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Implementation of Prosthetic Hand Design for Transradial Amputee by Using 3D Printing Technology to Enhance Life Quality

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ABSTRACT The target for this community service program is a resident of Jl. Parikesit RT 05 RW 03 Dusun Picis, Balongdowo Village, Candi District, Sidoarjo Regency. He had a work accident in one of the industries in the city of Sidoarjo in 2010 on the left wrist up to the fingers, so the doctor suggested amputation. He is actually still in his productive age (36 years old) but because of this situation, he is unable to carry out activities in the world of work and has decreased confidence in himself and avoids socializing in society. The purpose of this community partnership program (PKM) activity is to apply 3d printing technology in the manufacture of prosthetic hands for people who have transradial amputations as an effort to improve the quality of life. The implementation methods used are: a) the measurement of several physical parameters on the amputee such as the diameter of the arm circumference, the length of the amputated part, weight and height. In addition to physical parameters, we also carry out medical measurements, including obtaining information on health conditions such as blood pressure, heart health and blood glucose levels, b) designing prosthetic hands using 3D application programs and 3D printers, c) mechanical and functional testing for perform basic movements in the form of opening and closing the palms, d) monitoring and evaluation of the use of prosthetic hands. The results obtained from this activity are that the patient can use the prosthetic hand to assist with activities in carrying out daily activities. In this PKM activity, amputees have been tested, namely the movement of holding a mineral water bottle, holding a banana, peeling a banana peel and driving a two-wheeled motorized vehicle. Monitoring shows that patients need regular exercise in using prosthetic hands so that they are able to control and condition their use. In the future, several developments can be made, including in terms of control and size of the prosthetic hand so that patients can feel the benefits of a prosthetic hand that functions like a normal hand.

INDEX TERMS 3D printing, prosthetic hand, transradial amputee, community services.

I. INTRODUCTION

The target for this community service program is a resident of Jl. Parikesit RT 05 RW 03 Dusun Picis, Balongdowo Village, Candi District, Sidoarjo Regency. The resident had a work accident in one of the industries in the city of Sidoarjo in 2010 on the left wrist up to the finger, so the doctor suggested amputation. This situation is hereinafter referred to as transradial amputation, which is amputation carried out from the bottom [1], [2] The resident is actually still of productive

age (36 years) but because of this situation, he is unable to carry out activities in the world of work and has decreased confidence in himself and herself. withdraw from socializing in society. He actually has made several attempts to make prosthetic hands, even if only as a cosmetic and not as a functional movement. However, the control he faces is the cost of making prosthetic hands which is relatively expensive for

people in the lower middle class. With a price range from 15 million to 20 million.

basic, applied and development research activities. For this ongoing PKM activity, it is entering the step of implementing



FIGURE 1. The condition and situation of one of the residents who experienced an amputation

Based on its purpose, there are two prosthetic hands developed in the world, namely for cosmetic and functional purposes [3], [4]. In Indonesia, most prosthetic hands are still intended for cosmetic purposes, which means that they are only complementary but cannot perform their functions as a hand. Several cosmetic prosthetic hand making services have been found in big cities with relatively expensive manufacturing costs. The weakness of a prosthetic hand with a cosmetic function is that it cannot be used for daily purposes, such as holding and grasping an object.

Several researchers have developed prosthetic hands starting in laboratory and field testing [5] [6] [7] [7] [8]. Furthermore, several large companies have developed the manufacture of functional prosthetic hands that can be moved using the help of electromyography signals, which are signals generated by muscles during contraction. Several large companies, including Ottobock and Stepper, have made prosthetic devices that can be moved using bio-electrical signals (EMG), but the prices offered by these companies are very expensive, ranging from 250,000,000 to Rp. 750,000,000 [9] [10].

Under the research group “Intelligent medical rehabilitation devices”, Department of Electrical Engineering, Poltekkes Kemenkes Surabaya, at the Microcontroller Laboratory a functional prosthetic hand has been developed so that it can be used for basic daily needs, for example driving a motorbike, holding glasses, cellphones etc. The research group's roadmap “Smart medical rehabilitation tools is shown in Figure 1.3. Research roadmap related to community service activity roadmap. The roadmap describes several activities related to

applied research for community service activities, namely applying 3d printing technology in making prosthetic hands for residents who have transradial amputations as an effort to improve the quality of life. Based on direct observations and discussions with him, several problems were found, namely: he had a transradial amputation, namely amputation from the left wrist so that he could not carry out activities using two hands, for example driving a motor vehicle and some work that required coordination with two hands. . the amputee comes from a lower middle class family so they cannot afford to buy prosthetic hands because the prosthetic hands available have prices that are not affordable for the lower class. The amputee has decreased self-confidence and withdraws from socializing with the local community due to the loss of some limbs. Based on the problems faced by the amputee, through a community service program with the Community Partnership Program (PKM) scheme, through science and technology for the community, the proposer offers a solution (a) to design and manufacture a prosthetic hand device in the form of a transradial amputation, which is functional in nature that can be used for basic daily needs, for example: driving, holding a cellphone and a drink bottle in the left hand, (b) providing a prosthetic hand device at an affordable price with basic ingredients that can be obtained in the local market. The design is carried out using 3D printing technology and electronic technology that has been developed, (c) providing assistance to amputees in an effort to restore self-confidence and be able to socialize again after using prosthetic devices and evaluate usage after the next few months.

II. MATERIALS AND METHOD

Technology in Making Prosthetic Hands for People Who Have Transradial Amputations as an Effort to Improve Quality of Life". The solution steps that we offer to solve the problems

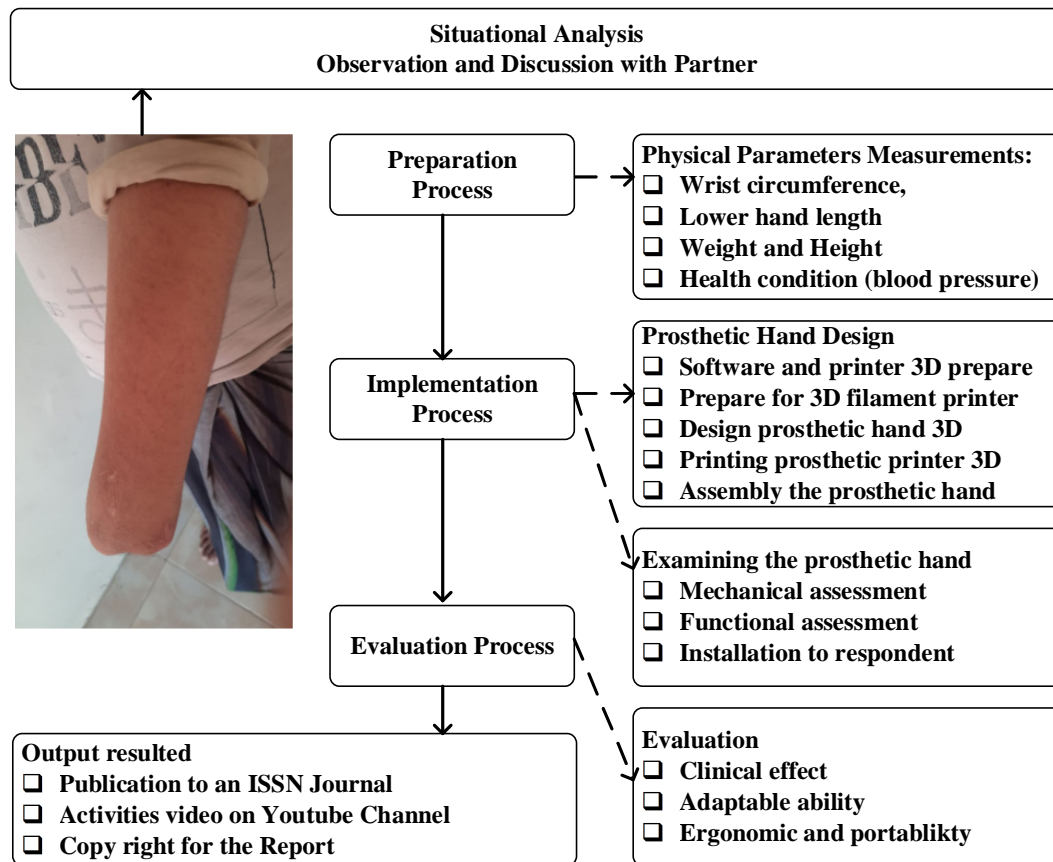


FIGURE 2. Execution method

A. MATERIALS

In this community service activity, it involved one subject who had an amputation of the left hand, namely the wrist. This amputation is caused by a work accident caused by human error. The characteristics of the respondents were 36 years old, height and weight 172 cm and 75 kg. At the time of physical measurement, the forearm length was 28 cm, wrist circumference was 15 cm, and arm circumference below the elbow was 20 cm. Furthermore, the material used for the manufacture of prosthetic hands is PLA (polylactic acid) filament, while for the purposes of making anti-slip stainless bracelets on each middle finger, flexible filament material (TPU type material) is used. 3D printer machine used for printing purposes prosthetic hand is using the Creality CR-6 SE (Creality, China) 3D printer machine where this printer has a maximum print volume capacity of 235 x 235 x 250 mm.

B. Method

This community service with the "Community Partnership Program" scheme is entitled: "Application of 3d Printing Vol. 1 No. 1, March 2022, pp:1-8
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faced by amputees are as shown in FIGURE 2. After observing and discussing the following steps:

Preparation. For the purpose of designing a prosthetic hand, it is necessary to measure several physical parameters on the amputee such as the diameter of the arm circumference, the length of the amputated part, weight and height. In addition to physical parameters, we also carry out medical measurements, such as blood pressure conditions, heart health and measuring blood sugar levels to determine the condition of diabetes mellitus.

Implementation. After the physical parameters are obtained, the next step is to design a prosthetic hand using a 3D application program. The main tools and materials needed are filaments made of PLA material and tools used to print prosthetic hands, namely using a three-dimensional printing machine (3D printing). The prosthetic hand printing process is carried out in parts, namely the fingers, palms, backs of hands, and sockets. After the printing process per part, the assembly process of each part is continued into a single unit (prosthetic hand). After the prosthetic hand is produced and has been assembled, the next step is to perform mechanical and

functional testing to perform basic movements. The basic movements that can be done include: opening and closing. Next is the installation of a prosthetic hand on the amputee.

Evaluation. To determine the functioning of the prosthetic device, after installation on the amputee, monitoring and evaluation is needed. Monitoring is carried out regularly every two weeks for several months, in the form of durability,

physical measurements on the patient based on the forearm circumference, wrist circumference, and forearm length as shown in Figure 4.1. After the physical measurement data is obtained, the next step is setting the parameters in the 3D application program for prosthetic hand design (OpenScad). The results of the prosthetic hand 3D model design are then exported to produce 3D files (files with the STL extension).



(a)



(b)

FIGURE 2 (a) Measurement of circumference below the elbow, wrist, and forearm length using a conventional meter, (b) The process of making a prosthetic hand using 3D printing technology according to the actual size

ergonomics and clinical impact on the amputee's body.

Output. After the end of the PKM implementation, the next step is to publish the results and evaluation of community service activities in the form of publications to journals and making copyrights

III. RESULT

The results and outcomes achieved are in accordance with the solutions offered in the community partnership program (PKM) activities, namely applying research technology for the community, especially people with lower elbow amputees. In this PKM activity, 3D printing technology is applied to make a functional prosthetic hand. This functional prosthetic hand has the ability to perform open and close palm movements. This movement can be used to perform the mechanism of grasping and releasing objects. This movement has been very helpful for people with amputation of the hand below the elbow in order to increase productivity and activities in daily life. This functional prosthetic hand is hereinafter referred to as a prosthetic hand. The first step to take is to perform

For the purpose of adjusting the density of the 3D printing design, 3D files with the STL extension are imported using the Ultimaker Cura application program. Furthermore, through the Ultimaker Cura application program, 3D files are exported to produce files with the GCODE extension where the file is ready to be inputted into the 3D printing machine.

The 3D printing is divided into several parts, including the forearm part of the elbow, part of the palm, back of the hand, upper arm support and part of the fingers consisting of five fingers. The overall results of the prosthetic hand assembly are shown in Figure 4.2. PKM activities also involve students in assembling prosthetic hands and practicing basic movements. In addition to practicing the basic movements of lifting the prosthetic hand, up, down, right and left, the amputee is also trained how to move the prosthetic hand for the purpose of holding frequently encountered objects such as mineral water bottles and holding bananas. In order for the prosthetic hand to hold an object, the patient must move the elbow inward so that there is a cable-string mechanism that will pull the fingers into grip. Prosthetic hand patients need several exercises to get



(a)



(b)



(c)



(d)

FIGURE 3. (a) an amputee wearing a prosthetic hand on the amputated left hand, (b) practicing basic movements when the patient is wearing a prosthetic hand, namely lifting up and down, moving the right and left side. (c) An example of the patient's activity when the prosthetic hand holds a medium-sized bottle of mineral water, (d) an example of the patient's activity when the prosthetic hand holds a banana

used to holding an object. Figure 3(c)(d) shows some examples when a patient holding a water bottle (Figure 3(c)) and when the patient is holding a banana (Figure 3(d)). In addition to activities related to food activities, in this PKM activity, patients are also monitored while driving a motorized

vehicle using a prosthetic hand (Figure 4 (a)). Officially, a prosthetic handover ceremony was held at the Balongdowo Village Hall witnessed by the Balongdowo Village Head (Figure 4 (b)). In this assessment, we can see that the respondent can handle the motorbike with more balance if we

compare when the user was not used the prosthetic hand. In this assesment, the prosthetic hand can hold and handle the steer firmly and smooth. This testing can be seen in **FIGURE 4 (a) and (b)**.

At the beginning of use, the patient feels discomfort and pain in the early weeks of using the prosthesis, but this problem can be overcome by covering the surface of the hand that will use the prosthetic with a socket in the form of a soft and rather



(a)



(b)

FIGURE 4. a) the responden ride a motorbike without the prosthetic hand, b) the responden ride a motorbike using the prosthetic hand

IV. DISCUSSION

Community Partnership Program with the title Application of 3d Printing Technology in Making Prosthetic Hands for People Who Have Transradial Amputations as an Effort to Improve Quality of Life. From the results of the implementation, it can be seen that amputated patients can perform the basic movements needed for daily activities. At the stage of implementing the activity, it can be seen that the respondent needs to do a lot of exercises in the use of prosthetic hands in order to operate the prosthetic hand properly. Several times trying to hold a bottle, respondents still have difficulty in doing so, this is because the 3D printing material has a slippery nature so that some objects will slip when held. On the other hand, when the respondent does the activity of driving a motor vehicle, it appears that the respondent gets a better balance than when the respondent does not use a prosthetic hand.

thick cloth. In this situation the amputee can use socks that are thick enough so that they can provide comfort when wearing prosthetics.

Physical disabilities experienced by a person can result in impaired physical ability to perform an action or certain movements related to activities of daily living. Physical limitations cause not having it work skills (production). This causes low income and is below the poverty line. Socially, physical disability affects the inability of relationships to take part in social activities or groups, clumsiness of human relationships in society, and the inability to influence each other in a social group or social interaction. So we need a tool to be able to carry out activities properly. The transradial prosthesis itself is a type of upper limb prosthesis that is designed to replace the missing limb just below the elbow, so that someone who has lost a lower limb can return to their activities using a transradial prosthesis.

Psychological approaches to amputation include measuring the amputee's ability to learn new tasks including putting on and removing a prosthetic, the ability to observe the

skin to avoid injury to the prosthetic socket, and caring for the appliance. The motivation to use prosthetics for daily activities is needed to get the benefits of this prosthetic, and also as an evaluation material for prosthetic hand researchers.

A prosthetic can be designed to meet specific occupational, recreational or social needs. mental condition, well-motivated and does not seem awkward in the use of daily prosthetics, and also psychological support from the closest family and community will help in the psychological adjustment of an amputee.

The use of prosthetic hands will improve the psychological appearance and improve the appearance and body image of an amputee. When starting the use of the prosthesis, it takes the ability of the mental and psychological support team from the closest people to motivate and provide continuous encouragement in the continuous use of the prosthesis so as to maximize the benefits of the prosthesis. In the end, the amputee will determine the means of movement with considerations: sustainable benefits.

Prosthetic hands provide psychological and social functions as well as their functional requirements. Even the prosthesis provides also a cosmetic function.

Many amputees view amputation as a punishment, which creates feelings of guilt and shame. Introversion (closed), self-pity, feelings of inferiority, and social isolation can occur. In addition to support from the closest people, adaptation to the use of the prosthesis should be facilitated by combination therapy, either individual or group therapy to educate and provide support. Individual therapy consists of emotional support by a psychologist, social worker or other health care professional to work on feelings of loss, anger and sadness. In this therapy, it is focused on how to overcome feelings of inadequacy, isolation and depression, so that it is hoped that in the future an amputee will be able to socialize in society with confidence and develop the potential that exists in him.

Several other researchers proposed the design of a prosthetic hand using 3D printing technology with the same result, namely control when holding some slippery objects, namely slipping [11] [12] [5] [13] [14]. Some researchers add rubber material to the palms and fingers. This is to reduce the occurrence of slippage when the prosthetic hand is used to hold the object.

V. CONCLUSION

The purpose of this PKM is to apply 3d printing technology in the manufacture of prosthetic hands for residents who experience transradial amputations as an effort to improve the quality of life. The results obtained from this activity are that the patient can use the prosthetic hand to assist with activities in carrying out daily activities. In this PKM activity, amputees have been tested, namely the movement of holding a mineral water bottle, holding a banana, and driving a motorized vehicle. From monitoring shows that, patients need regular exercise in using prosthetic hands. In the future, several

improvements can be made, including in terms of control and size of the prosthetic hand so that the patient can feel a prosthetic hand that functions like a normal hand. Measurement of physical parameters on the patient's hand (upper arm circumference, wrist circumference, and forearm length) is very important because it determines the printout of the 3D printer machine. Setting the infill parameters on 3D printing is very important to determine the weight of the prosthetic hand so that the patient is not too burdened with the prosthetic hand. The PKM Poltekkes Kemenkes Surabaya TEAM can carry out activities with the same theme with a wider scope through associations/associations/bonds of persons with disabilities on a regional, national and even international scale.

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