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Forearm amputees' views of prosthesis use and sensory feedback

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ABSTRACT

Study design: Qualitative descriptive.
Introduction: The lack of sensory feedback in today's hand prostheses has been in focus recently but the amputees' experiences need to be further investigated.
Purpose: To explore forearm amputees' views of prosthesis use and sensory feedback.
Methods: Thirteen unilateral congenital or traumatic forearm amputees were interviewed. The transcribed text was subjected to content analysis.
Results: Prostheses both facilitate and limit occupational performance. Appearance is important for identity and blending into society. The feeling of agency regarding the prostheses is present but not that of body ownership. Future expectations concerned improved mobility, cosmetics, and sensory feedback.
Conclusions: This study allows a deeper understanding of the complex relationship between a prosthetic device and the wearer. Today's prostheses allow the wearer to feel agency concerning the artificial limb but the lack of sensory feedback seems to be an important factor still blocking the achievement of body ownership of the prosthesis.
Level of evidence: Not applicable.

Introduction

Losing a hand or part of the arm through amputation is a devastating trauma for the person affected. Loss of sensory and motor function due to the amputation may be associated with disability, activity limitations and participation restrictions,[1] and are previously described as pain, dissatisfaction of activities of daily living and employment difficulties,[2,3] which may also influence the experience of health-related quality of life.[4] Whether the amputation is congenital or caused by a trauma it may be associated with disability.[5–8] Hand prostheses do not come even close to compensating for this loss. In recent years the technological progress has made advancements when it comes to grasp possibilities and range of movements of fingers,[9,10] but there are still drawbacks when it comes to conscious sensory feedback.[11,12] There are today no commercial available prostheses with sensory feedback.[12] The sense of touch plays an important role in the function of the hand and without a sensory feedback system the prosthesis cannot be used like the hand to explore the environment through touch.[5] Lack of sensory feedback in hand prostheses may limit their usefulness, and may also be one reason for their rejection.[13–16] A residual limb with good tactile sensation is often more useful than a prosthesis with no sensory feedback.[15,17] Vision and hearing can compensate to some extent for the lack of tactile sensation when handling objects,[14,18,19] but the precision that is needed for fine or complex movements and to control and moderate the exact grip force needed to avoid breaking or dropping the object, can be hard to learn without sensory feedback.[19,20] Prostheses today although lacking artificial sensory feedback can pass on some vibrotactile information to the user through the socket attached to the residual limb.[16] This type of rough sensory feedback can be useful but is far from accurate.[17] The lack of fine tactile sensation can make it hard to feel that the prosthesis is a part of the body.[15] Surveys have shown that sensory feedback is something that upper limb amputees want to have in their prostheses.[14] It has been suggested that phantom sensation may be reduced by active prostheses use[21] and sensory feedback is suggested to enhance this effect.[22]

Three types of sensory feedback in prostheses have been described in a recent review; to substitute sensory input with for example auditory input (substitution feedback), pressure to the prosthesis giving pressure to the skin (modality matched feedback) and when the input to a specific part of the prosthesis is experienced in the same lost body part it is called somatotopically matched feedback.[8,10,15,17,23–31] This study is based on knowledge of the importance of tactile sensation and the idea that sensory feedback in hand prostheses can improve their functionality and the users' sense of body ownership of the prosthesis. To our

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knowledge there are no previous qualitative studies that explicitly focus on the amputees' experiences of sensory feedback. There is a gap between current research prototypes and clinical application of prostheses with sensory feedback. It is therefore important to illuminate the prostheses users own experiences, needs and expectations for future research and prosthesis development.

The purpose of this study was to explore forearm amputees' views of prosthesis use and the perception of sensory feedback.

Methods

Study design and sample

A qualitative descriptive method with inductive approach was used in order to deepen knowledge of amputees' views of prostheses use. Two regional prostheses centers in Sweden were involved in the selection process and ongoing patients at either one of the two centers were selected. The inclusion criteria for the study were that the participants: had to be experienced prosthesis users in daily life; were adults (above 18 years of age); had unilateral transradial amputation due either to a traumatic amputation or a congenital reduction deficiency; suffered from no current psychiatric or cognitive disorders; and were able to communicate in Swedish. Purposive sampling was used giving a variation in age and gender. The aim of the study was to explore different views of sensory feedback and prostheses use in general. We therefore included participants both traumatic and congenital amputees having experiences of either myoelectric or cosmetic/esthetic prosthesis or both. Fourteen traumatically amputated met the inclusion criteria. Of these, three could not be reached, two refused for lack of time, one for the long distance to the clinic, and one gave no reason for declining. Seventeen individuals with congenital reduction deficiency also met the inclusion criteria. After six interviews with congenital amputees no new information was obtained which indicated that saturation was reached. The total amount of participants that were interviewed was 13.

Materials used

A semi-structured interview guide containing open-ended questions was used and the participants were asked to describe their experience of prosthesis use, the opportunities provided by the prosthesis and its limitations, sensory feedback from the prosthesis, body ownership of the prosthesis, phantom sensation and what they would like to see in the area of prostheses development. Follow-up questions were asked such as "How did you experience that?" "Can you describe that in more detail?" or "Can you give some examples of that?". See Appendix 1.

Data collection and ethics

The participants were contacted by telephone and given verbal information about the aim and the voluntary nature of the study. If they agreed to participate a meeting for an interview was arranged. Written information was given about the voluntary nature of the study and confidentiality was assured. Written informed consent was obtained. This study was performed according the ethical guidelines stated in the Helsinki Declaration and approved by the Regional Ethics Review Board in Lund (Dnr 2012/778). A pilot interview was carried out to evaluate the interview guide and minor improvements were made. All interviews were conducted and tape-recorded by the first author in a quiet room at the clinic, despite two interviews that were conducted at the participants' office as requested. The interviews lasted between 25 and 60 min and started with a repetition of the aim of the study. The interviews were recorded and transcribed verbatim by a secretary and the transcripts were then checked for accuracy by the first author. The first author translated the selected citations in the text from Swedish into English and the last author verified the translation.

Data analysis

The text was read and reread by the co-authors and subjected to qualitative content analysis.[32,33] Both co-authors started an independent analysis by reading each interview in order to gain a general impression of the content. Meaning units described as words or sentences related to each other through their content and related to the aim of the study were then identified.[33] The co-authors discussed their impressions of the text and compared their selected meaning units. A shortening and condensation of the meaning units into codes was made without losing the core. Codes are described as the labels of the meaning units.[33] Meaning units and codes that were similar in content were grouped together into sub-categories and abstracted into categories. Within each category and subcategory, similar statements were analyzed critically and questioned, then read and compared until a reasonable interpretation was reached. The categories and sub-categories were then discussed and adjustments were made to ensure that all aspects in the text were covered. Finally the categories were compared with each other and with the text. Regarding the authors' preunderstanding the first author is an occupational therapist working in rehabilitation after upper limb amputation and prosthetic training. The last author is an occupational therapist and researcher familiar with qualitative research methodology.[34,35] Both authors work in a specialized unit for hand surgery and hand rehabilitation. Both are educated in qualitative research methods.

Results

The participants represented a variety of occupations e.g. engineer, cleaner, receptionist, waiter, teacher and job coach. Nine of the participants lived together with their spouse or partner and of these, eight had children at home. The time since they had received their first prosthesis varied between 5 and 65 years with a median of 27 years. All the participants wore their prosthesis every day. The majority ($n = 7$) stated that they wore the prosthesis for the whole day – from early morning until bedtime, four wore it half the day and two wore the prosthesis for a shorter period while performing special tasks, Table 1. Ten participants had attended one or two previous laboratory experiments concerned with sensory feedback linked to the phantom hand map,[15,23,24,29,30] and one participant has been involved in tests with a prosthesis prototype with the sensory feedback concept.[24]

The text revealed the influence of the prosthesis on activity and participation, with or without it, as well as the participants' perception of the "hand" and body image. In addition the participants' descriptions of future expectations in the area of prosthesis development were highlighted. An overview of the main categories and the sub-categories is presented in Table 2.

Table 1
Participant characteristics in the study ($n = 13$)

Gender: Male/female (n)	5/8
Age: Average (range)	43 (29–71)
Cause: Trauma/congenital (n)	7/6
Prosthesis: Esthetic or cosmetic/myoelectric[a]/both (n)	5/6/2
Dominant hand amputated: Yes/No (n)	5/8

[a] Otto Bock System-Elektrohand Variplus speed.