Effects of Grip Power Training on Elbow Flexion Strength after Oberlin Transfer in Upper Arm Type Brachial Plexus Injuries

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Introduction: The patients with brachial plexus injuries (BPI) in C5-6 or C5-7 (upper arm type) showed significant disabilities in shoulder and elbow function. In upper arm type BPI, recovery of elbow flexion was often set as the primary goal of reconstruction to obtain the useful ability in upper extremity. Neurotization by transferring ulnar nerve fascicle to musculocutaneous nerve published by Oberlin et al. is common used for elbow reconstruction nowadays. Well recovery and minimal morbidity of donor nerve have also been reported by previous studies. In order to assist the elbow flexion contraction, grip force training is an important protocol during rehabilitation after Oberlin's procedure. However, few studies provided the evidence about correlation of improvements between grip power and elbow flexion strength. Therefore, the aim of the current study was to investigate the effects of grip power training on elbow flexion strength in upper BPI after Oberlin's transfer.

Methods: Fourteen subjects (12 males and 2 females) with upper BPI received Oberlin's procedure performed by the experienced surgeons were recruited in this study. The average age was 31.9 years (range: 20-56 years). Five patients had C5-C6 nerve lesions, and nine patients had C5-C7 nerve lesions. Twelve of these patients suffered from traffic accidents, and two were caused by cut injuries. Informed consent approved by institutional review board was provided to each subject before participating. The quantitative elbow flexion strength was measured by the custom-made dynamometer system with a torque sensor. Subjects were required to generate maximum isometric contraction and sustained at least for 3 seconds in sitting position with elbow in 90 degrees and forearm supination. The grip power was obtained by the digital hand dynamometer (Jamar Plus). Elbow flexion and grip strength of both arms were measured twice with a 30-second rest between tests. After the first evaluation, subjects were asked to improve the grip power by compressing the soft ball or hand grips at least 100 times per day. Then, they were followed up and re-examined about after 6 to 8 months. The torque of elbow flexion was converted to force by dividing the distance between elbow joint center and distal radius. Changes in peak values and variability in sustained period of elbow flexion isometric contraction were used to evaluate the training effects. The period of force sustained was defined from the history of force generation. The coefficient of variation (CV) and range ratio were calculated to represent the variability. Paired-t test was used to compare the difference between initial and followed-up values. The correlation between grip power and elbow strength changes were examined by person correlation tests. Significant level was set at p<0.05.

Results: The grip power of involved arm was about 23.9% body weight (BW) in the 1st examination, while the power improved to 27.1% BW after training. The elbow flexion strength of involved arm were about 4.8% and 6.4% BW for pre-training and after training, respective (Figure 1). Subjects showed significant improvements on elbow flexion and grip strength in involved arm after training (p=0.01 for elbow flexion, and p=0.03 for grip power), and no significant differences were found in non-involved arm. Highly positive correlation (p<0.01) between elbow flexion and grip strength changes after training were found in involved arm (Figure 2). In the period of force sustained, elbow flexion force generation could keep stable in non-involved arm, while the force was decreased or unstable in involved arm (Figure 3). Table 1 showed the results of variability of 2 examinations. However, no significant differences in CV or range ratio were found in both arms.

Discussion: In the current study, we obtained the quantitative elbow flexion strength after the intervention of 6-8 month grip power training in upper BPI patients with Oberlin's transfer. Grip and elbow flexion strength improved significantly, and showed the high correlation. Ulnar nerve is the donor nerve during Oberlin's procedure, and many flexor muscles of hand were innervated by it. Therefore, after reconstruction of nerve transfer, training muscles innervated by donor nerve might be benefit for the recovery of muscle innervated by the receipt nerve. Though the variability during force sustained period showed no significant difference after training, it still could be the index to evaluate the quality and endurance for force generation. It was supposed that increased muscle strength value may not be referred to the better endurance. In addition, the quality of force generation also affected the smoothness of movement during functional activities. Therefore, specific exercise protocols for enduring training and functional activities may be taken into consideration in the next rehabilitation phase.

Significance: In the current study, we provided the evidence that grip power training is beneficial for the recovery of elbow flexion strength in upper arm BPI patients after Oberlin's procedure. It could assist the prescription making in rehabilitation training after nerve transfer. We also provide the quality of force generation by evaluating the variability during force sustained period. In addition, the quantitative values of elbow flexion and grip strength provided in this study would be the reference values for the surgeons and therapists.

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Figure 1 Peak elbow flexion strength (EFlex) and grip power (G) in non-involved (Non) and involved (Inv) arms
Changes of Elbow Flexion & Grip Power

Figure 2. Correlation between changes of grip power and elbow flexion after training.
Figure 3: Time-Force of elbow flexion strength and definition of sustain period in both arms of one BPI patient.

Table 1: Variability of force sustained period in both arms.

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<th>Non-involved</th>
<th>Involved</th>
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<td></td>
<td>1st</td>
<td>2nd</td>
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<tr>
<td>CV (SD/\text{Mean} \times 100%)</td>
<td>3.3\pm1.5</td>
<td>3.4\pm1.9</td>
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<tr>
<td>Range ratio (\text{max-min}/\text{mean} \times 100%)</td>
<td>12.1\pm5.0</td>
<td>12.4\pm6.6</td>
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