

VA STUDY TO OPTIMIZE THE GEN 2 DEKA ARM: QUALITATIVE FINDINGS

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INTRODUCTION

In 2005 DARPA announced its "Revolutionizing Prosthetics" program and funded the development of the DEKA prosthetic arm. When the Gen 2 prototype DEKA Arm System became available for clinical research and testing, DARPA signed a Memorandum of Agreement with the Department of Veterans Affairs (VA) and provided additional funds to DEKA to support a VA Optimization Study of the DEKA Arm system. The purpose of this study was to obtain user feedback to inform design of the next prototype, the Gen 3 Arm.

The DEKA Arm is designed for users with amputations at the forequarter, shoulder disarticulation, transhumeral or transradial level. There are three versions available: shoulder configuration (SC), humeral configuration (HC) and radial configuration (RC). The Gen 2 Arms that we tested had 6 hand grips (power, chuck, lateral pinch, open pinch, closed pinch and tool grip), and used a variety of control inputs including EMGs, air bladders, and foot controls (Force Sensitive Resistors [FSR]) and Inertial Measurement Units [IMUs]).

STUDY DESIGN AND PURPOSE

The VA study was an iterative usability and optimization study employing a multiple case study design with a mixed-methodology approach. Concurrent quantitative metrics and qualitative data were collected to provide richer, more valid, and more reliable findings than a design based on either the qualitative or the quantitative method alone. The purpose of this paper is to describe our VA subjects' perspectives on using the Gen 2 DEKA Arm.

METHODS

Subjects

Twenty-six subjects were fit with the DEKA Arm (22 men and 4 women), ages 19 to 82 years. Five were on active duty in the U.S. military, 13 were veterans (not on active duty), and 8 had never served in the U.S. Armed Forces. Twenty-three subjects had unilateral upper arm loss and 3 had bilateral upper limb loss. Ten subjects were fit with SC DEKA Arms, 8 were fit with an RC, and 8 were fit with an HC. Four of the 10 subjects fit with a SC had short

transhumeral amputations. Subjects were seen at one of four participating sites, VA NYHHS (Manhattan), James Haley VA (Tampa), Long Beach VA (Long Beach), and the Center for the Intrepid (CFI).

Data Collection

Subjects were told that the primary objective of the study was to obtain feedback on the DEKA Arm prototype in order to inform the design efforts of the next prototype, the Gen 3 Arm. Their opinions about all aspects of the DEKA Arm were solicited throughout the study through surveys, semi-guided interviews, audio memos, and videotaped training and testing sessions. Subjects had approximately 20 hours of training in the use of the DEKA Arm (some subjects with SC configuration had up to 30 hours of training) and participated in multiple testing sessions.

Data Analysis

Qualitative data analysis involved open coding of transcripts from audiotapes, memos from videotaped sessions, and participants' responses to open-ended survey questions. Open coding was used to reduce the data to a set of important themes or categories. The data was synthesized in a cross-group analysis to compare similarities and differences in experience and recommendations of participants by DEKA Arm level. At each stage of data collection and analysis, members of the research team discussed key case findings and interpretations.

RESULTS

Main Impressions

At the end of the study subjects were asked, "What is your impression of the DEKA Arm?" A majority of subjects (21/25, 84%) had favorable impressions; 14 of these as unequivocally favorable and 7 were favorable with critical feedback. A higher percentage of subjects using the SC Arm were classified as unequivocally favorable (70% of SCs; 43% TC; 50% RC). The 7 subjects who had generally favorable impressions but had critical feedback commented on issues, including weight, reliability, ROM of the wrist, and the need to put the arm in standby mode while walking. Four subjects (16%), including one subject at each level, had unfavorable impressions of the DEKA Arm at the end

of the study. Weight was the most commonly cited criticism, but it was only one among a variety of issues mentioned.

Function with the DEKA Arm

Twenty-one of the 22 subjects who used a prosthesis prior to the study gave examples of new activities they had been able to perform with the DEKA Arm during the training protocol that they had not been able to perform with their current prostheses. The most frequently mentioned types of new functional activities were self-care and everyday household/office tasks. At the end of the study subjects were asked if there were any activities they could not do with the DEKA Arm that they were able to do with their current prostheses. Among the 22 subjects who answered this question, 77% said "no" while 23% answered "yes." Examples of activities from those who answered "yes" included: wash myself, drive a car, ride a bike. Some of these tasks were obviously related to limitations of the foot controls and the level of water resistance of the Gen 2 prototype.

Desire to Receive a DEKA Arm in the Future

At the end of the study subjects were asked if they would want to receive a DEKA Arm in the future and to explain why or why not. Nineteen out of 25 subjects (76%) answered "Yes." Many subjects explained that they wanted a DEKA Arm because of increased overall function, saying, for example, "will make everyday activities better", "would open up a whole new world of independence and quality of life." Eighty percent of those using an SC Arm, 86% of HC Arms, and 63% of RC Arms clearly wanted a DEKA Arm in the future. Two subjects stated definitively they did not want the Arm in the future (1 SC, 1 HC), while 4 said "Maybe" (3 RC, 1 SC). Among the subjects who said "Maybe", all that were users of the RC listed weight as a reason they may not want the Arm system.

Feedback on Grips

At the end of the study subjects were asked which, if any, of the hand grips they found most useful. Open and closed pinches were most frequently mentioned as most useful, followed by lateral pinch and chuck. At the same time subjects were also asked if there were any grips they would not use: 64% stated there were no grips they would not use and 36% thought there were one or more grips they would not use. Tool grip was most listed most frequently, followed by chuck grip.

Concerns about taking the DEKA Arm home

Subjects were asked to list their concerns about using a Gen 2 DEKA Arm at home. Twenty-one out of 25 subjects who responded to this question (84%) expressed at least one concern about using the prototype DEKA Arm at home, largely relating to repairs, water resistance, and weight. Despite concerns, 76% said they wanted to receive a DEKA Arm in the future. Subjects provided feedback on features of the arm system such as cosmesis, weight, controls, donning and doffing.

Recommended Improvements

Subjects were asked, "How do you think the DEKA Arm system could be improved to make it easier to use and more acceptable to other persons with upper limb loss?" The most frequently mentioned improvements were 1) to make it lighter in weight and 2) to improve controls. The next three most frequently mentioned categories related to 1) making the Arm system smaller/wireless/with less external components; 2) improving the wrist motions and 3) improving the socket fit and/or ease of donning and doffing the Arm system. Six subjects suggested improvements in cosmesis. Other less frequently mentioned improvements related to reducing noise, and improvements to the inflatable bladders or inflation process for socket bladders, made by 3 HC subjects.

CONCLUSION

Our subject's overall impressions of the Gen 2 DEKA Arm were favorable. The majority of subjects expressed a desire to obtain DEKA Arms in the future. Many of these same subjects also expressed critical feedback about the Arm, but this fact alone did not equate with desire to receive a DEKA Arm in the future. All subject feedback was shared with DEKA and many suggested improvements have been addressed in the Gen 3 design. Clinical studies of the Gen 3 Arm are now underway.

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