

Prototype Development of Multifunctional Adaptable Terminal Device for Trans-Radial Amputees for Enhanced Activities of Daily Living

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DOI: <https://doi.org/10.52403/ijhsr.20240924>

ABSTRACT

Background: Upper extremity amputation refers to the surgical removal of a portion or the entirety of one or both of the arms. This procedure may be necessitated by various medical conditions including traumatic injuries, vascular diseases, tumors, congenital anomalies, or severe infections affecting the upper extremities.¹ Upper extremity amputation significantly impacts an individual's functional abilities and quality of life, often necessitating comprehensive rehabilitation and the use of prosthetic devices to restore function and facilitate independence in activities of daily living.²

Objective: To provide a solution for trans-radial amputees by the means of developed multifunctional adaptable device prototype which is helping the patient to perform various daily activities with ease and efficiency.

Methodology: The multifunctional adaptable terminal device is designed to provide ADL activities to trans-radial amputees. It was designed to provide different types of attachments for trans-radial amputees so as to compensate the activities of daily living like combing, brushing, cooking etc.

Result: The prototype of a multi-functional adaptable terminal device might address the challenges faced by trans-radial amputation by offering benefits such as enhanced independence, personal hygiene (like brushing, combing etc), meal preparation, housekeeping, scheduling, communication, transportation, and more. The multifunctional adaptable terminal device is cost effective and patient can easily interchange the terminal device according to their comfort and need.

Conclusion: The prototype development of the multifunctional adaptable terminal device for trans-radial amputees represents a prosthetic design that can be affordable and can provide enhanced capabilities along with greater independence for users in their daily lives. The developed prototype will lead to an improvement in performing daily activities such as eating, dressing, and personal hygiene. It will help the patient to make their life easier for the patient with trans radial amputation to work, live, and take care of their fundamental needs by making them seamlessly handle multiple tasks.

Keywords: prototype, multifunctional, adaptable, Upper limb, trans-radial amputation, ADL activities.

INTRODUCTION

Amputation is loss of body part, usually a finger, toe, arm or leg. The very thought of losing an anatomical part is devastating to most people when it happens, amputation causes a threefold loss in terms of function, sensation and body image.¹ The Indications for amputation also varies according to age group of individuals. In elder population (50-60) years, PVD with or without diabetes is the main cause. In young adults' amputation is common due to traumatic causes. And in children limb deficiency is quite common. Among the acquired causes injury and malignancy are very common.^{2,3} Arms and hands are used for most activities of daily living, and are also important for communication and affection. Thus, the loss of an upper limb has an extensive effect on people's lives, resulting in a major restriction of function, sensation and appearance.⁴ In India, the prevalence of upper limb amputations is notably lower compared to lower limb amputations. Lower limb amputations account for the majority of cases, representing 94.8% of all amputations, while upper limb amputations make up only 5.2% of the total.⁵ A trans-radial amputation is a surgical procedure that involves the removal of a limb below the elbow, specifically focusing on the forearm area while preserving the elbow joint.⁶ The procedure aims to maintain functionality and mobility in the arm while addressing specific medical conditions or injuries that necessitate the amputation.⁶ The Trans radial amputees may encounter challenges with various activities of daily living (ADL) like combing, cooking, brushing, eating and more. These challenges highlight the impact of trans radial amputations on daily tasks and the importance of rehabilitation and prosthetic management to improve functional independence and quality of life for individuals with trans radial limb loss.⁷ There are different types of terminal devices are used for functional independence of upper limb amputation such as voluntary opening hooks, hands, voluntary closing

hooks, hands which are costly for economically weaker section population of India. The available designs are also not easy to use and are not widely acceptable by the upper limb amputees. Hence generating a need to create a more affordable and easier to use option by upper limb amputees.⁸

MATERIALS & METHODS

Study Design: Prototype Development

Stages of prototype development:

1. Gathering & Analysis of Requirement:

Gathering and analysing requirements for a prototype involves understanding the purpose of the prototype. The purpose of prototype is to help the patients with trans-radial amputation to perform their activity of daily living like eating, cooking, brushing etc.it involved following steps:

Research and Needs Assessment:

Initially interviews and surveys were conducted with trans-radial amputees to understand their specific needs and challenges in performing daily activities. It was identified that some common tasks which individuals with trans-radial amputation desires to perform in their daily lives includes personal hygiene (like brushing, combing etc), meal preparation, housekeeping, scheduling, communication, transportation, and more.

After this analysis of existing ADL devices and prosthetic attachments was done to identify strengths and weaknesses of devices in terms of usability and cost.

Concept Development:

The concept of multipurpose ADL device was developed keeping in mind the patient's requirements, preferences, difficulties faced in usage and cost of the terminal device.

The multifunctional ADL device was conceptualized addressing the needs, preferences, and challenges faced by the target users which was initiated after conduction of surveys, interviews, observations gathered in order to provide insights into how people currently manage

their tasks and what improvements they desire.

Major factors which were taken into account were usability, comfort, durability, and affordability.

2. Designing the Prototype:

Designing a prototype for Activities of Daily Living (ADL) activity involves creating a preliminary version of a multi-tasking device to test its functionality and fulfil basic need of patient.

A trans-radial amputee is an individual with a distal amputation below the elbow, lacking the ability to grasp objects with their residual limb, which impacts their participation in activities of daily living like brushing, cooking, eating, combing etc.

The design focused on creating adaptive equipment that addresses the specific needs of trans-radial amputees, such as providing mechanisms for grasping, stability, and comfort during ADL activities.



Figure shows Multifunctional adaptable terminal device with different ADL attachments

3. Creating a prototype:

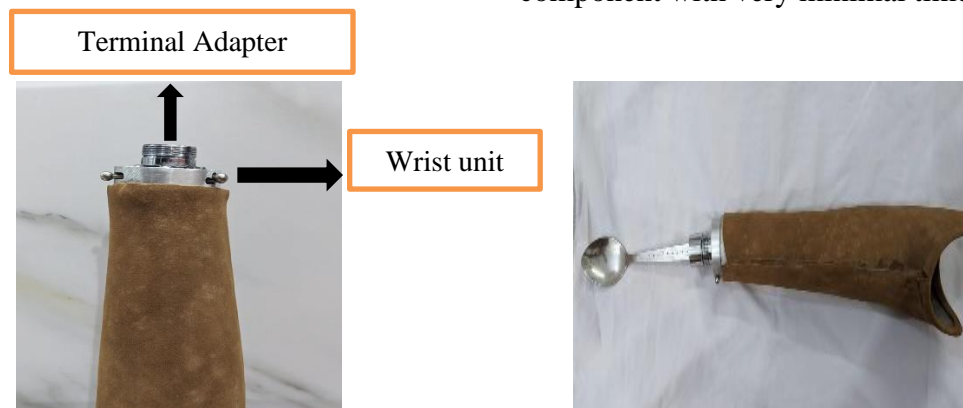
The primary function of an upper limb terminal device is to mimic the function of a human hand in terms of grasping, holding, control and precision however, the patient experiences the difficulties in performing daily living activities like cooking, brushing, combing and more. Thus, in this study an attempt is made to reduce the difficulties of daily living by modifying a multifunctional adaptable terminal device is design to provide different types of attachments for patient to interchange according to their need.

The terminal device is made up of stainless steel. The steel adapter is attached at the wrist unit for the attachment of terminal device. Adapter is fixed in the wrist unit the ADL device interchanges.

Customizability – The prototype is designed to be customized to accommodate the daily activities of life. The ADL device will be attached according to the patient preference.

Affordability - One of the key objectives of the prototype is cost effective alternative.

Ease of maintenance – the design of multifunctional terminal device is easy to maintain. It is easy to replace the damage component with very minimal time.





Final prototype design of multifunctional adaptable terminal device

RESULT

The aim of the study which encompasses designing a prototype of a multi-functional adaptable terminal device for trans-radial amputees to support the patients in performing daily activities. The trans-radial amputees' experiences difficulties in performing daily activities because of their limited range of motion. The present prototype of a multi-functional adaptable terminal device might address the challenges faced by trans-radial amputation by offering benefits such as enhanced independence, personal hygiene (like brushing, combing etc), meal preparation. Its durability and reliability of the terminal device will reduce the frequency of maintenance and replacement, offering a cost-effective solution for trans-radial amputees.

DISCUSSION

The performed analysis shows that there is a considerable variation in the population of upper limb prosthesis patients, due to individual anatomy, lifestyle, etc. Therefore, individual solutions should always be considered for the type of prosthesis, the socket, terminal device they are using. Performing activities of daily living mainly related to eating and dressing, such as combining fork and knife motion, cutting the vegetables, washing utensils. This is desired by all the users, independently either of the level of limb loss (e.g., trans-radial) or the type of prosthesis (e.g., body-powered, myoelectric). Therefore, a prosthetic system is required to perform basic grasping actions (corresponding to power, pinch, lateral, neutral and pointing of

the index finger) and simple manipulation tasks enabling the execution of ADLs.⁹

Many parameters have been investigated regarding upper limb prosthesis such as difficulty in performing ADL activities. As per the various literature available the most frequently reported reasons for failure of pursuing ADL activities with the mechanical upper limb prosthesis is due to heavy weight of the prosthesis and grip strength, generally the patient is unable to hold the brush or comb with the prosthetic hand.⁹

The purpose of this study was to find out the solution for the patient's having trans-radial amputation to perform their activities of daily living as they faced challenges to complete tasks like brushing, combing, eating, and more. Hence, the prototype developed in the present study is a multifunctional terminal device, which made easier for the patient to perform ADL activities with the help of interchangeable terminal devices which carries different-different ADL device like comb, toothbrush, knife etc. The patient can change the device according to his/her need of work. The multifunctional adaptable terminal device is cosmetically fine and light weight as compared to the mechanical prosthesis and patient can perform actions in a more coordinated manner and with less visual attention. These are skills desired by all the patients. The functional capability of the terminal device will depend on the patient's energy expenditure level, activity, movement of the elbow and more. Maintenance of the multifunctional terminal device is easy.

CONCLUSION

The prototype development of the multifunctional adaptable terminal device for trans-radial amputees represents a prosthetic design that can be affordable and can provide enhanced capabilities along with greater independence for users in their daily lives. The developed prototype will lead to an improvement in performing daily activities such as eating, dressing, and personal hygiene. Multifunctional adaptable terminal device can lead to make the life easier for the patient with trans radial amputation to work, live, and take care of their fundamental needs by making them seamlessly handle multiple tasks.

Future direction

The present study focused on developing a prototype multifunctional adaptable terminal device by using subsequent stages of prototype development process which includes analysis of problems and requirements, designing and creating prototype.

In future, it can be tested over population using parameters to check dexterity and functionality of prosthesis.

Limitations

The developed prototype was not tested to check its efficacy and effectiveness on the desired trans- radial amputees.

Declaration by Authors

Acknowledgement: None

Source of Funding: None

Conflict of Interest: The authors declare no conflict of interest.

REFERENCES

1. Mohan D. A Report on Amputees in India | P&O virtual library [internet]. Oandplibrary.org.2018 [cited 5 April 2018]
2. Essential of orthopaedics, J. Maheshwari.
3. Bhuvanewar CG, Epstein LA, Stern TA. Reactions to amputation: recognition and treatment. Primary care companion to the

- journal of clinical psychiatry. 2007; 9(4):303.
4. Pooja, G. D., & Sangeeta, L. (2013). Prevalence and aetiology of amputation in Kolkata, India: A retrospective analysis. *Hong Kong Physiotherapy Journal*, 31(1), 36–40.
5. Østlie, K., Skjeldal, O. H., Garfelt, B., & Magnus, P. (2011). Adult acquired major upper limb amputation in Norway: prevalence, demographic features and amputation specific features. A population-based survey. *Disability and Rehabilitation*, 33(17–18), 1636–1649.
6. Maduri P, Akhondi H. Upper Limb Amputation. [Updated 2023 Aug 8]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan
7. Smail, L. C., Neal, C., Wilkins, C., & Packham, T. L. (2020). Comfort and function remain key factors in upper limb prosthetic abandonment: findings of a scoping review. *Disability and Rehabilitation: Assistive Technology*, 16(8), 821–830.
8. National Academies of Sciences, Engineering, and Medicine; Health and Medicine Division; Board on Health Care Services; Committee on the Use of Selected Assistive Products and Technologies in Eliminating or Reducing the Effects of Impairments; Flaubert JL, Spicer CM, Jette AM, editors. *The Promise of Assistive Technology to Enhance Activity and Work Participation*. Washington (DC): National Academies Press (US); 2017 May 9.
9. Cordella, F., Ciancio, A. L., Sacchetti, R., Davalli, A., Cutti, A. G., Guglielmelli, E., & Zollo, L. (2016). Literature Review on Needs of Upper Limb Prosthesis Users. *Frontiers in Neuroscience*, 10

How to cite this article: Tuba Saleem, Shivangi Mehra, Sakshi Saharawat, Chitra kataria. Prototype development of multifunctional adaptable terminal device for trans-radial amputees for enhanced activities of daily living. *Int J Health Sci Res.* 2024; 14(9):188-192. DOI: <https://doi.org/10.52403/ijhsr.20240924>
