.Institute of Medicine. The national prevention council: bring- ing federal agencies together to build health and resilience in Americans. In: Cross-sector responses to obesity: models for change [Internet]. National Academies Press (US); 2015. Avail- able from: https://www.ncbi.nlm.nih.gov/books/NBK305199/
11.World Health Organization. Health Promotion and Disease Pre- vention. who.int.

12.Carroll K, Edelstein JE. Prosthetics and patient management : a comprehensive clinical approach. Thorofare, Nj: Slack Inc; 2006.
13.Armstrong J. The benefits and challenges of interdisciplinary client-centered goals setting in rehabilitation. New Zealand Jour- nal of OT. 2007;55(1):20–5.
14.Brouwers M, Roeling I, Van Wikjk I, Mooibroek-Tieben E, Harmer-Bosgoed M, Plettenburg D. Development of a test prosthesis: an important tool in the decision making process in providing patients with an upper limb prosthesis. In 2014.
15. Donaghy AC, Morgan SJ, Kaufman GE, Morgenroth DC. Team approach to prosthetic prescription decision-making. Curr Phys Med Rehabil Rep. 2020;8(4):386–95. (Findings from this arti- cle speak to informed patient care and optimal outcomes via a collaborative interprofessional practice approach.)
16.Malone J, Fleming LL, Roberson J, Whitesides T, Poole JU, Sternstein-Grodin R. Immediate, early, and late postsurgical management of upper-limb amputation. J Rehabil Res Dev. 1984;21:33–41.
17.Esquenazi A. Amputation rehabilitation and prosthetic restora- tion. From surgery to community reintegration. Disabil Rehabil. 2004;21(6):831–6.
18.Bradbury E. The psychological and social impact of disfigure- ment to the hand in children and adolescents. Dev Neurorehabil. 2007;10(2):143–8.
19.Saradijian A, Thompson A, Datta D. The experience of men using an upper limb prosthesis following amputation: posi- tive coping and minimizing feeling different. Disabil Rehabil. 2009;30(11):871–83.
20.Quinn M, Mahat G. Congenital upper limb deficiency: a case report. Contemporary PEDS Journal. 2019;36(3).
21.Crandall, David (Medical Director for the Amputee Program: Spaulding Rehabilitation Hospital, Boston; Member of the MGH ICAN Clinic, Interdisciplinary Care Amputee Network; Direc- tor, Amputee Rehabilitation Fellowship Harvard/ Walter Reed Army Medical Center Assistant Professor, Harvard Medical School). Personal Interview.
22.Burger H, Vidmar G. A survey of overuse problems in patients with acquired or congenital upper limb deficiency. Prosthet Orthot Int. 2015;40(4):497–502.
23.Michael J, Bowker J. Atlas of amputations and limb deficiencies. 3rd ed. American Academy of Orthopaedic Surgeons; 2016.
24.Meier R, Weed R. Life care planning and case management handbook. 2nd ed. CRC Press LLC; 2005.
25.Frossard LA. Can osseointegrated prosthetic attachment revo- lutionise the world of prosthetics: The truth and nothing but the truth.
26.Latour D. Ipsilateral scapular cutaneous anchor. International Society of Orthotics, 13th Annual Congress; 2007 Aug 3.
27.Hill W, Kyberd P, Norling Hermansson L, Hubbard S, Stav- dahl Ø, Swanson S. Upper limb prosthetic outcomes measures (ULPOM): a working group and their findings. JPO Journal of Prosthetics and Orthotics. 2009;21(9):69–82.
28.Kerver N, van Twillert S, Bongers R, van der Sluis C. User- relevant factors that determine choices for type of prosthesis and type of prosthesis control. In 2020. Findings from this article offer insight to the care continuum for the population.
29.Baun K, Miguelez J, Conyers D. Innovative outcome measures for upper limb prosthetic rehabilitation. In 2020.
30.Latour D. Improving outcomes for persons with congenital limb absences. Academy Today. 2020;16(4):11–3.
31.Wright V. Prosthetic outcome measures for use with upper limb amputees: a systematic review of the peer-reviewed lit- erature, 1970 to 2009. Journal of Prosthetics and Orthotics. 2009;21(9):3–63.
32.Zhang X, Baun KS, Trent L, Miguelez J, Kontson K. Under- standing the relationship between patient-reported function and actual function int he upper limb prosthesis user population: a preliminary study. Arch Rehabil Res Clin Transl. 2021;3(3).
33. Latour D. Unlimbited wellness: telehealth for individuals with upper-limb difference. Journal of Prosthetics and Orthotics. 2019;31(4):246–56. (This article explores the experiences of persons with upper limb absence and offers a relevant con- temporary solution.)
34. Hewitt MA, Smith DG, Heckman JT, Pasquina PF. COVID- 19: a catalyst for change in virtual health care utilization for persons with limb loss. Physical Medicine & Rehabilitation. 2021;13(6):637–46. (Findings from this article guide the care of individuals with upper limb absence.)
35.Pylatiuk C, Schulz S, Döderlein L. Results of an internet sur- vey of myoelectric prosthetic hand users. Prosthet Orthot Int. 2007;31(4):362–70.
36.Jang CH, Yang HS, Yang HE, Lee SY, Kwon JW, Yun BD, et al. A survey on activities of daily living and occupations of upper extremity amputees. Ann Rehabil Med. 2011 Dec1;35(6):907–21. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3309384/
37.Mc Guinness D, Atkins D. Demographic differences in the upper limb prosthetic rehabilitation experience. MEC20 Symposium [Internet]. 2020 Jul 23 [cited

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38.Corathers C, Janczewski M. The orthotic and prosthetic pro- fession: a workforce demand study [Internet].2006.Availablefrom:http://ncope.net/assets/pdf/final-report-publishing_3-07. pdf?20170104