Case Report

The Outcome of Biofeedback Muscle Re-education after Brachial Plexus Reconstruction: A Case Series

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ABSTRACT

The purpose of this report was to evaluate the outcome of biofeedback muscle re-education after brachial plexus reconstruction. A case series was conducted based on registry data of Rehabilitation Outpatient Clinic. A total of 20 subjects underwent surgical reconstruction to restore elbow flexion in the period of 2012-2014 were included in the study. All 20 subjects received biofeedback muscle re-education until end June 2015 (data extraction). Outcome measures were time to recovery (months) after surgical reconstruction and patients' compliance. Recovery is considered when muscle contraction of biceps (nerve transfer) and gracilis (free functional muscle transfer/ FFMT) are ≥ 100μV, recorded using EMG-surface electrode. Of 4 subjects underwent nerve transfer, all showed recovery with median time of 9 months. Of 16 subjects underwent FFMT, 5 showed recovery with median time of 9 months. The majority of subjects in both groups could comply with once in 2 weeks rehabilitation program.

***Keywords**: brachial plexus, reconstruction, biofeedback, rehabilitation*

Introduction

Adult traumatic Brachial Plexus Injuries (BPI) is a devastating condition that can limit participation.[1] Patients are mostly male at young age and still productive.[2,3] Management of brachial plexus injury is individualized, complex, and needs to be managed in a multidisciplinary team. Time of surgical reconstruction is critical, because in many cases spontaneous improvement does not occur. One of the main functional priority is to restore elbow flexion. [4,5] This can be treated with nerve transfer or free-functioning muscle transfer (FFMT)[6,7] The choices of type of surgery are made based on each surgeon's philosophy, knowledge, and experience. Other factors are of important considerations, such as subjects-related conditions and practicalities or resources availability.[8] The recovery process afterwards follows the rate of axonal regeneration, which is approximately 1 to 2.5 mm per day in humans. The elbow flexor muscles are located 50 cm or more from the site of repair, thus it may take more than 1 year for reinnervation.[5]

Postoperative rehabilitation program focuses on re-education of the nerve or muscle. The brain is trained to send information along a new nerve pathway or grafted muscle tissue. Biofeedback is an important method for re-education. It is a process that enables an individual to learn how to change physiological activity by receiving feedback signal from their own bodies, for the purpose of improving health and performance.[9] Biofeedback is used in muscle re-education to help the patient to perform selected and isolated muscle contraction, especially in the early phase of rehabilitation. After isolated muscle contraction is obtained, then it must be strengthened to achieve functional recovery. Biofeedback also helps the patients to stay motivated. The training program requires patients' (long-term) compliance.[5,10]

Motor recovery after surgery is commonly used as an outcome measure.[11] The sign of recovery is based on a grading system that measures joint movement, muscle strength, and EMG sign of reinnervation. This grading system can be measured individually or as a combination.[5] After nerve transfer, the average recovery time varies according to the selection of donor nerve.[6] At a follow-up of 1 year after FFMT and received postoperative EMG-feedback techniques, 66% subjects reached functional elbow movement with muscle acts strong against resistance, while 34% showed little or no elbow movement with no sufficient muscle power against gravity.[12] In some of the Asian studies, the duration of postoperative rehabilitation was less than 1 year. Some patients were unable to return at regular intervals for therapy and follow-up. Poor compliance with postoperative therapy at times can made appropriate aftercare difficult.[5] This is a report of case-series study to evaluate the time to recovery and patients' compliance after biofeedback muscle re-education post brachial plexus reconstruction to restore elbow flexion.

Material and Methods

A case-series study was conducted based on medical record (paper-based) registry data in the Rehabilitation Outpatient Clinic of Tertiary Referral Hospital, East Indonesia. A total of 20 subjects who underwent surgical reconstruction to restore elbow flexion in the period of 2012-2014 that came to the clinic were selected. From 20 subjects, 4 subjects underwent nerve transfer procedure, while 16 subjects underwent FFMT procedure. The demographic data collected from medical record were age, sex, mode of injury, and timing of surgery. Timing of surgery was defined by the time (in months) of surgical reconstruction after onset of injury.

All subjects received biofeedback muscle re-education program, performed with a Myomed 932 surface EMG Biofeedback Unit (Enraf Nonius, The Netherlands). Skin adhesive surface electrodes were used to record muscle activity. The two active electrodes from each channel were placed as close together as possible along the directions of the fibres of biceps brachii (nerve transfer group) or gracilis (FFMT group). The reference electrode was placed below the lateral condyle of humerus. The subjects were explained about the training procedure. The subject was asked to contract the muscle, and at the same time watched the muscle activity seen in the biofeedback unit, and try to increase the activity level. After each 6-second hold, there was 12-seconds rest. and repeated 5 times (Figure 1). The biofeedback muscle re-education program must be done once a week according to standard protocol in our rehabilitation outpatient clinic.

There were two outcome measurements reported in this study. First, time to recovery after surgical reconstruction. The definition was the time (in months) counted since the date of surgery until the date a subject has reached maximum muscle contraction ≥ 100µV of biceps brachii (nerve transfer group) or gracilis (muscle transfer group), recorded with biofeedback unit. Clinical experience in our rehabilitation outpatient clinic showed that when maximum muscle contraction reached 100 µV or more, were related with actual joint movement. Elbow movement is considered as the third recovery sign after nerve transfer that usually appears 6-12 months post-surgery.[8] Because this report was based on medical record, other factors that can affect recovery (such as: received other treatment at home or other facilities) were not controlled. The second outcome measurement was patient's compliance with the rehabilitation program, shown by frequency of visit. The outcome data was extracted from medical record by end of June 2015. Ethical clearance was given by Hospital Ethical Committee.

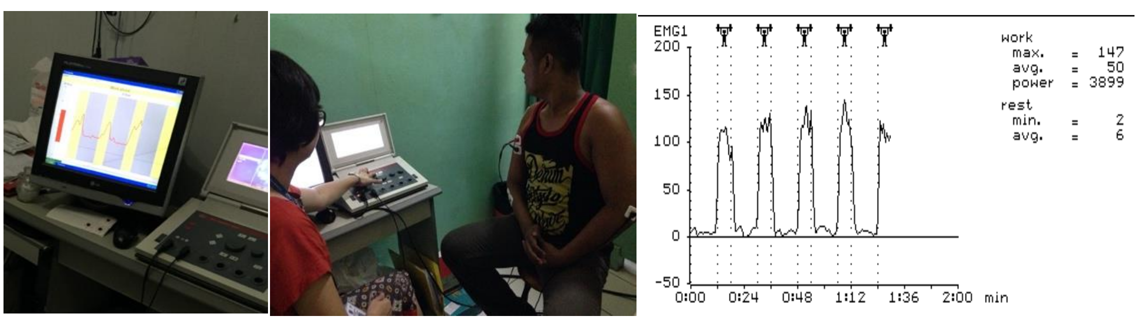

Figure 1. Biofeedback muscle re-education program

Result

Demographic characteristics of subjects were shown in Table 1. The mode of injury was motorcycle accidents in 19 patients. Only 1 patient who underwent nerve transfer had brachial plexus injury by means of a knife. Recovery began 3 months after FFMT in 1 patient. One patient who underwent nerve transfer showed recovery after 4 months of surgery. The rest 19 of the subjects showed recovery more than 6 months after surgery. The majority of subjects could comply with once in 2 weeks rehabilitation program, with percentage of 50% in the nerve transfer group and 56.25% in the FFMT group.

In the nerve transfer group, 1 subjects had spinal accessory nerve transfer to musculocutaneus, 1 patient had median fascicle nerve transfer to biceps branch, while in 2 subjects the registry data did not clearly recorded which nerve were transferred. All subjects (100%) showed recovery after surgical reconstruction with median time of 9 months.

In the FFMT group, all 16 subjects had gracilis muscle transfer. After surgical reconstruction, only 31% of subjects showed recovery after surgery with median time of 9 months. The majority of subjects (50%) have not yet showed recovery after >10 months of rehabilitation program. Small number of subjects (19%) had duration of rehabilitation program ≤ 9 months, have not showed any recovery (Figure 2).

Discussion

There are several factors to be considered for recovery after surgical reconstruction in brachial plexus injury, such as the nature of the plexus injury (including location, mechanism, and duration since injury), presence of associated injuries, surgical expertise, practical operative time constraints, and ability to provide and attend prolonged postoperative rehabilitation.[12] Age of the patient at the time of surgery is an important prognostic factor of recovery. Some surgeons recommended that patient age above 50 years may not be a good candidate for surgical exploration and functional recovery.[13] In this report, the median age of both nerve transfer and FFMT groups were below 50 years, thus should have good effect on recovery.

The mode of injury in this study were motorcycle accidents in all 16 subjects (100%) in the FFMT group, and in 3 out of 4 subjects (75%) in the nerve transfer group. Only 1 patient who underwent nerve transfer had brachial plexus injury by means of a knife. This subjects showed recovery 4 months after nerve transfer. From all 19 subjects who had motorcycle accidents, time to recovery had more wide variations. The variations could be due to the difference in injury severity, types of surgical, and compliance of rehabilitation program.

Table 1. Demographic characteristics of 20 subjects

Demographic data	Nerve transfer (n=4)	FFMT (n=16)
Age (years)	33	21
Median		
Sex		
Male	3 (75%)	10 (62.5%)
Female	1 (25%)	6 (37.5%)
Mode of Injury		
Motorcycle accidents	3 (75%)	16 (100%)
Other trauma	1 (25%)	0
Timing of surgery (months)		
Median	3.5	17
Number of subjects that showed recovery at the time of data extraction	4/4 (100%)	5/16 (31.25%)
Time to recovery (months)		
Median	9	9
Compliance with Rehabilitation Program		
Twice a week	0	0
Once a week	1 (25%)	5 (31.25%)
Once in 2 weeks	2 (50%)	9 (56.25%)
Once a month	1 (25%)	1 (6.25%)
> Once a month	0	1

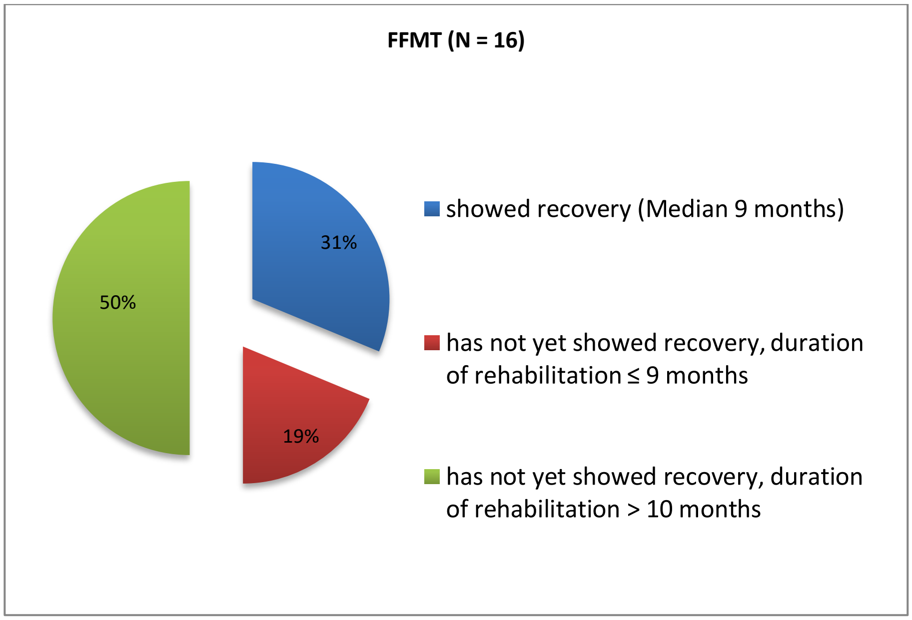

Figure 2. The FFMT Group; 50% subjects have not showed recovery after > 10 months of rehabilitation

Nerve transfer is considered superior to muscle transfer in adult brachial plexus injury, if the nerve transfer get good result.[8] One of the advantages is that it may preserve better anatomy and pathway, and less donor site morbidity. But, it should be done before 5 months[8], or at the optimal time window of 6-9 months.[6,7,14] Nerve transfer is considered unlikely to success beyond 12 – 18 months after injury.[15] In our study, from a total of 20 subjects, 4 were chosen for nerve transfer. The duration between injury and surgery (median time of surgery) was 3.5 months. All 4 subjects (100%) showed recovery with median time of 9 months. The average recovery time of MRC Grade 3 (useful motor recovery) after spinal accessory nerve transfer was 17.5 months, and for fascicles of the median nerve transfer was 8 months.[6] In our study, 1 subject had spinal accessory nerve transfer to musculocutaneus showed recovery after 10 months, and 1 subject had median fascicle nerve transfer to biceps branch showed recovery after 19 months.

Delayed for surgery in most of the subjects in this study could be caused by technical problem such as limited resources and unequal distribution of surgeons trained in brachial plexus reconstruction, long waiting list for surgery due to loads of subjects in the referral hospital, and demographic as well as social economy factors. This condition is quite common in Indonesia. In prolonged delay post injury, the only option to restore function is through a free muscle transfer. The benefit to the use of FFMT is the possibility of providing prehensile function.[5,12] In our study FFMT was performed using gracilis muscle. The median time of surgery in the FFMT group was 17 months. The sign of recovery was seen in 5 out of 16 subjects (31.25%), with median time to recovery of 9 months. One study has shown that after gracilis muscle transfer, during a minimum follow-up period of 1 year, 13 out of 29 subjects had motor elbow function restoration ≤ M3 (modification of the BRMC grading system), and 16 subjects had ≥ M4.[12] The grading system was based on combination of EMG sign of reinnervation, joint movement, and muscle strength. Of the 29 gracilis muscle transfers reported 5 failed. Other study showed that the M3 antigravity muscle strength was obtained after 18 months.[16] In our study, the majority of subjects (50%) in the FFMT group have not yet showed recovery after more than 10 months of rehabilitation program. The cause of non-return of function could be due to graft failure because vascular insufficiency. Some subjects could show no return of function although the grafted muscle survived.[12] Chance of recovery might still possible in 3 subjects (18.75%) who had not reach a follow up of 1 year after surgery. Recent study showed that subjects at a follow-up of 24 months after elbow flexion reconstruction can reach M3/M4 elbow flexion muscle grade.[17]

Technical factors such as social economy, educational status, distance to rehabilitation facility as well as transportation and availability of family members to bring the patient, are still a big issues in our country. Although before surgery subjects have been motivated to follow extensive rehabilitation program up to 2-3 years depends on the type of surgery performed.[5,9] At the early phase, an intensive-supervised therapy with the rehabilitation team is needed. In the later phase, to decrease the frequency of supervised therapy, the patient may do electrical stimulation two to six stimulation sessions a day with a portable home unit.[9] In this study, the majority of subjects in both nerve transfer and FFMT groups could not comply with standard rehabilitation (once a week) program. Most of the subjects (>50%) could comply with once in 2 weeks program. These factors can influence the functional recovery after surgical reconstruction in BPI subjects. Other confounding factors such as whether subjects received other treatment at home or other facilities were not controlled in this report.

The current report has several limitations. Our data extraction was based only from the medical record (paper-based) registry data. There were some (important) details not recorded completely, and we had difficulty in tracing the missing data. Because there were data inconsistency of joint movement and muscle strength reported in the medical record, we did not include them as outcome measurements. In developing countries such as Indonesia, technical factors in medical record registry data handling and management, need to be improved to promote good service as well as for research and educational purposes.

Recovery after brachial plexus reconstruction is a long-term effort. Many factors influence the recovery after brachial plexus reconstruction to restore elbow flexion. This report showed that sign of recovery (median time of 9 months) were seen in all 4 subjects (100%) after nerve transfer reconstruction. In subjects who underwent FFMT reconstruction, sign of recovery were seen in 31.25% of subjects (median time of 9 months). Progress is expected to continue years after surgery. Further evaluation and follow-up are needed in subjects that show no recovery after 2 years of surgery. Poor compliance, as one of important factors for functional improvement, is still a big problem in developing country such as Indonesia.

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