INTRODUCTION

History of prosthetics dates back to the famous ancient Roman, General Marcus Sergius who is considered the first documented user of a prosthetic limb. In the second Punic War, Sergius lost his right hand and was given a prosthesis, fashioned from iron that enabled him to hold his shield and continue fighting. His loss of limb happened very early in what would become a long military career. The history of prosthetics has always been intertwined with the history of warfare.

Today is an exciting moment in the evolution of prosthetics. It’s a time when great strides are being simultaneously made on both aesthetic and functional fronts, thanks to new technology and the never-before-seen pace of innovation. Modern materials like carbon fiber has made prostheses both lighter and stronger. Advancements like 3D printing and biomaterials have enhanced the lives of amputees and will continue to do so. An even more exciting advancement in science is Composite Tissue Allografts.

There are basically two types of upper limb prosthesis - Body powered & Externally powered. The conventional or Body - powered prosthesis consists of a socket, suspension, interposition joints, terminal device and a control system. Upper limb body-powered prostheses are less likely to break down and may enable the amputee to work faster. In addition, body-powered systems enable the amputee to get some sensory feedback since they are using the shoulders to open or close the terminal device. In doing so, the amputee can sense how much tension needs to be placed on the cable to operate the terminal device so as to perform the task.

External power for upper extremity prosthesis refers to the use of small electric motors incorporated into the prosthesis to control various functions. At present reliable external power units are available for terminal device operation, wrist rotation and elbow flexion-extension. The electric motors are controlled by switches or myoelectric signals. Small switches are incorporated into the prosthetic socket and are operated upon contact by the amputee. Pull switches incorporated into conventional harness and cable motions are also available.

The Myoelectric hand prosthesis is an alternative to conventional hook prostheses for patients with traumatic or congenital absence of forearm(s) and hand(s). These prostheses have a stronger pinch force, better grip, and are more flexible and easier to use than conventional hooks. Myoelectric control is used to operate electric motor-driven hands, wrist, and elbows. Surface electrodes embedded in the prosthetic socket make contact with the skin and detect and amplify muscle action potentials from voluntarily contracting muscle in the residual limb. The amplified electrical signal turns on an electric motor to provide a function (e.g., terminal device operation, wrist rotation, elbow flexion). The recent electronic control systems perform multiple functions and thus allow for sequential operation of the terminal device.

Evaluation of Prosthetic usage and short – term outcome of Upper Limb Amputees

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Abstract

Aim: To evaluate the Prosthetic usage and to assess the short term outcome of Upper Limb Amputees.

Design: Descriptive Cohort study.

Materials and Methods: 40 Upper limb amputees who have received Prosthesis from Government Institute of Rehabilitation Medicine, Chennai were called for follow –up. Using data from Medical Records and by an interview a proforma was filled.

Results: Majority of the amputees 65%, were independent in all activities of daily living. 25% were partially dependent and the 4 bilateral amputees who comprised 10% were fully dependent for their ADL. Symptoms of overuse injury were reported 35%. Majority of amputees, around 62.5% reported Phantom pain and 40% stump pain. More than half of the study group, 55% have discarded their body powered prosthesis after about a month’s time.

Conclusion: Prosthesis usage of more than 8 hours was quite less and the overall rejection rate of prosthesis was 55%. Hence the role for designing and fabrication of advanced prosthetics systems and newer developments are the need of the day for restoring function to the upper limb amputee.

Key words: Amputees, Prosthesis, ADL (activities of daily living), Phantom pain, i- limb.
elbow motion, wrist rotation and hand motions. Myoelectric hand prostheses provide improved function and range of functional position as compared to “hook” prostheses. Myoelectric hand prostheses can be used for patients with congenital limb deficiencies and for patients with amputations sustained as a result of trauma or surgery. The motor and drive mechanisms typically last 2 to 3 years and may need to be replaced after this period. When used on a child, the sockets may need to be replaced every 12-18 months due to growth. With heavy use the entire prosthesis might require replacement by the fifth year.2-8 The device is appropriate for both above-the-elbow and below-the-elbow amputees, and for both unilateral and bilateral amputees. Patients must possess a minimum microvolt threshold (i.e., minimum strength of microvolt signals emitting from the remaining musculature of the arm) and pass a control test to be considered a candidate. Myoelectric hand prostheses are indicated for persons at least one year of age or older. Children with congenital absence of the forearm(s) and hand(s) are usually fitted with a conventional passive prosthesis until approximately age 12 to 16.

Phantom limb is the sensation that an amputated or missing limb is still attached to the body and is moving appropriately with other body parts. Approximately 60 to 80% of individuals with an amputation experience phantom sensations in their amputated limb, and the majority of the sensations are painful. Phantom sensations may also occur after the removal of body parts other than the limbs, e.g. after amputation of the breast, extraction of a tooth (phantom tooth pain) or removal of an eye (phantom eye syndrome). The missing limb often feels shorter and may feel as if it is in a distorted and painful position. Occasionally, the pain can be made worse by stress, anxiety, and weather changes. Phantom limb pain is usually intermittent. The frequency and intensity of attacks usually decline with time.9,10

This study was conducted to observe the changes in lifestyle, complications and compliance with prosthesis among upper limb amputees. One of the main aims of the study was to find out the hours of usage of prosthesis by upper limb amputees. Further, the incidence of complications like phantom pain, stump pain and over use injury of the normal limb in upper limb amputees was evaluated. Life style modifications of upper limb amputees following the amputation regarding the activities of daily living, leisure activities, occupation and social engagement were also assessed.

MATERIALS AND METHODS
This is a descriptive cohort study of upper limb amputees who have received prosthesis during the period from January 2014 to December 2015 at Government Institute of Rehabilitation Medicine, Chennai, India. Data was collected from the medical records as well as through interview of the amputees.

40 Upper limb amputees who had received Prosthetic at least 6 months ago were called for follow-up. Proforma was filled using data from Medical Records and by an interview. Demographic details such as age, sex and education was obtained. The cause, level of amputation, dominance of the involved limb was noted.

The data compiled through the interview included the type of prosthesis used, cosmetic or body powered and whether they had changed the type of prosthesis. The compliance was evaluated by assessing the number of hours the amputee used the prosthesis in a typical day. If prosthesis was not being used why and since when it was discarded was also considered for the data. Information regarding the occupation prior to amputation, and any change in vocational following amputation and current employment status was collected. The level of independence whether partial or complete was observed, as well as any engagement in recreational and social activities after amputation. Presence or absence of phantom pain and stump pain or any symptoms of overuse injury such as shoulder pain, wrist pain, swelling in the normal limb were observed.

RESULTS
Demographic details revealed a male preponderance in the age group of 20 to 35 years. Involvement of the dominant limb was 22(55%), non-dominant limb was 14 (35%) and 4 patients(10%) were bilateral amputees.

![Fig 1. Dominance of the amputation](image)

All the 40 patients had received prosthesis – a total of 44 prostheses since 4 patients were bilateral amputees. 24 (55%) prostheses were functional body powered prostheses -16 above elbow & 8 below elbow. 20 (45%) were cos-
metic prostheses -16 below elbow & 4 wrist disarticulation. Among these 4 below elbow amputees had obtained Myoelectric prosthesis on their own from private concerns.

Majority of the amputees 26 (65%) were independent in all activities of daily living. 10 (25%) were partially dependent on their family for bathing and dressing. The 4 bilateral amputees (10%) were fully dependent for their ADL though they had functional prosthesis but did not use them as they needed assistance for donning and doffing. Moreover the body powered prostheses were heavy and were difficult to use for ADL, but was used occasionally for cosmesis.

Overuse injury of the normal side was evidenced by complaints of shoulder and wrist pain and was reported by 14 patients (35%).

10 Patients (25%) were continuing the same occupation,12 Patients (30%) had changed their occupation following the amputation.7 Patients (17.5%) were students and they were continuing their studies and 11 Patients (27.5%) have stopped working and are supported by their family members.

25 patients (62.5%) reported Phantom pain and 16 patients (40%) stump pain. This complication was common to prosthetic users and non-users. Minimal Life style modifications were done by these amputees, 70% of the amputees continued their recreational activities. Some had changed the sports to one which does not need both upper limbs like Chess, Table Tennis etc. They took part in family functions and outdoor activities some wearing their prosthesis and a few without them. However 30% of the amputees had no recreational activities and avoided socialising.

Prosthesis use of 8hrs/day was noted in 14 patients (35%) who were distal amputees using only a cosmetic prosthesis and the 4 using Myoelectric prosthesis. 4 patients (10%) used their prosthesis for 4 hours or less. Majority of the amputees, 22 (55%) have discarded their body powered prosthesis after about a month’s time, the main reasons being prostheses provided inadequate function, was heavy and the suspension caused shoulder pain.

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**DISCUSSION**

Amputation is one of the lifesaving surgical procedures performed by the orthopaedic surgeons and the general surgeons. The social, psychological and economic burden of the amputation on patient and family is enormous. The challenges faced by the upper limb amputees in restoring function is huge compared to the lower limb amputation and functional restoration is the mainstay of any amputee rehabilitation.

The majority of our patients were male patients and it is comparable to studies from many authors. In our study 55% of patients received the functional body powered prosthesis and 45% used cosmetic prosthesis while in a study conducted by the Chul Jo Hung et al.
cosmetic hand prosthesis (80.2%) was the most used upper limb prosthesis.

On functional assessment our patients found limitation in bathing and dressing as the major activities of daily living affected, while Chul Jo Hung et al 15 reported lacing shoes, removing bottle-tops with a bottle opener, and using scissors as the major functional limitations. He has also reported that the correlation between satisfaction with the prosthesis and level of amputation or prosthetic type is not statistically significant.

With regard to occupation of the amputees, in our study 57.5% of patients have either changed their jobs or have stopped working, while in the study by Chul Jo Hung et al 15, it was 69%; He also observed that clerical workers were most likely to return to work; however 17.5% of the patients in our study were students who were never employees, in addition to the 57.5% who either changed their jobs or left them.

62.5% of our patients reported Phantom-limb pain 40% reported residual limb pain, while in a study conducted by Marisol A Hanley et al 16 it was 79% and 71% respectively. They also reported that non amputated limb pain can cause the highest levels of interference and pain related disability days. It is clear that pain in the amputated limb or normal limb can be a significant factor in the functional outcome of the upper limb amputee.

Prosthesis use of 8hrs/day was noted in 14 patients (35%) and 10% (4 patients) used their prosthesis for 4 hours or less in our study which is comparable to observation made by Chul Jo Hung et al 15 where it is 44.7%. He also observed that most patients preferred cosmetic usage than functional usage. In his study only 30% reported satisfaction with their prosthesis.

Majority of the amputees, 22 (55%) have discarded their body powered prosthesis after about a month’s time, the main reasons being prostheses provided inadequate function, was heavy and the suspension caused shoulder pain. Wright et al 14 reported 38% rejection rate in his study. The main causes for poor prosthetic usage were stiff shoulders and brachial plexus injury in their study.

In a study by H.Burger et al 17 majority of the patients (70%) were prosthesis for cosmetic purposes only. The major reason for non-usage of prosthesis in this report was heat and consequent sweating of the stump.

Francesca Cordellae et al 18 has made a list of requirements of an upper limb prosthesis based on user needs. It insists on (i) acceptability on the grounds of hand function (ii) developing prosthetic systems satisfying user wishes; (iii) method to understand or questionnaires for understanding the user satisfaction with their prostheses. These requirements reinforce that the human hand is a powerful tool for sensing and means of social and physical interaction. The 21 degrees of freedom for hand and 6 for wrist and major role of thumb opposition has to be given priority while developing the prosthesis. Advances in the management of amputees need to address the above issues. Osseointegration is a new method of attaching the artificial limb to the body. This method is sometimes referred to as exoprosthesis (attaching an artificial limb to the bone), or endo-exoprosthesis. This allows better control of the prosthesis and attempted in the lower limbs. The main disadvantage of this method is that amputees with the direct bone attachment cannot have large impacts on the limb, such as those experienced during jogging, because of the potential for the bone to break. 19

The i-LIMB prosthetic hand was developed by a technology company based in Scotland. The thumb and three digits are powered individually; the little finger is slated to the third finger. The thumb can rotate, so that the hand can perform the three most common grip configurations of the human hand. The digits can be articulated to hold a mug and the thumb can be held against the phalange of the index finger to hold a key, or against the first and second digits to grasp a pen. This prosthesis is therefore anatomically more similar to that of a human than any previous prosthetic hand. It is covered with high definition silicon rubber to give the appearance of a real hand. 20

Hand prostheses that are currently available on the market are used by amputees to only a limited extent, partly because of lack of sensory feedback from the artificial hand. A pilot study has shown how amputees can experience robot-like advanced hand prosthesis as part of their own body. A perceptual illusion was induced, by which touch applied to the stump of the arm was experienced from the artificial hand. This illusion was elicited by applying synchronous tactile stimulation to the hidden amputation stump and the robotic hand prosthesis in full view. This stimulation caused referral touch sensation from the stump to the artificial hand, and the prosthesis was experienced more like a real hand. This illusion can work when the amputee controls the movements of the artificial hand by recordings of the arm muscle activity with electromyograms. 21

A traumatic arm amputation was reattached surgically for the first time in 1962 when Malt and McK-
hann22 described their experience with a ten-year-old boy, but microsurgical techniques were not used, as blood vessels were large enough to be repaired by conventional methods. In 1965, the first successful replantation of an amputated finger by microvascular technique was done by Komatsu and Tamai23 in Japan. The first microsurgical transplantation of the great toe (big toe) to thumb was performed in April 1968 by Mr. John Cobbett24 in England. In the 1970s, a number of surgeons opened the way to the routine use of free flaps to cover defects around the body.

This has paved way for the next concept of hand transplantation. With “organ transplantation” booming in the state of advanced surgical techniques, a successful transplant method is the next step forward in the rehabilitation of an upper limb amputee. The first allograft hand transplantation in India was performed by Subramania Iyer25 in Kochi, Kerala. A new hope has now risen for the upper limb amputees, to live a more dignified life, a life with quality.

CONCLUSION
Restoration of the upper limb function following amputation is the most challenging task for any Rehabilitation physician. Our study has again highlighted the issues faced by the present day problems by the upper limb amputee. With prosthetic usage for more than 8 hours being only 35%, with high overall rejection rate being 55% and symptoms of overuse injury in the unaffected limb being 35%, these finding reinforce the necessity for further research in the development of novel designs of prosthesis and in innovative concepts like allograft hand transplantation.

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