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Prosthetic reconstruction to restore function in transcarpal amputees

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Summary Mutilated hands at the distal level may pose a challenge for reconstruction. Biological treatment options may require multiple surgical interventions and a long rehabilitation course with little hope of good functional outcome. Standard hand prostheses are also not an ideal solution, as they are too long and cumbersome for partial hand injuries. This paper outlines the functional outcomes of prosthetic reconstruction with devices customized for the transcarpal amputation levels. The functional outcome was evaluated with the Action Research Arm Test (ARAT), Southampton Hand Assessment Procedure (SHAP), and the Disabilities of the Arm, Shoulder and Hand questionnaire (DASH). Functional evaluation was performed at least 12 months after final fitting. Psychological assessment was performed with the Short Form-36.

The three patients achieved a mean ARAT score of 35.67 ± 0.58. The average SHAP score was 74 ± 7.81. The average DASH score was found to be 16.11 ± 12.03. The reconstructed hand achieved a score of 75.27 ± 8.16% in SHAP and 62.57 ± 1.02% in ARAT in relation to the healthy hand. All patients exhibited average physical and mental component summary scales in the Short Form-36.

The majority of transcarpal amputations are seen in manual laborers due to work-related trauma. Returning to work is the main goal in such young and otherwise-healthy patients. As shown with this study, prosthetic fitting results in quick and reliable functional reconstruction. Therefore, this treatment should be considered as an option during the initial decision-making process of reconstructing difficult traumatic injuries of the hand.

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Introduction

Trauma is the leading cause of upper-limb amputations, especially in young individuals.[1] Most of these amputations result from work-related trauma, burns, or soft tissue avulsion injuries.[1] This is in contrast to lower-limb amputees, which mainly comprise elderly patients with end-stage vascular diseases or diabetes.[2] The loss of a hand or parts thereof may permanently impair one's working status and independence in daily life.[3] Hands are essential to one's interaction with one's environment, one's appearance, and one's personal and professional development. As such, mutilating injuries impair psychological well-being and quality of life.[3]

Due to improvements in acute trauma care and microsurgical techniques, limb salvage is possible in most cases. Even if multiple digit amputations are necessary, a sensate partial hand is superior to all prosthetic options.[4] However, in some cases, due to the severity of the injury, the entire hand must be amputated at the transcarpal level. These distal amputations pose a major challenge, as biologic reconstructions are very limited.[5] Before the microsurgical era, the Krukenberg procedure was a sophisticated method to rehabilitate below-elbow amputees with long residual limbs.[6] In patients with bilateral amputations, the Krukenberg procedure offers the capability of a sensate pinching forceps. As microsurgical techniques were introduced to surgical practice, free vascularized tissue transfers presented new options with the Krukenberg procedure declining in popularity.[5] Currently, it is possible to restore some prehensile function using microsurgical techniques such as single or multiple toe-transfer procedures.[7,8] Although excellent outcomes have been reported for allogeneic human hand transplantation at this level of amputation, immunosuppressive side effects may not outweigh the benefits for a unilateral hand loss.[9–11] Alternatively, for transradial amputees, functional restoration with a prosthetic device may provide the best option with no need of additional surgery or lifelong medication.[11]

Historically, the first electronically driven hand prostheses were pioneered by Reinhold Reiter at the end of World War Two.[12,13] Ergonomic and functional prosthetic features have improved over time, and prosthetic fitting with myoelectric devices has been established as the standard of care in upper-limb amputees.[14,15] These myoelectric systems are controlled by two individual muscle groups at the remnant limb of the amputee, using one muscle group to open and another to close the hand, with some advanced devices allowing movements of the wrist or specific grip patterns.[12] However, standard myoelectric prostheses cannot be used in transcarpal or transmetacarpal amputees, as the remaining limb is too long to match the length of the contralateral arm after prosthetic fitting. As the wrist and forearm still retain some useful function, the residual limb must not be shortened to provide space for parts of the prosthesis. For these cases, compact and low-weight myoelectric prostheses have been specifically designed,[16] although clinical outcomes have not been reported. These terminal devices enable a prosthetic fitting of transcarpal or short transmetacarpal amputees by matching the length to the contralateral arm. Due to the limited space, no active rotator can be installed, as residual wrist movements are sufficient for limited pronation and supination.

The best treatment is selected based on multiple factors, including the risks, time commitment, patients' expectations, and costs.[17] Ultimately, the treatment with the least risk should be chosen in the patient's best interest. In this study, we present the functional outcome of three transcarpal amputees after customized prosthetic fitting using questionnaires and objective hand function tests.

Patients and methods

Patients

Three patients who underwent prosthetic fitting after unilateral transcarpal amputation of the hand were enrolled in this case series to evaluate the functional outcome of prosthetic reconstruction. All three patients were enrolled from the special outpatient hand clinic at the Medical University of Vienna. They were fitted with a customized Transcarpal Hand DMC Plus myoelectric prosthesis (Otto Bock Healthcare Products GmbH, Vienna, Austria) (Figures 1–3). All three patients provided informed consent for participation in this study, which was reviewed and approved by the local institutional review board at the Medical University of Vienna.

Outcome measures

The global upper-extremity function was evaluated using the Action Research Arm Test (ARAT), Southampton Hand Assessment Procedure (SHAP), and the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire, which monitor hand and extremity function that is closely related to activities of daily living (ADLs).

The ARAT is an observational test used to determine upper-limb motor function, and it has been validated for use in patients with cognitive impairment of hand control.[18] It consists of four sections with different tasks and a maximum of 57 points attainable.[18] The ARAT was performed according to the standardized approach of Yozbatrian et al.[19] The SHAP is a clinically validated hand function test that was originally developed to assess the effectiveness of upper-limb prostheses; it has also been applied to the assessment of musculoskeletal and