Elbow Joint Proprioceptive Sense in Total Arm-Type Brachial Plexus Injured Patients after Neurotization: A Preliminary Study

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Background: *Joint proprioceptive sense is a special sense, which is composed of joint kinesthesia and joint reposition sense. Cells that receive proprioceptive sensation normally can be found in skin, soft tissue, tendon, and muscle around the joint. Their function coordinates with visual sensation and sensation from the vesicular organ to acknowledge position of the body. The proprioceptive sense provides information for motion in the dark, the ability to manipulate objects out of view, and protective sensation. There are several reports on the recovery of motor function after neurotization in brachial plexus injured patients. To date, there has been no study relating to recovery of proprioceptive sensation in brachial plexus injured patients after neurotization.*

Objective: *To study elbow joint position sense or proprioceptive sense in total arm-type brachial plexus injured patients after neurotization.*

Material and Method: *The present study was undertaken at a major academic tertiary care center in Bangkok, Thailand from October 2012 to January 2014. The design of this prospective cohort study included seven total arm-type brachial plexus injured patients before neurotization and seven total arm-type brachial plexus injured patients after neurotization, the latter seven of whom experienced recovery of motor power of biceps to at least MRC III. All patients were examined using the CONTREX dynamometer to assess elbow joint position sense. Patients were asked to recognize elbow joint position sense at two different target angles-mid-range and end-range. The differences between the actual angles and the angles perceived by the patients were calculated and statistically analyzed using the Wilcoxon signed ranks test.*

Results: *There were no statistically significant differences in age or side of injury between the two groups of patients. In the pre-neurotization group, there was a statistically significant difference between the injured side and normal side in mid-range (50%) and end-range (90%) target angles. However, elbow joint position sense in the after neurotization group (with MRC III motor recovery) showed no statistically significant difference between the injured side and the normal side in mid-range (50%) and end-range (90%) target angles.*

Conclusion: *Total arm type brachial plexus injured patients recover proprioceptive sense in the elbow after neurotization.*

Keywords: *Brachial plexus injury, Joint position sense, Elbow joint, Neurotization*

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The term "proprioception" was first introduced by Sherrington in 1906. Proprioception is a type of feedback mechanism from the limbs to the central nervous system. It includes joint position sense, kinesthesia, and sense of tension. Joint position sense is one of the most common forms of measurement of proprioception. Joint position sense provides: ability to perceive joint position; information for motion in the dark; ability to manipulate objects out of view; and, protective sensation[1,2]. Proprioceptive information is received from the Ruffini ending, Pacinian corpuscles, and unmyelinated free nerve endings, which are found in the joint capsule. The receptors are stimulated when a joint moves near the end-range of motion. Other receptors include spindle receptors and the Golgi tendon organ, which is found in muscle and tendon. These receptors provide proprioceptive sense relating to change in muscle length and tension.

In patients with brachial plexus injury, muscles around the elbow joint are weak and the joint capsule and ligaments are abnormally loose, which may resulted in loss of proprioceptive sensation in the affected arm.

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There have been several reports on motor recovery in brachial plexus injury patients. However and to date, there have been no reports focusing on the recovery of proprioceptive sensation after neurotization[3-6].

The aim of this research is to study elbow joint position sense or proprioceptive sense in total arm-type brachial plexus injured patients after neurotization.

Materials and Method

From October 2012 to January 2014, a prospective cohort study was undertaken that compared seven total arm-type brachial plexus injured patients before neurotization to seven total arm-type brachial plexus injured patients after neurotization, the latter of whom had recovery of motor power of biceps to at least Medical Research Council (MRC) III. This study was undertaken at a major academic tertiary care center in Bangkok, Thailand. All of the patients in this study were examined using the CONTREX dynamometer to assess elbow joint position sense. Patients were asked to recognize and remember their elbow joint position sense at two different target angles: mid-range and end-range. The differences between the actual angles and the perceived angles as described by the patients were calculated and statistically analyzed using the Wilcoxon signed ranks test.

Inclusion criteria for this study were: 1) total arm-type brachial plexus injured patients before neurotization; 2) over 18 years of age; and, 3) motor recovery of biceps to at least MRC III. Exclusion criteria for this study were: 1) patients with spinal cord or brain injuries; 2) uncooperative patients; 3) patients who had pathology of the elbow joint, such as stiffness or previous elbow surgery; and, 4) patients who had generalized ligamentous laxity.

Total range of motion (ROM) was measured by digital goniometer. The reposition test was performed using the CON-TREX MJ system, which was composed of a chair, table, dynamometer, power-module, monitor, printer, and control-unit (Fig. 1).

The patient was seated in the chair of the CON-TREX MJ system and had a tampon and elastic bandage tied to the wrist of the arm being tested to minimize or eliminate skin sensation. The patient's eyes were then covered with an eyeshade and earplugs were placed in the patient's ears to minimize or eliminate visual and auditory feedback (Fig. 2). The dynamometer was then turned on and two target angles were set: one angle at mid-range (50%) and the other at end-range (90%). The patient was instructed to memorize the position of his elbow for 10 seconds. The dynamometer then gradually changed the angle. The patient was instructed to ask the examiner to halt the dynamometer when the patient thought his elbow had returned to the preset angles (mid-range and end-range). The test was repeated three times and the average value was calculated. A test of the non-injured side was then performed.

Fig. 1 The CON-TREX MJ system.

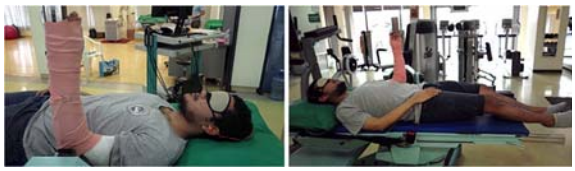

Fig. 2 Patient positioned on the CON-TREX MJ system.

Statistical analysis

The Wilcoxon signed ranks test was used for the statistical analysis of the data in the present study.

Results

The present study was conducted on two groups of total arm-type brachial plexus injury patients; one group included patients before neurotization and the other group after neurotization. Each group had seven patients. The pre-neurotization group consisted of 5 males and 2 females. All of the patients in the post-neurotization group were male. The sides of injury in both groups were the same-5 left and 2 right. The median and mean ages of the patients were 21/22.7 in the pre-neurotization group and 38/34.71 in the after neurotization group. There was no statistically significant difference in age and side of injury between the two groups (Table 1).

Elbow joint position sense in the before neurotization group resulted in a mean absolute angle difference at mid-range (50%) of 19.60° on the injured side and 3.70° on the normal side. The mean absolute angle difference at end-range (90%) was 12.40° on the injured side and 5.50° on the normal side. There was a statistically significant difference between the injured side and the normal side at the mid-range (50%) and at end-range (90%) target angles (Table 2).

Elbow joint position sense in the after neurotization with MRC III motor recovery patient group resulted in a mean absolute angle difference at mid-range (50%) of 5.90° on the injured side and 3.90° on the normal side. The mean absolute angle difference at end-range (90%) was 5.80° on the injured side and 5.20° on the normal side. There was no statistically significant difference between the injured side and the normal side at mid-range (50%) and at end-range (90%) target angles (Table 3).

Discussion

The ultimate goal of treatment of the affected arm in total arm-type brachial plexus injured patient is to restore normal arm function, which includes motor, sensory, and prehensile function. Most of the studies that have focused on treatment of brachial plexus injury assessed only motor and protective sensory recovery, which may not fully represent and account for the ability to use the arm in daily activity (functional outcome)[7,8]. The present study aims to include and

Table 1. Patient demographic data

	Group 1, before neurotization (n = 7)	Group 2, postoperative (n = 7)	*p*-value
Age (years)			
Median (range)	21 (16-37)	38 (26-43)	0.006*
Mean (SD)	22.71 (6.99)	34.71 (7.20)	
Injured side (%)			
Left	5 (71.4)	5 (71.4)	0.999**
Right	2 (28.6)	2 (28.6)	

*Mann-Whitney U test; ** Fisher's exact test

Table 2. Group 1 patient data-before neurotization (n = 7)

	Injured side	Normal side	*p*-value
Absolute difference (degree)			
Mid-range target angle (50%)			
Median (range)	19.60 (1.80-49.00)	3.70 (0-18.00)	<0.001
End-range target angle (90%)			
Median (range)	12.40 (0.50-34.50)	5.50 (0.90-17.10)	0.004

p-value for Wilcoxon signed ranks test

Table 3. Group 2 patient data-after neurotization (n = 7)

	Injured side	Normal side	*p*-value
Absolute difference (degree)			
Mid-range target angle (50%)			
Median (range)	5.90 (0.40-50.00)	3.90 (0.40-17.00)	0.130
End-range target angle (90%)			
Median (range)	5.80 (0.70-32.20)	5.20 (1.20-18.30)	0.794

p-value for Wilcoxon signed ranks test

assess another factor that contributes to the prehensile movement of the limb.

Hattori reported recovery of elbow joint position sense in total arm type brachial plexus injured patients after double free muscle transfer procedure[9].

From the present study, there was a statistically significant difference between the injured side and the normal side in the pre-neurotization group (Group 1). But, in the after neurotization group with MRC III recovery (Group 2), there was no statistically significant difference between the injured side and the normal side. This finding indicates a loss of the joint position sense after brachial plexus injury and the subsequent recovery of this sense after neurotization. Possible rationales behind proprioceptive recovery of the elbow in the present study include: 1) the recovery of normal tightness of the joint capsule and tension of muscle and tendon across the elbow joint, which allows the receptors around the joint capsule (Ruffini ending, Pacinian corpuscles, and unmyelinated free nerve endings) and muscle (spindle and Golgi tendon organ) to have improved-to-normal function. Second, skin stretching during elbow motion might help to stimulate cutaneous nerve receptors.

There were two key limitations associated with the present study. First, research data had to be collected from two groups (pre-neurotization and after neurotization), but these two groups were not the same population. Second, the size of the groups in this study was small; an increase in group size may result in different findings.

Conclusion

Total arm-type brachial plexus injured patients recover elbow joint position sense or proprioception after neurotization.

Potential conflicts of interest

None.

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การรับรู้อากัปกิริยาของข้อศอกในผู้ป่วยที่ได้รับบาดเจ็บร่างแหประสาทแขนแบบทั้งหมดหลังจากผ่าตัดต่อเส้นประสาท, งานวิจัยเบื้องต้น

เทอดศักดิ์ หอมศรีประเสริฐ, รุ่งศักดิ์ ลิ่มทองแท่ง, ต่อพล วัฒนา, สายชล วงตระกูล, ภานุพันธ์ ทรงเจริญ

ภูมิหลัง: การรับรู้อากัปกิริยา (proprioception) เป็นความรู้สึกเกี่ยวกับตำแหน่ง (joint position sense) และเกี่ยวกับการเคลื่อนไหวของข้อ (joint kinesthesia) ที่ไม่สืบเนื่องกับการมองเห็น ซึ่งจะมีประสาทสัมผัสในบริเวณผิวหนัง เนื้อเยื่อ เอ็นและกล้ามเนื้อรอบๆ ข้อเป็นหน่วยรับความรู้สึก มีหลายงานวิจัยรายงานพบการฟื้นตัวของกล้ามเนื้อแขน หลังจากการผ่าตัดต่อเส้นประสาทในผู้ป่วยที่ได้รับบาดเจ็บร่างแหประสาทแขนแบบทั้งหมด แต่จนถึงปัจจุบันไม่มีการศึกษาถึงการฟื้นตัวของการรับรู้อากัปกิริยาของข้อศอกหลังจากได้รับการผ่าตัดต่อเส้นประสาท

วัตถุประสงค์: เพื่อศึกษาการฟื้นฟูของความรู้สึกเกี่ยวกับตำแหน่งของข้อศอกที่ได้รับบาดเจ็บของร่างแหประสาทแขนแบบทั้งหมด หลังได้รับการผ่าตัดต่อเส้นประสาท

วัสดุและวิธีการ: ได้ทำการศึกษาตั้งแต่เดือนตุลาคม พ.ศ. 2555 จนถึง มกราคม พ.ศ.2557 ได้ทำการศึกษาในผู้ป่วยที่ได้รับบาดเจ็บร่างแหประสาทแขนแบบทั้งหมดที่มารับการตรวจในโรงพยาบาลศิริราช โดยมีกลุ่มก่อนผ่าตัด 7 ราย และหลังผ่าตัด 7 ราย ซึ่งมีการฟื้นตัวของกล้ามเนื้อในการงอข้อศอกสามารถต้านแรงโน้มถ่วงได้ ได้นัดมาตรวจการรับรู้การเคลื่อนไหวของข้อศอกโดยใช้เครื่อง CONTREX MJ และเก็บค่าความผิดพลาดของมุมเป้าหมายที่มุมกึ่งกลางของมุมข้อศอก (mid-range) และมุมเกือบงอศอกสุด (end-range) โดยทำในแขนทั้งสองข้างและทำทั้งหมด 3 ครั้งต่อมุม และนำค่าความผิดพลาดที่ได้มาเปรียบเทียบกันระหว่างแขนข้างที่ได้รับบาดเจ็บกับแขนข้างปกติของผู้ป่วยโดยใช้ Wilcoxon signed rank test เป็นตัวทดสอบ

ผลการศึกษา: ผู้ป่วยที่ได้รับบาดเจ็บร่างแหประสาทแขนในกลุ่มก่อนได้รับการผ่าตัดต่อเส้นประสาทเมื่อตรวจความรู้สึกเกี่ยวกับตำแหน่งของข้อศอกโดยเทียบแขนข้างปกติกับแขนข้างได้รับบาดเจ็บ พบว่ามีความแตกต่างทางสถิติอย่างมีนัยสำคัญ แต่ในกลุ่มผู้ป่วยหลังได้รับการผ่าตัดต่อเส้นประสาทที่สามารถงอศอกต้านแรงโน้มถ่วงได้ เมื่อตรวจความรู้สึกเกี่ยวกับตำแหน่งของข้อศอกเปรียบเทียบแขนข้างที่ได้รับบาดเจ็บกับแขนข้างปกติของผู้ป่วย พบว่าไม่มีความแตกต่างทางสถิติ

สรุป: ผู้ป่วยที่ได้รับบาดเจ็บร่างแหประสาทแขนทั้งหมดมีการสูญเสียความรู้สึกเกี่ยวกับตำแหน่งของข้อศอกและเมื่อได้รับการผ่าตัดต่อเส้นประสาทจนผู้ป่วยสามารถงอข้อศอกต้านแรงโน้มถ่วงได้ พบว่ามีการฟื้นฟูของความรู้สึกเกี่ยวกับตำแหน่งของข้อศอกกลับคืนมาด้วย