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Uses of Prosthetics for Improving Quality of Life: A Basic Review

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Abstract: ***Prosthetics, the artificial devices designed to replace or augment missing or impaired body parts, have played a pivotal role in enhancing the quality of life for individuals. Over the years, advancements in prosthetic technology have led to remarkable improvements in functionality, comfort, and aesthetics. These innovations have not only restored mobility but have also significantly impacted the overall well - being and quality of life for millions of people worldwide. Justification: The article on the use of prosthetics for improving quality of life provides a comprehensive overview of the positive impact these devices have on individuals. It delves into how prosthetics restore functionality, independence, and mobility to those who have experienced limb loss or impairment. The piece emphasizes the psychological, social, and physical benefits, showcasing how these devices not only aid in daily activities but also contribute significantly to emotional well - being and societal integration. Overall, it's a valuable resource underscoring the transformative role prosthetics play in improving the lives of many. Result: The article highlights the transformative impact of prosthetics on enhancing quality of life. It discusses technological advancements, personalized solutions, and the emotional benefits for individuals. Overall, it underscores the profound positive effects of prosthetics in improving mobility, restoring functionality, and fostering independence for people with limb loss or disabilities. Materials and methods: This article was written after collecting required a systematic literature search using databases like PubMed, Indian j Plast Surg, JSTOR, Science direct, Google Scholar, NCBI and academic journals. It also Included studies examined the impact of prosthetic devices on quality of life in individuals with limb loss or impairment and it also include" Technology for monitoring everyday prosthesis use (Chadwell 2020) ", "Implementation of 3D printing technology in the field of prosthetics: Past, present and future" (Mareno 2019), " Technological advances in prosthesis Design and rehabilitation following upper extremity loss" (Bates 2020), " Acost - effective prosthetic leg: design and development " (Hogue 2022), " Prosthetic Rehabilitation in the lower limb " (O'Keeffe & Rout 2019). Objective: Role of prosthetics in enhancing daily functionality and restoring independence for individuals.***

Keywords: Impact of Prosthetics, restoring Sensation, psychological reactions, return to daily life, future of prosthetics.

1. Introduction

The World health organisation provides a global estimate of 35 – 40 million people who required prosthetics [1] (Chadwell et al., 2020) and recent technological and surgical advances have begun to shape prosthetic design and the lives of those who wear them like myoelectric sensors (fig: 1), osteointegration and targeted muscle reinnervation. (fig: 2) [2 - 5] (Bates et al., 2020).

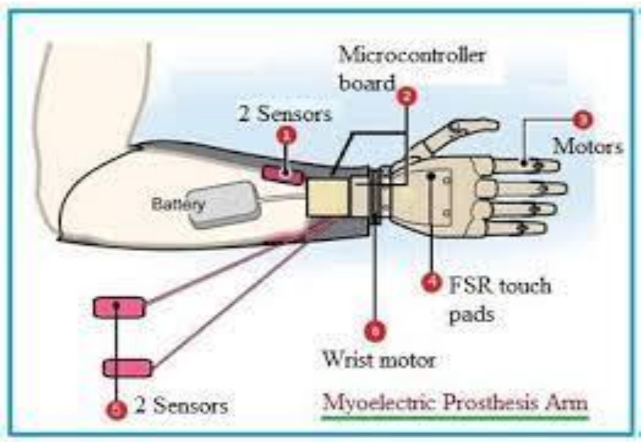

Figure 1: Myoelectric arm

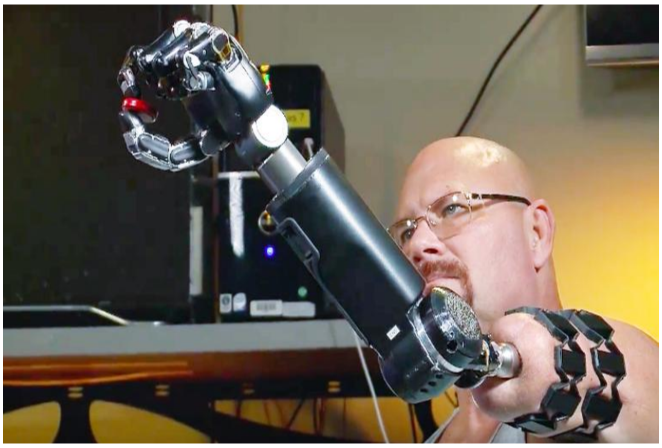

Figure 2: Targeted muscle reinnervation

Millions of people have been affected by limb loss (fig 3), but recent studies by World Health organization indicate that only 10% of those have access to prosthetic care [6 - 7] (Smith 2021)

Prosthetics has continued to develop across the world throughout course the course of history dated back to the ancient Egyptian and Roman empires and also in the late 1800s, John Hanger's prosthesis which is called as the hanger limb [8] (Manero et al., 2019). Prosthetics were known to be ancient technology and replacement body parts and also have a long inventive history following those early design, prosthetic improved by leaps and bounds, world war

I and II, as well as other large - scale conflicts unfortunately increased demand for prosthetics. [9 - 10] - (Donald., 2017)

A prosthesis is a blessing for the amputee patients, which can help them to live happily and it allows amputees to go about their regular lives as normal persons [11] (Hogue et al.,).

Amputation surgery is often considered simple with predictable outcomes; nonetheless amputations are troubled with high risk of consequential complications, among traumatic amputees, 51 % suffer from anatomical sequelae, 63% suffer from one or more skin problems, around 70% amputees develop phantom limb pain (PLP) or residual limb pain (RLP) and 14.5 % of traumatic lower limb amputees and 25 – 56% amputees develop social problem [12 - 16] (Hobusch et al., 2020).

Data from census 2011 states that there are 5, 436, 000 with locomotor disability in India and major cause of amputation is trauma [17 - 18] (Bernard O Keefe and Shraddha Rout) and in India official statistics indicate that 2.2% of general population are people with disability [19] (Ghosh et al., 2019).

India famed Jaipur foot (fig: 3), artificial limbs manufacturing corporation of India (ALIMCO) are mainly useful for the masses and at AIIMS Delhi, 129 patients got prosthetic limbs in 2022 and 135 in 2021 and the quality of prosthetics has really improved [20] (Jaiswaland Ghosh 2023). India has more than half million amputees, with ten of thousands added tothe amputee population every year [21] (Deraj., 2019).

Figure 3: Jaipur foot

Technological integration of artificial intelligence and machine learning in the field of assistive technology has become boon for persons with disabilities as because it aids for simulating various anatomical and biochemical functions of the lost parts of the human body i. e., electronic circuitry, software robotics, etc. to develop devices like bionic leg (fig: 4) and human is the most intelligent creature in the planet for their brain power and neural network. The human brain is extremely complex with more than 80 billion neurons and trillion of connections [22] (Nayak and Das., 2020)

Figure 4: Bionic leg

Artificial intelligence and machine learning is key that allow amputees to move their prosthesis intuitively (NISO 2020). AI is fuelling smarter prosthetics than ever before as prosthetic and real is shrinking, advances in batteries, brain - controlled robotics and AI, today's mechanical limbs can do everything from twist and point to grab and lift, for eg. like brain operated arm which is capable to reaching out and touching, the linx (fig: 5) which is capable to climb every mountain and the Michelangelo which is capable of painting masterpieces [23] (Powell., 2017)

Figure 5: linx

One of the first thoughts many people have when they learn they are going to need arm or leg amputated is "My quality of life will never be the same" and some have gone as far as to think that their life is over. [24] (Georgia Prosthetics). Prosthetic technology has advanced to a remarkable degree, driven largely by amputees' demand and preliminary studies report that amputees have increased independence [25] (Marks, Michael., 2001).

Impact of Prosthetics on Mobility and Independence:

Surgical innovations: Several recent surgical innovations have improved the functionality of myoelectric prostheses. Targeted muscle reinnervation (TMR) is a surgical procedure that gives traumatically or surgically transacted nerves a new motor target. The procedure has dual advantages: preventing or treating painful neuromas and improving myoelectric prosthesis functionality [26]. By giving the transacted nerve "somewhere to go and something to do," it regenerates in an organized fashion and is less likely to develop a painful neuroma [27, 28]. TMR was first developed among patients with shoulder disarticulations and above - elbow amputations (Fig: 6) [29 - 31] (Bates et al., 2020)

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Figure 6: A patient uses the Myolab II (Fillauer, Chattanooga, TN) to train in preparation for his myoelectric prosthesis following shoulder disarticulation and targeted muscle reinnervation. Image courtesy of Ryan Blanck, CPO

Microprocessor controlled movement:
The first artificial knee with an "on board" computer to improve the symmetry of amputees' gait across a wide range of walking speeds was developed by Blatchford in the early 1990s. Studies have confirmed that these "intelligent prostheses" offer amputees a more reliable gait pattern during the swing phase of the gait cycle, permitting them to walk with more confidence and in a more energy efficient manner (32 - 33). The Otto Bock C - Leg takes this a stage further, offering not only symmetry in the swing phase but also markedly improved security in the stance phase—that is, the knee will not buckle unintentionally during standing (fig: 7). Sensors in the ankle and shin of the prosthesis continually assess the position of the leg in space as the amputee is walking. The data are fed into two microprocessors inside the knee, and the resistance from a hydraulic damper is adjusted up to 50 times a second, optimising knee stiffness throughout the entire gait cycle (fig: 8). Preliminary studies report that amputees have increased independence with such a responsive and stable electronic prosthesis, confidently tackling more difficult and varied activities than they did with other limbs (33 - 34)

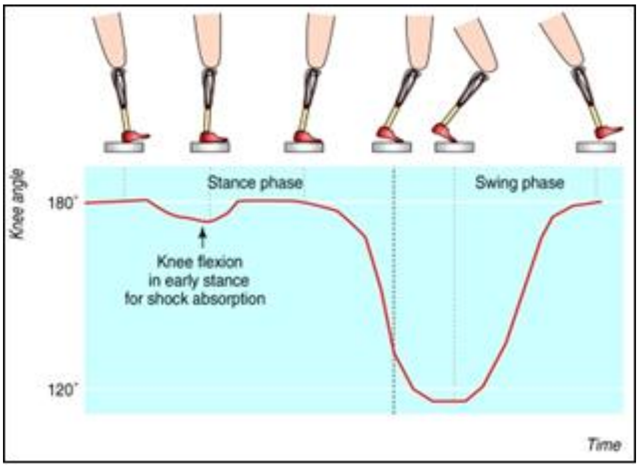

Figure 7: Advanced prosthetic knees allow a controlled amount of flexion during initial weight bearing (stance flexion) to simulate a more normal gait pattern and to absorb some of the impact of walking on an artificial limb. (Picture courtesy of Otto Bock)

Figure 8: The Otto Bock C - Leg with computer - controlled knee and integrated motion and force sensors to optimise hydraulic damping, making both walking and stair descent easier. (Picture courtesy of Otto Bock)

Restoring Sensation: Many sensory implants are undergoing research and development. These range from implants placed on or within peripheral nerves to those that directly stimulate the somatosensory cortex. In contrast to implanted sensors, surface - level sensors can be integrated into prosthetic skin and represent promising advances for light touch, proprioception, and temperature detection. [36] recently describe the use of metal oxide semiconductor nanomembranes and their potential integration into prostheses' cosmetic "skin" or glove. These ultrathin devices, which can endure about 30% of mechanical deformation, could offer intelligent feedback and a closed - loop human - machine interface. Whether this level of deformation is adequate for functional pinch or for grip strength for higher activity tasks remains to be seen.

Temperature sensors placed on a robotic hand that applies voltage to a soft thermal stimulator on human skin may be used to detect temperature of the external environment or of specific objects. Haptics is another method of communicating information from the environment to the patient through a prosthesis. Haptic devices use various sensory modalities such as vibration, stretch, and pressure to provide the user with sensory feedback. Use of tactile feedback to convey pressure and vibration sensed by a prosthesis has previously been established and continues to evolve as smaller and more powerful sensors, actuators, and processors are developed [37, 38].

Psychological reactions and changes after amputation:
After amputation, psychological difficulties may occur because of altered perceptions and distorted body image of oneself. The belief that they will be considered incomplete is painful. When patients have difficulty accepting new body image and social stigma, theirvulnerability is stimulated, and it is easy to use non - adaptive coping mechanisms [39, 40].

Return to daily life:
Group psychotherapy can be applied to support patients and their families, such as peer support groups. It can help patients improve their symptoms and self - growth and offer education and support to patients and their families [41]. It is possible to expand coping skills and improve self - management to promote adaptation through group psychotherapy with therapeutic or supportive characteristics [42]. Group psychotherapy is possible across various methods, such as face - to - face, telephone, and e - mail, and can deal with psychoeducation, problem - solving, communication, and CBT approaches [43]. Peer groups provide information on problems that patients may encounter after amputation (use of prosthesis, change of relationship, job retraining, etc.). This promotes positive adaptation and emotional support for patients and their families (44)

Future of Prosthetics

3D Printing:
3D printing generates physical items from a digital file by layering numerous materials to create a single structure. The structure is built using a computer - aided design file in a format compatible with 3D printing devices. Because of its research - based, innovative, and fast - moving characteristics, 3D printing is ideally suited to the medical business. This approach uses 3D scanning techniques such as MRI, X - ray, CT, or 3D ultrasound to provide a volumetric anatomy picture.3D printing is an up - and - coming technique to bring exactly designed and fitted replacement organs to patients waiting, suffering, or even dying and need aid right away (45, 46, 47)

3D bioprint works similarly to 3D printing technologies in that material is deposited or solidified in consecutive layers to produce 3D models.3D bioprinting employs stem cells or cells grown fromtissue samples. A binding gel or collagen scaffold holds these cells together. Patients natural tissue would develop over the 3D printed body parts and organs, eventually replacing the cells with their own. (48, 49)

Neural Control of Prosthetics: Neural interfaces operate where the nervous system and an artificial device intersect. Interfaces can monitor nerve signals or provide inputs that let amputees control prosthetic devices by direct neural signals, the same way they would control parts of their own bodies (50)

AI - powered myoelectric prosthetic hands:
AI is being used to give prosthetic arms the autonomy to perform actions such as finger movement. For instance, in 2017 a team of researchers from Newcastle University created a prosthetic hand that uses computer vision to identify the object that it's about to grasp and adjusts the grip without manual intervention from the user. (51)

AI - powered prosthetic leg: For a person using a prosthetic leg, tasks such as jumping over obstacles, walking on uneven grounds, or navigating a flight of stairs can be challenging. Mechanical engineers from Utah university have taken steps to make these common tasks easier by develop a bionic leg that leveraged AI and machine learning to adapt to different environments based on feedback from the user's residual limb. (52)

A robotic hand future: There's promise for amputees with advances in robotics, machine learning and prosthetics. With time, the costs of components will go down and these technologies will become integral parts of artificial limbs. These developments we hear of are incremental changes that will add up to improve future artificial limbs; improvements that will turn them into truly artificially intelligent limbs. We're still years from seeing A. I. - limbs being commonplace but it's a time to look forward to. (53)

2. Conclusion

Using of prosthetics for improving quality of life demonstrates that prosthetic devices have evolved to provide better mobility and psychological well - being for users. Customization, technological progress, and interdisciplinary collaboration play crucial roles, while challenges such as cost and accessibility still exist. Continuous efforts in research and healthcare are essential to improving the lives of individuals with limb loss or impairment through prosthetic interventions.

3. Recommendations

Certainly, here's some set of concise recommendations based on a literature review for using prosthetics to improve quality of life:
1) Customize prosthetics for individual needs.
2) Embrace advanced prosthetic technology.
3) Prioritize rehabilitation and training.
4) Offer psychological support and counselling.
5) Schedule regular follow - ups for maintenance.
6) Provide education and resources.
7) Encourage community engagement.
8) Support research participation
9) Explore assistive technologies.
10) Plan for long - term care.
11) Advocate for accessibility and affordability.

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