18 Functional and Psychosocial Outcomes of Bionic Reconstruction and Impact on Quality of Life, Body Image Perception and Deafferentation Pain

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Global brachial plexopathies represent one of the most severe nerve injuries and usually affect young individuals at the prime of their life. Restoration of motor function in the shoulder and elbow do not automatically translate into improved functionality in daily life and/or psychological well-being. A vast majority of brachial plexus patients report to feel functionally limited to a great extent due to non-recovery or elbow recovery only. As with traditional primary and secondary reconstructions, it is thus important to highlight functional as well as psychosocial outcome variables following bionic reconstruction in patients with complete brachial plexus injuries. Here we describe effects of bionic hand reconstruction on various aspects of life including functionality, overall quality of life, body image, and deafferentation pain.

Background

Global brachial plexopathies including multiple nerve root avulsions have permanent and devastating effects on a patient's physical, psychological, and socioeconomic well-being [23]. Typically, global brachial plexopathies affect young individuals at the prime of their life and in otherwise healthy condition [27]. Advances in microsurgical techniques as well as increasing numbers of civilian brachial plexus injuries (BPI) have promoted tremendous progress in brachial plexus repair [4]. Although stabilization of the shoulder joint and restoration of elbow function is achieved in the majority of patients, some still suffer from various physically and psychologically debilitating sequelae, which can further hinder psychosocial adjustment following the accident [11]. A "good" motor result, which may

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O. C. Aszmann, D. Farina (eds.), *Bionic Limb Reconstruction*,
https://doi.org/10.1007/978-3-030-60746-3_18

satisfy the reconstructive surgeon, does not always meet patients' expectations as isolated functional gain might not improve the overall functionality in daily life and therefore does not automatically translate into psychological well-being [12, 19].

As with classic primary and secondary reconstructions, it is thus important to evaluate not only functional outcome measures of bionic reconstruction but also psychosocial outcome variables, which focus on patient-centered, subjective data highlighting benefits and merits of prosthetic hand replacement in patients with BPIs [15]. This chapter is dedicated to summarize effects of bionic reconstruction on various aspects of life including functionality in daily life, overall quality of life, body image, and deafferentation pain. Single steps of the procedure ranging from identification of eligible patients to final prosthetic fitting can be found in Chap. 17.

Functional Outcomes

In all patients with brachial plexus injuries, qualifying for bionic reconstruction global arm and hand function is assessed before elective amputation and after final prosthetic fitting with two-objective hand function tests (ARAT [31] and SHAP [21]) and a patient-reported questionnaire addressing subjective disability (DASH [18]). For detailed information on functional testing see Chap. 7.

As can be expected, all patients interested in the procedure of bionic reconstruction mainly report to feel functionally limited to a great extent due to either non-recovery or elbow flexion recovery only following various primary and secondary reconstructions performed elsewhere. Several national and international media reports have promoted interest in bionic reconstruction with the majority of patients explicitly wishing for functional improvement upon initial consultation.

It has been shown in various studies that bionic reconstruction enables prosthetic hand use after elective transradial amputation of the impaired plexus hand [1, 16]. A stable shoulder joint and good elbow function (>M4) to control the prosthetic hand in three-dimensional space have previously been defined as prerequisites for prosthetic hand replacement [16].

The concept of bionic reconstruction, however, is also applicable for patients without sufficient elbow function. If residual myoactivity can be detected at a more proximal level with identification of two or more separable EMG signals, which will later translate into antagonistic prosthetic functions, a short transhumeral or glenohumeral amputation of the functionless arm is performed to allow fitting of a prosthetic arm including a prosthetic elbow [14]. Widespread research in the field of prosthetics has promoted tremendous progress, particularly bringing forth improvements to replicate motor function and control [9]. Logically, the number of neuromuscular units that can be established as well as their function (i.e., signal consistency and amplitude) is related to enhanced control of a myoelectric prosthetic device. As a consequence of extensive neurological damage following a brachial plexus avulsion injury, however, residual myoactivity in these patients is often faint with absent, weak, or cognitively confusing signals [1]. Therefore, intense cognitive training programs are essential to realize good prosthetic hand use after elective amputation [26]. Patients in whom incompliance is expected thus do not qualify for bionic reconstruction. It is also important to stress that a myoelectric prosthesis by no means compares with a biological hand in terms of functionality [13]. However, given the futile hand function in patients with long-standing inveterate brachial plexopathies, excellent prospective prosthetic hand use justifies elective amputation and prosthetic hand replacement [16]. Patients need to be thoroughly informed that the bionic hand or arm will always remain an "assist" extremity, which will still considerably expand manual capacity during daily life activities due to regained bimanual dexterity [16].

Improved functionality after prosthetic replacement of the impaired plexus hand is not only reflected by significant increases in objective hand function scores, which have been reported in the literature [1, 16]. Likely even more important, statements of patients who have undergone bionic reconstruction highlight its efficacy to regain hand function. After having lived without any function in their limb for years or even decades, most patients are overwhelmed, for example, when they realize for the first time that they are able to prepare a meal all by themselves using two hands again. Patients can go back to pursuing hobbies, are reintegrated into working life, and report of increased self-confidence due to regained functionality.

Effects of Bionic Reconstruction on Quality of Life

Even if some function can be restored, patients with global brachial plexopathies still have to cope with several stressors including reduced self-sufficiency, dependence on others, occupational retraining following the accident, financial instability due to unemployment, as well as dissatisfaction with aesthetic appearance of the withered arm and hand [11, 19]. Symptoms of depression and/or anxiety appear in nearly one third of patients with complete BPI [19].

As an integral part of our assessments, quality of life is evaluated with the SF-36 Health Survey [30]. The questionnaire addresses eight independent subscales: physical functioning, physical role functioning, bodily pain, general health, vitality, social role functioning, emotional role functioning, and mental health. As is in agreement with previous studies, upon initial consultation, most of our patients have inferior results in regard to physical functioning and mental health as compared to healthy norm samples. Vitality and social role functioning are usually limited to a great extent.

Patients who have undergone bionic reconstruction stress that prosthetic hand replacement has changed their life in many ways. Not only do they report of improved physical functioning but also increased vitality and social and emotional functioning due to regained bimanual interaction with their environment. Returning to former social activities is usually accompanied by appreciable improvements in patient satisfaction [25]. Increased self-sufficiency and reduced reliance on others are rated as one of the most important benefits resulting from bionic reconstruction.

Effects of Bionic Reconstruction on Body Image

Clinicians familiar with brachial plexus injuries know that the affected limb will eventually become atrophic and cold with a distal bluish discoloration due to autonomic paralysis [5]. Since our hands represent the instruments with which we interact with our environment daily, this apparent physical deficit may cause psychological distress and potential social pressure [20]. Psychological sequelae include a disturbed body image and negative self-evaluation [20].

We regularly assess body image perception with the Body Image Questionnaire (FKB-20) before and after bionic reconstruction. This questionnaire is widely used for the diagnosis of body image disorders and evaluation of subjective body awareness [7]. Two scales can be identified: the scale "negative body evaluation" allows conclusions about physical appearance, body image, and associated subjective well-being with a person's body image [8]; the scale "vital body dynamics" addresses bodily strength, fitness, and health, which are subjectively rated by the patient [8].

By evaluating pre- and post-bionic reconstruction scale scores we have found that prosthetic hand replacement restores an intact body image by resolution of the negative body evaluation present in the majority of brachial plexus patients [15]. During follow-up visits patients, regularly report of a high grade of embodiment of the prosthetic hand, stating that the prosthesis had become an integral component of their self-image using phrases like "For me this is not a mechatronic device. This is my new hand. I put it on right after waking up and mostly fall asleep at night having forgotten to take it off" [15].

Effects of Bionic Reconstruction on Deafferentation Pain

Deafferentation pain following brachial plexus avulsion injury is a severe chronic pain syndrome, which affects 70–90% of patients [2, 24, 28]. Mechanisms for its development are described in Chap. 16.

The approach of elective amputation has already been described for severe cases of complete BPI without the primary intention to replace the limb with a prosthesis [22]. Despite the fact that none of these used functional prostheses, afterward all were still satisfied with the decision to have the impaired hand amputated, as it served to relief patients of the burden of a flail, insensate arm [6, 12]. Importantly, however, chronic deafferentation pain did not improve by sole amputation of the deafferented hand. This is not surprising since the pain's origin is thought to arise in the dorsal horn of the spinal cord [29]. Additionally, supraspinal central mechanisms are then thought to maintain the pain [10]. Following the "inner amputation," which occurs after brachial plexus avulsion, the central nervous system (CNS) is deprived of its neurological connection to an extremely relevant piece of anatomy—the hand—which in fact entertains most of the primary motor and sensory cortex related to movement [23]. By replacing the functionless, insensate appendage with a prosthetic hand, the CNS again receives afferent input from the previously deafferented hand. Firstly, the patient receives visual feedback from his functioning hand, which he starts to use again on a daily basis, thereby slowly expelling the deafferented phantom hand from his awareness.

Motor recovery following classic reconstructive surgery, may it be very limited, has been associated with reduced deafferentation in various studies [2, 3, 17]. The fact that bionic reconstruction—successfully restoring hand function in patients who have lived without any function for a long time—effectively reduces deafferentation pain is thus not surprising. We refer to this phenomenon as "functional re-afferentation."

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