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Clinical Article

Selective Musculocutaneous Neurotomy for Spastic Elbow

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Objective : The purpose of this study was to investigate the effectiveness and outcome of selective musculocutaneous neurotomy (SMcN) for spastic elbow.
Methods : We retrospectively reviewed the medical records of 14 patients with spasticity of their elbows. The patients were selected using clinical and analytical scales, as well as nerve block tests, for assessment. Their mean age was 37.29 years (range, 19-63 years). SMcN was performed for these patients, and the mean follow-up period was 30.71 months (range, 19-54 months).
Results : The modified Ashworth scale (MAS) scores recorded before and after the SMcN showed that the patients' mean preoperative MAS score of 3.28 ± 0.12 was improved to 1.71 ± 0.12, 1.78 ± 0.18, 1.92 ± 0.16 and 1.78 ± 0.18 at postoperative 3, 6, 12 months and last follow-up, respectively. On the basis of a visual analogue score ranging from 0-100, the patients' mean degree of satisfaction score was 65.00 ± 16.52 (range, 30-90).
Conclusion : We believe that SMcN can be a good and effective treatment modality with low morbidity in appropriately selected patients who have localized spastic elbow with good antagonist muscles and without joint contracture.

KEY WORDS : Elbow · Muscle spasticity · Musculocutaneous nerve · Neurotomy · Surgical procedure.

INTRODUCTION

Spasticity has been defined as an increase in muscle tone as a result of the hyper-excitability of the stretch reflex and is characterized by a velocity-dependent increase in tonic stretch reflexes[4]. Spasticity results from various etiologies such as stroke, traumatic brain injury, multiple sclerosis, and cerebral palsy. Regardless of its cause, most types of spasticity have similar symptoms and deformities. Common manifestations of spastic disorders involving the upper limb include spastic flexion of the elbow, pronation of the forearm, flexion-adduction of the wrist, and flexion of the fingers with swan-neck finger deformity. This restricts voluntary movements and gives patients an unpleasant feeling as well as limitations during daily routine activities. It can also cause severe pain, pressure sores, joint contracture, and deformity of the limb. Various methods have been tried to relieve spasms. Medical treatment, physiotherapy and occupational therapy play an important role in relieving spasticity and improving motor functions. However, in some cases, these therapies cannot relieve spasticity because of the presence of resistant spasticity[12]. In an attempt to relieve these symptoms, various surgical treatments have been tried. Of these, microsurgical selective peripheral neurotomy has proven to be an effective surgical treatment for some localized forms of spasticity[9,12]. However, only a limited number of published studies have dealt with upper limb spasticity[6,12]. This study included 14 patients, with localized spasticity, who underwent selective musculocutaneous neurotomy (SMcN). The purpose of this study was to validate the long-term effectiveness and safety of SMcN for spastic elbow.

MATERIALS AND METHODS

Fourteen patients (10 males and 4 females) underwent SMcN between January 1999 and March 2007. The mean age of the participants was 37.29 years (range, 19-63 years). The mean follow-up period was 30.71 months (range, 14-54

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Table 1. Clinical characteristics and surgical results in 14 patients who underwent SMcN

Case No.	Age, Sex	Cause	Preop pain VAS	Last F/U pain VAS	Preop MAS	Postop 3M MAS	Postop 6M MAS	Postop 12M MAS	Last F/U MAS	F/U Duration (Months)	VAS of Satisfaction
1*	63, F	CVA	6	2	4	1	1	1	1	56	90
2	23, M	CVA	0	0	3	2	2	2	2	24	70
3	22, M	CP	0	0	3	1	2	2	2	35	60
4*	36, M	MS	5	0	3	2	3	3	3	14	30
5	31, M	CP	0	0	4	2	2	2	2	44	50
6	19, F	CP	0	0	3	2	1	2	2	30	70
7	29, M	CP	0	0	3	2	2	2	2	26	60
8	24, M	TBI	0	0	3	2	2	1	1	35	80
9	61, F	CVA	0	0	3	2	1	2	1	37	70
10*	44, M	TBI	7	5	4	2	3	3	3	19	40
11	27, M	TBI	0	0	3	1	1	2	1	32	80
12	32, F	CP	0	0	3	2	2	2	2	29	60
13*	54, M	CVA	6	3	4	2	2	2	2	25	70
14	57, M	CVA	0	0	3	1	1	1	1	24	80

*Indicates patients who suffered from pain with spasticity. SMcN : selective musculocutaneous neurotomy, VAS : visual analogue scale, MAS : modified Ashworth scale, CVA : cerebrovascular attack, CP : cerebral palsy, TBI : traumatic brain injury, MS: multiple sclerosis

months). The etiologies of spastic elbow were cerebrovascular attack (n = 5), traumatic brain injury (n = 3), cerebral palsy (n = 5) and multiple sclerosis (n = 1). Four patients (cases 1, 4, 10 and 13) suffered from pain with spastic elbow (Table 1). Surgery was indicated when no other non-surgical treatments were available. The results from preoperative nerve block test established whether the deformities were a result of muscle spasticity alone or occurred in association with an additional orthopedic complications. Surgical indication was limited to spastic elbow, which was mediated mainly by the biceps brachii and the brachialis muscles, innervated by the musculocutaneous nerve. The test was also used to assess the residual motor function of antagonist muscles, mainly extensors muscles. According to Sindou et al.[15], in the cases involving the complete absence of antagonist muscles, good results cannot be obtained with SMcN alone; combined orthopedic surgery is also required. Such cases were excluded in this study. A positive block test was defined as a considerable decrease in upper-limb deformities and/or functional improvements. Patients who responded to the nerve blocks were enrolled in the study. Preoperatively, a multidisciplinary team established a modified Ashworth scale (MAS) for the biceps brachii and the brachialis muscles. All patients were reexamined as outpatients at 3, 6, and 12 month intervals, with the last follow-up after surgery (Table 1). Preoperative and postoperative MAS scores were compared using the paired t-test. A probability value less than 0.05 was considered statistically significant. The degree of patient satisfaction was checked using the visual analogue scale (VAS) at the last follow-up.

General anesthesia was induced without a long-acting muscle relaxant, in order to detect the motor responses elicited by bipolar electrical stimulation of motor branches during surgery. The skin was incised longitudinally. The incision extended from the inferior edge of the pectoralis major, medial to the biceps brachii, down 4-5 cm. The superficial fascia was opened and dissected between the biceps, laterally, and the coracobrachialis, medially. The dissection proceeded in this space, where the musculocutaneous nerve lies anterior to the brachialis muscle (Fig. 1). Motor branches to the biceps and the brachialis muscles were identified and partially resected. Opening the epineurium allowed the nerve's fascicles to be dissected under the operating microscope. The motor fascicles were distinguished from the sensory fascicles using a nerve stimulator (Model OCS-1 Ojemann Cortical Stimulator, Radionics, Burlington, MA., USA)[2,12]. Generally, 50-80% of the motor fascicles were sectioned 5mm long. The proximal stump was coagulated with bipolar forceps to prevent regrowth and possible neuroma formation.

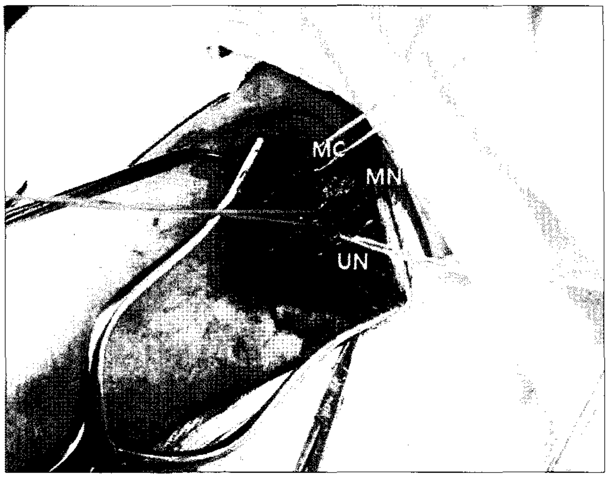

Fig. 1. Intraoperative photographs depicting views of the right arm. MC : musculocutaneous nerve, MN : median nerve, UN : ulnar nerve.

RESULTS

The MAS scores, recorded pre- and postoperatively, showed that the mean preoperative MAS score of 3.28 ± 0.12 was decreased to 1.71 ± 0.12, 1.78 ± 0.18, 1.92 ± 0.16, and 1.78 ± 0.18 at postoperative 3, 6 and 12 month intervals, and the last follow-up, respectively. Elbow spasticity was decreased significantly between preoperative and last follow up (p < 0.001) in patients who underwent SMcN (Fig. 2). On the basis of the VAS, which ranges from 0-100, the patients' mean degree of satisfaction score was 65.00 ± 16.52 (range, 30-90). No recurrence appeared during the follow-up period. Patients with accompanying preoperative pain had poorer MAS and VAS scores than patients with no preoperative pain; however statistic significance was not evaluated because of the small number of cases. In three of the four cases, pain associated with spasticity was relieved by more than 50 percent (Table 1). Postoperative complications occurred in two cases. Wound infection occurred in case 4 and transient paresthesia occurred in case 13.

DISCUSSION

Spasticity is a motor dysfunction arising from an upper motor neuronal lesion as a result of stroke, spinal cord injury, multiple sclerosis or traumatic brain injury[4]. While the pathophysiology of spasticity is not completely understood, it is thought to be related to changes in the balance between excitatory and inhibitory inputs to the motor neuronal pool. Patients with a spastic upper limb demonstrate recognizable antigravity postural patterns characterized by shoulder adduction and elbow and wrist flexion. This posture significantly interferes with body image and also with the patients' activities of daily living, including personal hygiene and ambulation. The reciprocal pattern of arm swing is an important component of gait, so restricting arm swing can impair the body's balance and decrease gait efficiency. While this study did not investigate quantitative gait analysis, it was noticed that the balance and speed of gait were improved because a patient's arm swing patterns were improved after surgery.

Effective management of spasticity is challenging for both patients and physicians. The management goals of spasticity include increasing mobility with range of motion, and improving hygiene, body image and functional level. Nonsurgical treatments that seek to improve spasticity include physical agents, oral antispastic drugs, and neuromuscular blockade by local injection of phenol and botulinum toxin. Surgical treatment options include spinal cord stimulation, intrathecal baclofen infusion, selective neurotomy, and orthopedic surgery. Each method has individual advantages and disadvantages. Oral antispastic agents are simple to apply, but often provide limited relief for a short duration and frequently lead to side effects such as confusion, sedation, dry mouth, and weakness[1]. Neurolysis by phenol or alcohol injections reduces spasticity effectively in cases of post-stroke hemiparesis, but the effect is quantitatively less selective and inconsistent. Severe pain is considered to be a major limitation of these treatments[3,7]. Intrathecal baclofen therapy is an invasive treatment method that requires an implantation procedure and can lead to adverse reactions, such as headache, nausea, vomiting, excessive weakness, transient urinary retention, and highly significant reduction of muscle tone; however some subsequent functional gains make the procedure favorable for use in intractable spastic hemiplegic patients[8]. Epidural spinal cord stimulation has been used to manage not only pain but also spasticity and dystonia, and to improve deteriorated consciousness. However, so far, its effects have been modest and variable, and the treatment is very expensive[17]. Posterior or anterior rhizotomy and dorsal root entry zonotomy (DREZotomy) have also been performed to reduce upper limb spasticity[10,16]. These operations are not effective for limited elbows and can lead to serious complications resulting in flaccid paralysis, atrophy, sensory loss, and respiratory compromise[5,16]. Intrathecal baclofen therapy, epidural spinal cord stimulation, rhizotomy and DREZotomy have diffuse effects that affect all the extremities.

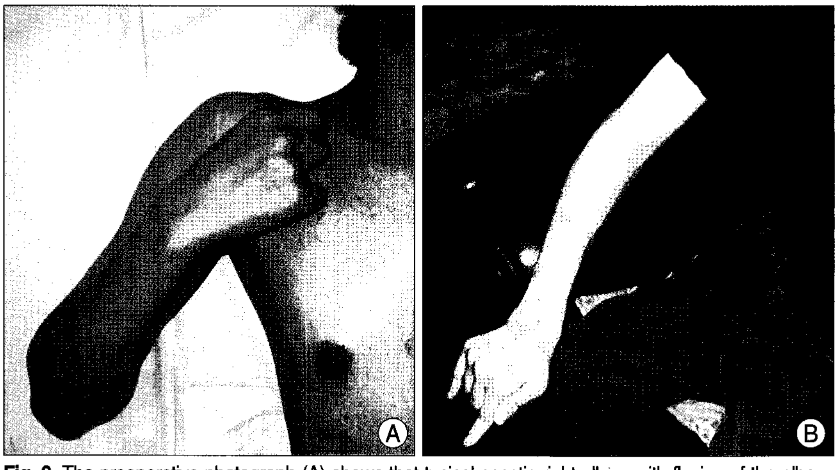

Fig. 2. The preoperative photograph (A) shows that typical spastic right elbow with flexion of the elbow, pronation of the forearm. The postoperative photograph (B) shows that right elbow spasticity decreased with good posture.

The current treatments of focalized spasticity, including spastic elbow, have been botulinum toxin injection, orthopedic surgery and selective peripheral neurotomy[6,13,15]. Botulinum toxin is, recently, the most widely used treatment for focal spasticity[13,14], but the clinical effect is reversible due to nerve sprouting and muscle reinnervation. Since this treatment does not provide permanent relief, it may have to be repeated after a few months. Orthopedic surgery (e.g., tenotomy, tendon transposition, lengthening of spastic muscles) can reduce spasticity[6,15]. However, it is useful only when severe musculotendinous contractures are mainly apparent from anesthetic block test. It is important to note that most orthopedic surgery requires casting after operation, which delays early rehabilitation. However, SMcN has a permanent effect and allows early rehabilitation without immobilization.

The most important step is to select good surgical candidates and the preoperative nerve block test is essential for good surgical outcome[6,12,15]. This study excluded cases of excessive contracture and no antagonist muscle power. Our results showed that SMcN provided a good prognosis when the limb had good power in the antagonist muscle and lacked joint contracture.

Some studies have reported the effects of SMcN in spastic elbow. Purohit et al.[12] reported that a selective musculocutaneous fasciculotomy, in 52 patients with spastic elbow related to cerebral palsy (average age, 9.5 years), provided 63% complete relief and 37% improved with some degrees of persistent spasticity. Purohit's study was limited to patients with cerebral palsy, but we studied patients with various causes of spastic elbow, including cerebrovascular attack, traumatic brain injury, and multiple sclerosis.

Maarrawi et al.[6] reported that, in patients with spastic elbow, the mean preoperative MAS score was improved significantly after SMcN. In all the patients in our study, three months follow-up postoperative MAS scores were decreased and the changes of MAS scores were variable individually between the 3 months and 12 months follow-ups. However, in almost all cases, the MAS score was steady after the 1-year follow-up and the MAS scores at the last follow-up period improved significantly more than preoperative. The changes of MAS score during postoperative 1-year were thought to be the effect of postoperative rehabilitation. Continuous comprehensive postoperative rehabilitations are important for a better outcome.

This study encountered mild postoperative complications in two of the 14 cases studied. One case with a wound infection was improved with treatment of antibiotics; one case with paresthesia was transient. In well-selected patients with spastic elbow, SMcN could be an alternative method, with a low morbidity rate in patients suffering from severe harmful spasticity that has been refractory to conservative therapy[6,9,11,16].

CONCLUSION

This study concludes that SMcN can be a good and effective treatment modality, with low morbidity, in appropriately selected patients who have localized spastic elbow with good antagonist muscles and without joint contracture. However, a prospective study with more patients is needed to fully validate the study's conclusion.

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