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An evaluation of the use made of cosmetic and functional prostheses by unilateral upper limb amputees

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Abstract

There is currently a distinction drawn between a prosthesis considered to be provided for purely cosmetic reasons and a functional prosthesis provided to enable the amputee to achieve basic hand function. Using video analysis the study reported in this paper demonstrates that for non-manipulative actions cosmetic prostheses are actively used in the performance of everyday tasks as frequently as functional prostheses. The study provides evidence for a cosmetic prosthesis to be presented to an amputee as a realistic initial prosthesis and not as the option of last resort if a functional prosthesis is rejected. It is also recommended that training is provided in the use of cosmetic prostheses in two-handed tasks.

Introduction

Rehabilitation of upper limb amputees is usually considered successful if the amputee wears a functional prosthesis, is observed using it appropriately during clinic based training and assessment sessions, and reports wearing it for a substantial period of the day at home and in work and social situations. Wearing a prosthesis for purely cosmetic reasons can result in the wearer being classed as an unsuccessful user of a prosthesis (Roeschlein and Domholdt, 1989; Muilenburg and LeBlanc, 1989). There is little understanding of use made of cosmetic prostheses in the everyday life of the wearer or of the actual role of functional prostheses in situations other than observations made in the clinic situation and self reports from wearers.

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A large number of studies have been conducted to evaluate the use made by amputees of their prostheses. Most of these studies have used postal questionnaires sent to upper limb amputees who have been identified from clinic records (Gaine *et al.*, 1997; Wright *et al.*, 1995; Burger and Marinček, 1994; Roeschlein and Domholdt, 1989; Millstein *et al.*, 1986). Some studies obtained information from upper limb amputees from questionnaires administered during structured interviews conducted in the clinic environment (Silcox *et al.*, 1993; van Lunteren *et al.*, 1983; Northmore-Ball *et al.*, 1980). All of these studies have relied on self reporting by amputees regarding the length and occasion of wear of their prostheses. From the reports, success of prosthetic use has been determined by the amount of reported wear and number of occasions when the prosthesis has been worn. Heger *et al.* (1985) and Northmore-Ball *et al.* (1980) used participants as their own retrospective controls in comparative studies of myoelectric and conventional prostheses by asking participants currently wearing myoelectric prostheses to recall their usage of the conventional prostheses which they had worn prior to the fitting of myoelectric prostheses. Retrospective accounts of usage have obvious limitations.

There are inherent problems with questionnaires that rely on self reporting and patient recall. Participants are likely to be influenced by motivational factors and give responses that they consider the generator of the questionnaire would see as desirable (Manstead and Semin, 1996). Postal questionnaires may be completed in consultation with or even by another person. This is likely to happen if questionnaires are sent to children or if

participants have difficulty writing. The most serious threat to question reliability is ambiguity (Oppenheim, 1983), which could be particularly relevant to the use of the words "wear" and "use" when referring to prostheses (Burger and Marinček, 1994).

A few studies have assessed the use of prostheses in a more structured way in clinic situations by timing wearers performing set tasks (Datta *et al.*, 1989; Stein and Walley, 1983). It is likely that participants assessed in a clinic situation will respond and perform in a way that is expected of them from the information and training they have been given by clinic staff. This is even more likely if the tasks administered as part of the study are the same or similar to those used in training and if the tests are administered by clinic staff. Participants' behaviour in the clinic situation may not reflect their behaviour in everyday life.

Van Lunteren *et al.* (1983) visited upper limb amputees in their own home, conducting a semi-structured interview consisting of 220 questions and observing participants performing up to 50 daily living activities (ADL). Analysis of the ADL activities was undertaken by defining specific mechanical or motor functions performed by the participants. Although different sets of participants wore cosmetic, body powered or myoelectric prostheses they appear not to have performed the same ADL tasks and therefore comparison between prostheses might be unreliable. However the study did reveal that passive grasping function is sometimes used by wearers of cosmetic hands and that the use of the direct grasping function is not generally used by wearers of functional prostheses.

In order to gain more valid and relevant information regarding normal, everyday prosthetic use it was decided to conduct a video analysis of upper limb amputees wearing prostheses and performing familiar tasks in their own homes.

Method

All amputees registered with the Cambridge Disablement Services Centre in May 1996 with a unilateral absence of an upper limb were identified from clinic records. Amputees over 80 years old were excluded as a number of them were living in residential care. Children under the age of 16 were also excluded. It was considered that amputees in both of these groups were unlikely to be routinely carrying out tasks to be used in the study. Amputees with forequarter amputations and partial hand amputations were also excluded as their prostheses were likely to be "one off" designs. All potential participants were sent a letter explaining the study and asking them if they would be willing to take part. The letter was followed by a telephone call which allowed any questions or queries to be answered and appointments to be made for the researcher to visit amputees who were willing to participate in the study. Any potential participant who could not be contacted by telephone was sent a letter asking them to contact the researcher either by telephone or letter. A stamped addressed envelope for a reply was enclosed in this communication.

All participants were visited in their own homes at a time that was convenient for them. They were asked a number of questions regarding their prosthetic history and patterns of wear. All participants were videoed performing three everyday tasks:

1. Making and serving a cup of tea or coffee.
2. Preparing a piece of toast including putting butter and jam on it and cutting the slice of toast in half.
3. Writing their name on a piece of paper, putting it into an envelope and sealing it; then after a few minutes they were asked to open the envelope and take out the letter.

These tasks were chosen as it was considered they would be regularly performed by participants and they would normally involve the use of two hands. The paper and envelope were supplied by the examiner and were identical for all participants. Participants were encouraged to use the equipment and utensils that they used daily and to wear the prosthesis and terminal device (TD) that they wore most often during the day. A small and relatively unobtrusive hand held camera was used for videoing.

Analysis of videos

A standardised category system was devised to analyse the video recordings. This system was developed using the videos from nine participants who formed a pilot group. These participants were chosen as a sample varying in level of amputation, reason for limb absence, age, gender and type of prostheses and terminal

device used. Two broad categories of actions were identified these two categories were further divided into specific descriptors.

1. Manipulative (all these actions with the exception of "change" were made by operating the functional mechanism of a TD):
   Grip – open TD and close on object.
   Release – open TD to release object.
   Hold – hold object in TD for at least 3 seconds.
   Transfer – hold object in TD and move it from one place to another.
   Change – change orientation of TD.
2. Non-manipulative (All these actions are made without operating the functional mechanism of a TD):
   Support – support object with TD.
   Stabilise – hold an object down with the TD.
   Push – push object using TD.
   Pull – pull object using TD.
   Wedge – hold object between body part and TD.
   Balance – support self with TD.
   Self grooming – touch own body part with TD.
   Steadying – hold down object using part of prosthesis other than TD.
   Prosthesis hold – hold object between body part and prosthesis other than TD.
   Prosthesis balance – stabilise or support self with prosthesis other than TD.
   Stump hold – hold object between stump and body part.

The reliability of the descriptors was assessed by an independent rater's analyses of three of the participants' videos. Agreement of 88% was found.

Analysis of the videos was done using a video cassette recorder and VDU. Each participant's video was viewed using a frame by frame analysis which allowed detailed observations of all the actions made by each participant when performing each of the three tasks. A record of each action made by each participant involving his or her prosthesis was entered on to a score sheet under the appropriate descriptor. The number of actions were than totalled for each descriptor for each participant. The computerised statistical package for social science data (SPSS) was used for the analysis.

The sample

A total of 121 potential participants was identified from clinic records. Some 66 (54%) of these agreed to take part in the study, 16 (13%) stated that they never wore their prostheses, 14 (11.5%) were unwilling to take part, and 25 (20.5%) could not be contacted and did not respond to letters sent (Table 1). Thus of the 80 contactable and relevant potential participants 82.5% participated in the study.

It is possible that potential participants who could not be contacted and who did not respond to letters were likely to be non-users. A further check of clinic records showed that 13 (52%) had no contact with the DSC over the previous 3 years. It is therefore possible to conclude that the participant group represented a higher proportion of wearers than the non-participant group.

There was no statistically significant gender differences between participants and non-participants. Amongst the male potential participants there was a significantly higher participation among amputees with a left sided absence than those with a right (X^2 =4.7, df=1, p<.05).

Table 1. Potential participants by gender, age, reason and side of amputation and willingness to participate in study. *TH=Trans-humeral; TR=Trans-radial

	Male								Female								
	Congenital				Acquired				Congenital				Acquired				
	Left		Right		Left		Right		Left		Right		Left		Right		
	TH	TR	TH	TR	TH	TR	TH	TR	TH	TR	TH	TR	TH	TR	TH	TR	Total
Participants	1	8	0	1	8	13	12	9	0	5	2	3	1	0	1	2	66
Unwilling	0	1	0	1	0	1	5	2	0	1	0	2	0	0	0	1	14
Non users	0	3	0	1	2	0	3	4	0	2	0	0	0	0	1	0	16
No contact	0	6	0	1	1	1	4	7	0	2	0	1	1	0	0	1	21
Total	1	18	0	4	11	15	24	22	0	10	2	6	2	0	2	4	121

Table 2. Average age of participants.

	Male	Female
Total potential participants (N=121)	52	46
Actual participants (N=66)	58	42
Non participants (N=55)	50	53

The age of the actual participants ranged from 16 to 79 years. Ages were recorded on the day the first contact was made by letter. Table 2 provides the average age of participants by gender. Females were on average younger than males and those females who participated in the study were on average younger than those who did not.

Fifty (76%) of participants reported that they wore their prostheses for 12 hours or more each day. Some 4 (6%) reported that they wore their prostheses for less than 1 hour a day. The average reported wearing time per day was 10 hours. There was no difference in the reported wearing time between participants who wore functional prostheses and those who wore cosmetic prostheses.

Results

For performing all three tasks, participants wore their prostheses with the TD they reported wearing most frequently. All participants completed the tasks independently. Five participants did not use their prostheses while performing any of the tasks, all of these participants had absences at trans-humeral level.

Terminal devices

Table 3 provides a list of the TDs worn by participants when performing the tasks, with the means and maximum and minimum number of actions made for each category of TD. The most worn TD was the cosmetic foam hand. Some 10 participants wore this as an integral part of a cosmetic one piece prosthesis, 3 as an integral part of an endoskeletal prostheses and 10 were fitted into the wrist unit of a standard resin prosthesis.

There was a significant difference between the categories of TDs in relation to the total number of actions made over all three tasks ($df=11$, $p<.0018$). The split hook and myoelectric hands were the most used TDs but the number of actions made with the split hooks ranged from as few as 24 actions to as many as 101 across all three tasks. This wide range in the number of actions made was observed for mechanical hands, heavy duty split hooks, cosmetic foam hands, and Steeplon hands. The maximum number of actions name with cosmetic foam hands were only slightly less than the maximum number made with myoelectric hands.

Twenty-six participants used TDs that could be considered functional i.e. the TD was capable of grasp/release action (1, 2, 3, 4, 5 in Table 3). However these TDs could only be used actively if the operating mechanisms were in place. Of the 26, 20 participants' mechanisms for operating the functional capacity of their TDs were in place, for the purpose of further analyses

Table 3. Total number of actions made for each category of TD used by participants across all three tasks for all descriptors

		Actions		
Terminal device	Total	Mean	Max.	Min.
1. Myoelectric hand	3	58.6	78	47
2. Mechanical hand	6	18.6	53	5
3. Split hook	12	58.6	101	24
4. Heavy duty split hook	4	38.0	84	4
5. Rubber hand with operating thumb	1	64.0	64	64
6. Rubber hand	1	43.0	43	43
7. Foam hand	23	24.5	71	0
8. Reinforced foam hand	3	34.6	38	28
9. Steeplon hand	8	24.5	45	5
10. Steeplon hand with spring thumb	2	7.0	14	0
11. C hook	1	21.0	21	21
12. Sack hook	2	36.0	47	25

Table 4. Mean, maximum and minimum number for all actions and non-manipulative actions only for each group of TDs

		All actions			Non-manipulative actions		
Group	Number	Mean	Max.	Min.	Mean	Max.	Min.
1. Actually functional	20	51	101	4	30	77	4
2. Potentially functional	6	30	51	9	30	51	9
3. Cosmetic	37	24	71	0	24	71	0

this group was classed as the *actually functional* group. Six participants did not have the mechanisms for operating their TD in place, this group was classed as the *potentially functional* group. Some 40 participants used TDs that had no grasp/release function. Of these 37 could be classed as cosmetic i.e. the TD was in the shape of a hand (6,7,8,9,10 in Table 3). Three could be classed as tools (11, 12 in Table 3). The numbers in these last two groups were so small that they were not included in further analysis

Actions

Overall there was a significant difference between the groups in relation to the total number of actions made across all three tasks for all descriptors (df=2, p=<.0005) with the actually functional group performing more actions than the potentially functional and cosmetic groups.

Manipulative responses were virtually possible only amongst those wearing actually functional prostheses, when manipulative descriptors were removed from the analyses there was no significant difference between the three groups in relation to the number of actions made across all three tasks for non-manipulative descriptors (df=2, p<.5615) (Table 4).

As can be seen from Table 5, stabilising was the action most frequently performed by all three groups of TDs. There were no statistically significant differences between the 3 groups in relation to the number of actions made for each non-manipulative descriptor with the exception of *pull*. The cosmetic group made less pull actions (df=2, p<.0138). Pull would have been a difficult action to perform with a foam hand.

A series of ANOVAs were performed to explore the effects of level of amputation, side of amputation, reason for limb absence (acquired

Table 5. Total number of actions for each descriptor over all three tasks for actually functional, potentially functional and cosmetic TDs

		Act-functional TDs (20)		Pot-functional TDs (6)		Cosmetic TDs (37)	
	Descriptor	Total	Average	Total	Average	Total	Average
Manipulative	Grip	127	6.35				
	Release	123	6.15				
	Hold	120	6				
	Transfer	30	1.5				
	Change	21	1.05	3	0.50	1	0.02
Non-manipulative	Support	38	1.9	10	1.66	63	1.7
	Stabilise	337	16.85	105	17.5	483	13.05
	Push	86	4.3	23	3.83	99	2.67
	Pull	28	1.4	6	1.0	9	0.24
	Hold/TD	4	0.2	3	0.50	18	0.40
	Balance/TD	15	0.75	5	0.83	60	1.62
	Self grooming	43	2.15	11	1.83	34	0.91
	Steadying	8	0.4	0	0	15	0.18
	Pros. hold	27	1.35	10	1.66	63	1.7
	Pros. balance	3	0	5	0.83	13	0.35
	Stump hold	17	0.75	4	0.66	17	0.45

or congenital), gender and age on the total number of actions for all descriptors over all three tasks. There was a significant effect of level of amputation (df=2, p<.000); participants with a trans-radial (TR) absence performed significantly more actions over all three tasks than participants with trans-humeral (TH) absences. None of the other effects proved significant.

Of the 46 participants with an acquired absence, 24 (52%) had lost a dominant hand and 18% (39%) a non-dominant hand. Four (8%) considered they had been ambidextrous before their amputation. The effect of hand dominance before amputation and side of amputation on the total number on non-manipulative actions made over all three tasks for amputees for acquired amputations only was explored. No significant relationships were found.

Discussion

A number of potential participants when contacted by telephone judged they would be unsuitable for the study as they did not "use" their prostheses. When asked if they "wore" their prostheses they said yes but stated that they did not use the prostheses as they had been trained to use them. Some said they only wore their prostheses for cosmetic reasons. Most amputees expressing these views did agree to take part in the study when it was explained to them that the emphasis would be on performing everyday tasks and not demonstrating their skills in prosthetic use. Had these participants just responded to a questionnaire an accurate record of their prosthetic use may not have been obtained.

Twenty (30%) participants wore prostheses that could be activated for manipulative functional use; 4 participants in this group made no manipulative actions with their TDs. If active manipulation of a TD is seen as the determinant of good prosthetic use then the number of "good" users found in this study would be less than 25%. If involvement of the prostheses in tasks is seen as the determinant of prosthetic use then many more participants could be considered to be good users of prostheses. There was a wide range in the number of actions made by participants in all three groups. This highlights the need for a systematic review of training. The use of video to record performance of familiar tasks would be an excellent method for reviewing an amputees' use of their prostheses. This video could be played back to the amputee as a means of providing feedback and stimulating discussion relating to the use of the prosthesis.

There was statistically no difference between groups in relation to the total number of non-manipulative actions performed. Participants who wore cosmetic prostheses used them non-manipulatively on average as frequently as participants who wore functional prostheses. The small but non-significant difference between the groups in relation to the mean for non-manipulative actions made (Table 4) could result from the fact that participants issued with functional prostheses are given training in the use of their prostheses and are likely to be re-assessed when visiting the clinic. Amputees who choose to wear cosmetic prostheses do not routinely receive training in the possible use of the prostheses in performing two-handed tasks. It is more likely that this group use the postal service for repairs and replacements and therefore make fewer visits to the clinic and do not have the use of their prostheses regularly reviewed. It is not surprising that amputees who wear cosmetic prostheses unjustifiably consider themselves to be non-users.

Clearly for the small group of amputees who used the operative functions of their prostheses a level of skill had been achieved in the use of their TDs for grip, release and hold but it could be argued that these three actions are all part of a single grasping action. If this criterion had been applied to the recording of the actions made by participants using functional TDs then there would have greater similarity between the groups in relation to the total number of actions made.

Evidence from this study provides support for the prescription of a cosmetic prosthesis for an amputee's first prosthesis. It would be important that training be given and progress reviewed. If the amputee decides that they need a greater range of manipulative skills then a functional prostheses could then be considered.

This study's finding that pre-amputation hand dominance made no significant difference to the number of actions made by participants wearing a prostheses agrees with other studies (Gaine *et al.*, 1997; Roeschlein and Domholdt, 1989). However there would appear to be evidence from this study that amputees with a left-sided absence are more likely to wear prostheses than those with a right absence. The number of amputees

registered with the Cambridge DSC with an acquired absence on the right side was higher than those with a left absence yet a significantly higher number of amputees with a left sided absence agreed to take part in the study. Interestingly it was also found that there was a significantly higher number of unilateral congenital amputees with a left-sided absence than those with a right-sided absence registered not only with the Cambridge DSCs but nationally (Fraser, 1997). It might be possible to conclude from these findings that amputees with a left absence are more likely to wear prostheses than those with a right abscence. The reason for this could be that a prosthesis fulfils more satisfactorily the functions of a left or non-dominant hand than those of a right or dominant hand. An amputee expecting to perform fine motor tasks with a prosthetic device is frequently frustrated by lack of skill and speed, which can lead to the rejection of the prosthesis. More emphasis on two-handed tasks with the use of prosthetic devices for holding and stabilising and the intact hand for manipulating might be the best approach when training unilateral upper limb amputees in the use of their prostheses.

Amputees with an absence of an upper limb at trans-humeral (TH) level made less use of their prostheses when performing the tasks yet they reported wearing their prostheses on average as many hours a day as amputees with an absence at trans-radial (TR) level. It could possibly be concluded that TH amputees were more likely to be wearing their prostheses for cosmetic reasons or as "sleeve fillers". However it was found in a separate study of two amputees with an absence of an upper limb at TH that better standing balance was achieved when they were wearing a prosthesis than when they were not wearing one (Clapp, 1998). Both amputees appeared unaware of their improved balance when wearing their prostheses but both had commented that they felt "lost" without their prostheses. This finding suggest that a prostheses has a valuable function in maintaining symmetrical balance and body posture. A comparative study between amputees who wear prostheses and those who do not in relation to posture and balance would be of interest.

Conclusion

This study has shown that prostheses that might be considered to be worn for purely cosmetic reasons are in fact used functionally when performing everyday tasks. It would therefore seem to be important that an amputee who chooses to wear a cosmetic prostheses is not considered to be a poor user and that a cosmetic prosthesis is presented to amputees not as an option only if functional prostheses are rejected but as a realistic alternative choice and that effective training in the use of cosmetic prostheses is routinely given.

The role the prosthesis plays in what might be considered two-handed tasks should also be reviewed in the elight of this study. TDs appear to be designed primarily to reproduce aspects of fine hand function i.e. grip, release. In training amputees to use their prostheses they are frequently encouraged to practice picking up small objects with their TDs (Lake, 1997). The unilateral amputee may well demonstrate a high level of skill in the performance of these tasks in the clinic situation but is more likely to use his intact hand to execute these tasks in everyday life. He/she may become frustrated when performing such tasks with the prostheses if, as has been shown, they take longer than with the intact hand (Stein and Walley, 1983). If the role of the prostheses in supporting, stabilising, pushing, pulling, holding and facilitating balance in everyday life situations is accepted as more useful than that of manipulating small objects in the clinic situation; this could have a major influence on the design of prostheses and TDs and also influence training. A number of participants in this study were found to be using Steeplon hands. They reported that the shape of this hand was useful for pushing and pulling, and carrying things. They could lean on it to achieve balance and stabilise and support objects. Most of these participants had been issued with a foam hand to replace their Steeplon hand but they had found the foam hand did not perform the functions that the Steeplon hand did. The fingers of the foam hand could not be shaped to achieve carrying, or pushing or pulling; neither were they robust enough to lean on even when reinforced. Unlike the Steeplon hand the foam hand could not be easily cleaned, an important consideration if working in an area operating strict health and safety checks. Due to problems in manufacture the Steeplon hand is no longer available however the features of this highly "functional" if not cosmetically acceptable TD should be seen as important in the design of TDs in the future.

This study demonstrates that substantial improvements are possible in both the design and training in the use of upper limb prostheses.

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