Utilizing Wrist Movement for Prehension in an Atypical Case of Bilateral Partial Hand Amputation

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ABSTRACT

This case study presents upon the unique utilization of wrist movement for prehension in an atypical case of bilateral partial hand amputation. The patient in question presented with a single residual metacarpal on both extremities. These digits were sensate. Mobilization was limited to wrist flexion with limited extension range. Recognizing the value of these sensate digits and the remaining active motion of the distal extremities, a two-position APRL thumb was placed on the ventral aspect of the wrist to provide an opposition post to the residual digit. This approach was used bilaterally, permitting bilateral active prehension with a sensate digit.

This concept was further exploited in the fabrication of custom silicone restoration prostheses in which the individual digits mobilized the metacarpal region of the hands bilaterally while the silicone thumbs were stabilized against the ventral aspects of the forearms.

The prosthetic solutions enabled the patient to benefit from the residual sensation and mobility afforded by his unique presentation to produce bilateral active prehension.

INTRODUCTION

Service missionaries in Uganda, Africa identified an individual with atypical bilateral traumatic partial hand amputations. After failing to identify capable resources in his home country, the patient was brought to the United States for prosthetic rehabilitation. The patient's presentation included bilateral preservation of a single metacarpal (suspected to be the first but possibly the second). These residual digits retained the advantage of sensation and could be actively mobilized using wrist flexion (Fig 1).

Following a remote Skype-assisted evaluation, attempts were made to identify local resources that might provide acceptable prosthetic care. When these could not be identified, the decision was made to bring the patient to the US for prosthetic rehabilitation.

Figure 1: Active wrist flexion range of motion with a single distal metacarpal digit bilaterally

PRIMARY PREHENSILE DEVICES

Recognizing the value of exploiting the active mobilization provided by the wrist joints and the preserved sensation of the residual digits, the use of a two position thumb mounted proximal to the wrist joints was explored with wrist flexion closing the grip and wrist extension opening the grip (Fig 2).

Figure 2: Simulation of wrist-enabled prehension with the wrist joint extended and flexed.

With this approach validated, test sockets were fabricated to allow dynamic use of this prehensile approach (Fig 3). These were constructed of fiberglass, molded directly over flexible inner sockets with the two position APRL thumb units epoxied to the fiberglass frames.

Figure 3: Demonstration of tip prehension and writing using a test socket prosthesis.

With the patient demonstrating functional prehension bilaterally, these devices were subsequently manufactured definitively. In the definitive construction, the flexible sockets were trimmed distally to the wrist crease to augment the exposed skin and associated sensory input as well as the mobility of the residual digits. Leather sleeves were fitted to the thumb component to increase the localized coefficient of friction and subsequent prehension (Fig 4).

Figure 4: Definitive fabrication of the primary prehensile prostheses

SECONDARY COSMETIC PROSTHESES

In addition to the primary prehensile devices, the patient was concerned about the cosmetic appearance of the partial hand amputations and the associated limitations related to societal interactions and educational and vocational opportunities. Accordingly, custom silicone restorations were additionally fabricated. In doing so, attempts were made to facilitate a degree of active prehension using the principles described above.

In the evaluating the dynamic fit of inner silicone sockets, material bunching in the volar aspect of the wrist was observed. This was addressed by removing a wedge of silicone in the region to permit full flexion mobility at the wrist (Fig. 5).

Figure 5: Removal of a silicone wedge at the ventral aspect of the wrist permitted additional wrist flexion mobility in the silicone inner socket

This done, the external cosmetic silicone elements were constructed. The metacarpal region of the restoration was fabricated over the residual digits bilaterally, the finger restorations extending distally. The thumb restorations were brought proximal to the wrist such that wrist flexion reduced the distance between the silicone fingers and the silicone thumb (Fig 6). This created a degree of active opposition that allowed for limited prehensile function.

Figure 6: Demonstration of active prehension with the silicone restoration prostheses using active wrist motion, including holding a partially filled cup of water

HEAVY DUTY PROSTHESES

Recognizing that both of the prosthesis types described to this point would best be described as light to medium duty solutions, a final set of body powered prostheses with heavy duty terminal devices were also provided. These were controlled by individual figure-9 control harnesses allowing the patient to mix devices on task specific bases (Figure 7). Tamarak Flexure joints at the radial aspect of the wrists preserved wrist flexion mobility. This flexion, combined with residual pronation and supination permitted reasonable prepositioning of the body powered terminal devices

Figure 7: Patient utilizing his primary prehensile device on his left extremity and a heavy duty body powered device on his left extremity

CONCLUSION

Following prosthetic fittings, the patient returned to Uganda. As expected, the prehensile devices became his primary resource for upper limb function. He also reported use of the heavy duty prostheses for more aggressive tasks like gardening and hauling water. The silicone prostheses were rarely worn with the patient citing discomfort. Following the departure of the Uganda-based Service Missionaries, the patient was lost to further follow up.

ACKNOWLEDGEMENTS

Paul Tanner fabricated the Silicone Prostheses