IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

A Design And Development Of Body-Powered Prosthetic Wrist Unit Facilitate Sagittal Plane Motions.

[1] M.S. Rishikesh, [2] Ashmita Milan, [3] Dewendra Prasad, [4] Parthasarathi Swain

[1]B.P.O. Intern, [2] Demonstrator (Prosthetics & Orthotics), [3] B.P.O. Programme Coordinator, [4] Prosthetist & Orthotist

[1,2,3] Department of Medical Science (Unit: Material Development - Aids & Appliances), National Institute for Empowerment of Persons with Multiple Disabilities (NIEPMD) (Divyangjan), Chennai, Tamil Nadu, India.

[4]Department of Prosthetics & Orthotics, Composite Regional Centre for Skill Development, Rehabilitation and Empowerment of Persons with Disabilities (CRC), Patna, Bihar, India

Abstract

Prosthetic devices have been developed to restore function and mobility to individuals with amputations. However, available prosthetic wrist units often lack the range of motion and dexterity of the natural wrist, limiting the user's ability to perform tasks that require precise wrist movement.

Therefore, the development of a body powered prosthetic wrist unit can provide the same dexterity of the anatomical wrist joint and locking mechanism in various ranges for performing various activities of daily living.

I. INTRODUCTION

Prosthetic wrist units are designed to serve two basic functions: to attach a terminal device to the forearm of the prosthesis and to permit the amputee to preposition the terminal device prior to operation. The need for the first function is obvious. To the uninitiated, the importance of the second function of wrist units may be less clear.[1]

In amputations above the wrist, the flexion and extension motion is completely lost. Also, the above-elbow (trans humeral) amputee has lost all ability to supinate and pronate the prosthetic forearm.[2] The trans radial amputee with a short residual forearm (50% or less than the length of the non-amputated forearm) no longer retains active transmissible supination and pronation. Even at the very long trans radial levels of amputation, the motions of supination and pronation are severely restricted. Consequently, the upper-limb amputee must be provided with a device that permits some form of substitution for active forearm rotation with flexion and extension movement.[3]

Prosthetic limbs are designed to replace or augment lost or impaired upper limb functionality due to congenital conditions, amputations or injuries. The prosthesis tends to serve more as a cosmetic accessory than a functional tool. However, users often utilize the prosthesis primarily for its cosmetic appeal, neglecting its full potential.

The loss of a limb can significantly impact an individual's quality of life, affecting their ability to perform daily activities, maintain independence, and engage in social interactions.

Prosthetic devices have been developed to restore function and mobility to individuals with amputations. However, current prosthetic wrist units often lack the range of motion and dexterity of the natural wrist, limiting the user's ability to perform tasks that require precise wrist movement.

Therefore, there is need of a body powered wrist unit which can provide the same dexterity of the anatomical wrist joint and locking mechanism in various ranges for performing various activities of daily living.

II. METHODOLOGY

Flexion, Extension and Rotation are the three most integral functions of the wrist joint. Integrating these functions into an amputee at the trans-radial and trans-humeral level is a sole factor to consider to boost the efficiency of terminal device functionality. Re-establishing these functions will have various extraneous factors to consider especially when it comes to the economic crisis. The advancement of prosthetic devices over decades is immense. And so are its over exorbitant budgets which makes the individual unaffordable to these modern trends.

This project focusses on conceptualizing and utilizing locally available resources with dynamic characteristics to present a design of wrist unit which provides sagittal plane motion (flexion and extension) with pre-position locking mechanism.

Material Selection

The following materials were selected for the design and fabrication of the body-powered prosthetic wrist unit:

- Terminal device with adapter (Terminal plate)
- Wrist quick disconnect
- Knob as lock with bolt - the movements will be locked by the knob with the bolt placed laterally.
- Rotator with rotation controller - The rotator provides sagittal plane motion as flexion and extension
- Rotator adaptor - the rotator will be connected to rotator adaptor
- Stabilizer- The stabilizer helps in positioning the rotator and rotation controller with the help of friction mechanism.
- Stabilizer adaptor- The stabilizer adaptor is connected to the terminal device with 6mm bolt and nut mounted directly and the stabilizer adapter is attached to the stabilizer

MATERIAL ADOPTED FOR 3D PRINTING

The material opted for 3D printing is Poly-lactic acid which has characteristics like tensile strength of 50 Megapascals, moderately flexible, the melting point ranges from130-180 degrees, selectively corrosive to specific materials like carbon / iron and is non-toxic, readily available, and inexpensive.

TOOLS, EQUIPMENTS & MACHINARIES

1. Measuring tape
2. 3D printing machine
3. PLA (POLYLACTIC ACID) spool
4. Drilling machine

WORKING PRINCIPLE

The rotator provides sagittal plane motion as flexion and extension, the rotator will be connected to rotator adaptor and the movements will be locked by the knob with the bolt placed laterally. The stabilizer adaptor is connected to the terminal device with 6mm bolt and nut mounted directly and the stabilizer adapter is attached to the stabilizer. The stabilizer helps in positioning the rotator and rotation controller with the help of friction mechanism. The adapters are attached with the 4mm screws with the stabilizer as well as the rotator in order to eliminate unwanted movement.

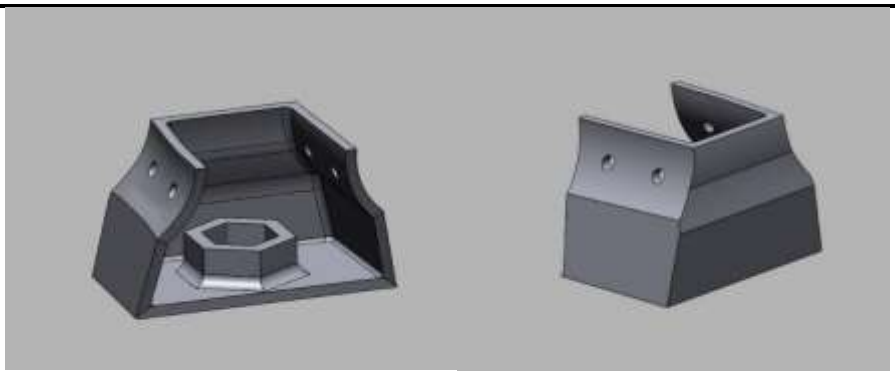

FIGURE 1 Rotation Adaptor Design Made From Software

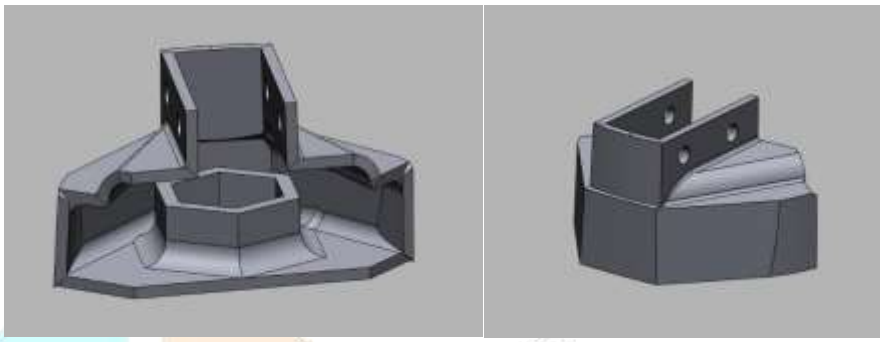

FIGURE 2: Stabilizer Adaptor Design Made From Software

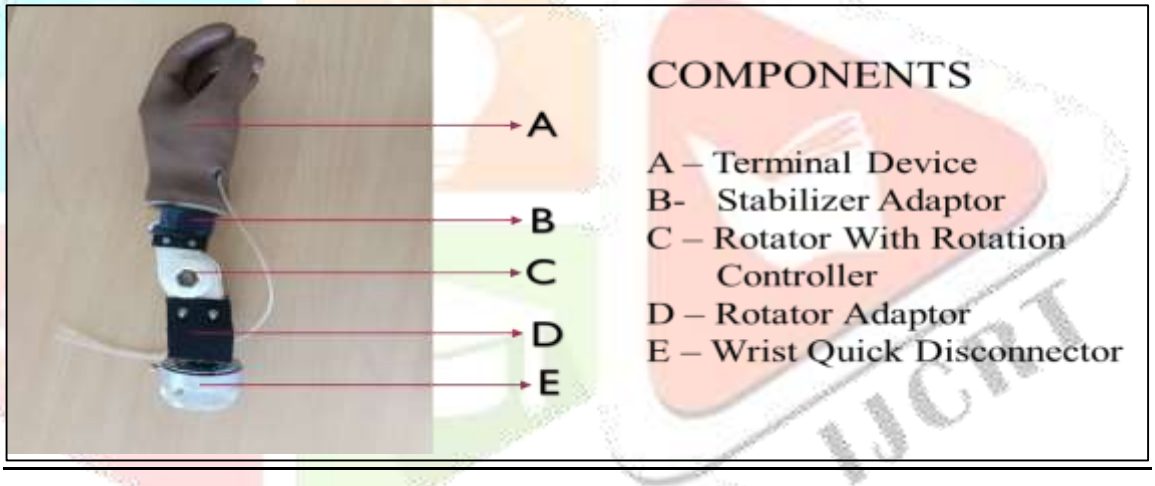

FIGURE 3: The Prototype of the Developed Body-Powered Prosthetic Wrist

III. DISCUSSION

The current design is a prototype which is regarded to perform just as good as any other prosthetic wrist joint mechanisms. And it also serves its purpose for the design by providing flexion and extension (sagittal plane motion) by a locking mechanism with a specified or desired position. All the components of the prototype were designed with PLA FILAMENT (POLY- LACTIC ACID).

All the prosthetic wrists act as an anchor point between terminal device and forearm shell. But in those prosthetic wrist units, range of motion from neutral to 90 degree of flexion is achieved but no extension is allowed from the neutral position. The wrist extension serves as an important means for holding weighted objects reducing strain to the residual limb which no previous prosthetic wrist units possessed. Also, it has been observed that when user operates or uses this kind of wrist units for various ADL activities, the

achieved wrist flexion is either reduced or directly comes to neutral position which certainly affects the ADL activities. To address this issue a wrist joint must incorporate a locking mechanism.

To serve for the above difficulties and issues, a new prosthetic wrist unit was fabricated which has a blend of 3D printing technique and a manual locking technique with simple mechanism which provides sagittal motions with locking mechanism which is economically and functionally more advantageous than the existing designs. The model was fabricated using the 3D designing software by altering the dimensions approximately to the required limit which makes it suitable for prosthetic application. The design irregularities and the abnormalities were found out using the software. The design odds that have been identified still being worked on to ensure the quality of the product in the near future.

Upon its finalization, the reduced dimensional prototype of the newly designed prosthetic wrist unit will be fitted to the trans-radial and trans-humeral amputee population and there after more scientifically approved tests will be carried out to analyze the validity and reliability of the product with the existing prosthetic wrist units.

FIGURE 4: Final Prototype Design of Prosthetic Wrist Unit

IV. CONCLUSION

Currently available body-powered prosthetic wrist units have limited functionality, particularly provision of wrist motion in the sagittal plane. The sagittal plane is essential for various body mid line daily activities, such as feeding, grooming, and manipulating objects etc. The lack of sagittal plane motion in current prosthetic wrist unit forces users to adopt compensatory movements, leading to fatigue, reduced dexterity, and increased risk of secondary musculoskeletal problems. This design has the potential to improve the quality of life for individuals with trans-radial and trans-humeral amputations by providing a more functional and intuitive prosthetic wrist unit.

The proposed prosthetic wrist unit can facilitate sagittal plane motion and transverse plane rotation, just by the addition of an existing wrist quick disconnect wrist joint reducing the need for compensatory movements, thus improving overall dexterity.

There is potential to improve the quality of life for individuals with trans-radial and trans-humeral amputations by providing them with such Prosthetic wrist unit which will enable them to perform Activities of Daily Living especially Mid-line body activities with greater ease and independence. Future research directions include clinical trial, miniature design, material testing to know its application and utility for upper extremity amputee.

V. ACKNOWLEDGEMENTS

I would like to extend my sincere gratitude to Shri. Dewendra Prasad, B.P.O. Programme Coordinator, NIEPMD, Chennai for providing me with all the provision for my project and providing his sincere and valuable guidance and encouragement. Also, I thank Ms. Ashmita Milan, Demonstrator (P&O), NIEPMD, Chennai for correcting and guiding me throughout and Shri Parthasarathi Swain, Prosthetist and Orthotist, CRC, Patna, Bihar for encouraging me in every path and also Shri. Anish Arumugaraj, Senior application engineer, ALTEM technologies Pvt. Ltd., Bengaluru for lending a hand in 3D designing and printing. Last but not the least, I would like to thank all the faculties and technical staffs of Prosthetic & Orthotic unit (NIEPMD), Ethical Committee of NIEPMD, my family and friends for supporting and guiding me in the journey.

Source of Funding: None

Conflict of Interest: The authors declare no conflict of interest

AUTHORS' CONTRIBUTIONS:

The entire clinical course of **"A DESIGN AND DEVELOPMENT OF BODY-POWERED PROSTHETIC WRIST UNIT FACILITATE SAGITTAL PLANE MOTIONS: A PROTOTYPE"** service delivery was done by Mr. M.S. Rishikesh towards the fulfilment of a bachelor's degree research project under the guidance of Shri Dewendra Prasad & Ms. Ashmita Milan. The manuscript preparation is done by Ms. Ashmita Milan and Mr.M.S. Rishikesh. The research study was carried out in the premises of NIEPMD, Chennai.

REFERENCES:

1. Fan, Hangbing & Wei, Guowu & Ren, Lei. (2022). Prosthetic and robotic wrists comparing with the intelligently evolved human wrist: A review. Robotica.
2. Kim Y, et al. (2020). Novel prosthetic wrist joint with adaptive stiffness control. IEEE Trans Neural Syst Rehabil Eng, 28(3): 541-550. DOI: 10.1109/TNSRE.2020.2974111
3. Smith J, et al. (2022). Prosthetic wrist joint with sagittal plane motion. J Prosthet Orthot, 34(2): 123-132. DOI: 10.1097/JPO.0000000000000345