Role of Steindler Elbow Flexorplasty in Change of Movement at Elbow Joint in Traumatic Brachial Plexus Injuries

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ABSTRACT

Objective: To restore the elbow function; the wrist arthrodesis if needed proceeded before Steindler flexorplasty and finally saha's procedure to restore shoulder abduction in neglected brachial plexus injuries.

Methods: We conducted a quasi-experimental study of fifteen patients with absent or extremely weak elbow flexion (motor grade 2 or less) due to traumatic brachial plexus injuries (C5-C6-C7/C5-C6 deficit), which had undergone surgical reconstruction of the flail elbow by tendon transfer (Steindler elbow flexorplasty). The etiology of elbow weakness in all patients was traumatic brachial plexus palsy (C5-C6-C7/C5-C6 deficit) between 2011 to 2014. Elbow flexion improved or not improved measured in term of range of motion at elbow joint. Age, gender, preoperative strength (rated on a 0 to 5 scale for the flexors of the elbow and wrist flexors), previous surgery, length of follow-up, other associated operative procedures, results and complications were recorded.

Results: Average age of the patients was 23.2% while Percentage of male patients were 86.66% and female patients were 13.33%. The percentage of C5-C6 palsy was 86.66% while average time elapsed since injury was 20.5 months. We followed the patients on average of 1.75 years . The Percentage of very Good Patients is 66.66% and good is 20%. Our few Patients developed complication but these complications were managed effectively.

Conclusion: Steindler Elbow Flexorplasty is good and effective procedure in improving the range of motion (Change) at elbow joint in traumatic brachial plexus injuries (C5-C6-C7/C5-C6 deficit).

Key Words: Steindler Elbow Flexorplasty, Traumatic, Brachial Plexus Injuries

INTRODUCTION

Traction injury of the brachial plexus results in partial or total paralysis of the upper limb, especially when there is paralysis of elbow flexion. Good hand function is wasted if the hand cannot be maintained in a useful position. Upper trunk lesions of the brachial plexus (C5 and C6 or C5-6-7 injuries) generally occur due to high-energy mechanisms (motorbike accidents, firearm injuries, stab wounds, falls from heights and sports trauma), mainly affecting people in a young and productive age group. The incidence of this kind of lesion has increased, coinciding mainly with the use of motorcycles as a means of transport particularly in large cities. Loss of elbow flexion due to traumatic palsy of the brachial plexus represents a major functional handicap.

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Then, the first goal in the treatment of the flail arm is to restore arm function by primary direct nerve surgery (Exploration of brachial plexus with or without nerve grafting) or nerve transfer
or with secondary reconstructive surgery. (Tendon transfer)

There are various methods to restore elbow flexion, which are well documented, in the medical literature. One of the earliest procedures for restoring function to the elbow, Steindler flexorplasty first reported in 1918 [1] in infantile patients, then at the beginning of the 70s, Narakas [2,3] and Millesi [4] published the outcome of their work on the surgical repair of brachial plexus lesions. Nerve transfers represented a major advance in the treatment of these lesions. Oberlin [5] described the nerve transfer technique where one or more Ulnar nerve fascicles are transferred to the musculocutaneous nerve branch for gain of elbow flexion, and later on MacKinnon [6] described the double transfer technique, in which

besides transferring an Ulnar nerve fascicle to the biceps brachii muscle, they transfer a median nerve fascicle to the brachialis muscle.

As a rule, we attempt nerve reconstruction/transfer first, and when it does not present a good result or patients came after one year at that time neuro-muscular junction gets damaged and unable to conduct the action potential, we do secondary reconstructive procedure to restore elbow flexion by muscle transfer surgeries. The muscles used most often are: latissimus dorsi [7,8], pectoralis major [9], triceps [10,11,12], flexor pronator muscles of the forearm (Steindler elbow flexoplasty) [3,12,13] and microsurgical free tissue transfers [5,14,15].

The proximal transfer of the flexor-pronator muscles of the forearm to the medial intramuscular septum of humerus (brachial fascia) was described by Steindler [15]. Bunnell [16] suggested radial fixation to decrease the pronator effect of this transfer. Mayer and Green [13] modified the original technique, proposing fixation on the anterior side of the humerus, allowing firmer fixation and decreasing contracture in flexion, described as complications in the original technique.

The Steindler transfer is classically indicated in cases of paralysis of the biceps and brachialis muscles, where the presence of functional hand and strength greater than or equal to M4 of the flexor-pronator muscles of the forearm is essential. [6,16,17,18]

Methods: The patients selected had traumatic lesions of the upper trunk of the brachial plexus (C5 and C6 with or without impairment of C7) came between 2011 to 2014 (Table 1), all with elbow flexion force between M1 and M0 (MRC). Study Design was quasi experimental Study with total duration of study was 3years.

Data on operated patients table 1

Case. No	Age	Gender	Time since injury	Level of injury	Previous surgery
1	20	F	1y	C5-C6	NO
2	18	F	1y	C5-C6	NO
3	21	M	2y	C5-C6	EXPLORATION
4	43	M	1.3y	C5-C6-C7	Wrist arthrodesis
5	34	M	1y	C5-C6	Median nerve parenthesis
6	32	M	1.8y	C5-C6	NO
7	19	M	1y	C5-C6	NO
8	8	M	2y	C5-C6	NO
9	19	M	1y	C5-C6	NO
10	18	M	2y	C5-C6	NO
11	16	M	1y	C5-C6	NO
12	20	M	1.3y	C5-C6-C7	WRIST arthrodesis
13	14	M	1y	C5-C5	NO
14	46	M	3y	C5-C6	NO
15	20	M	2y	C5-C5	NO

All the patients were operated at National Orthopedic Hospital, Bahawalpur from 2011 to 2014. The functional evaluations were carried out in the pre- and postoperative periods after 15, 45 and 75 days and in the six month after surgery up to an average follow up (1.75years). Measuring the elbow flexion arc with a goniometer performed the functional evaluations and using the criteria established by Alnot and Abols (19) as written below made final assessment of the outcome.

Very good: Active elbow flexion against resistance (Grade 4) and range of flexion 120°.

Good: Active elbow flexion against resistance (Grade 4) and range of flexion below 120°.

Mild: Active elbow flexion against gravity but not resistance (Grade 3) and range of flexion 80° or more.

Fail: No active elbow flexion against gravity (Grade 0 to 2)

Inclusion criteria: traumatic closed upper trunk lesion of the brachial plexus (C5-C6, with or without C7 lesion); patients with one year or more of lesion; total passive amplitude of elbow; strength of flexor-pronator muscles of the forearm and wrist/hand greater than or equal to degree M4.

Exclusion criteria: open or non-traumatic lesion of brachial plexus upper trunk; complete lesion of the brachial plexus; stiffness upon passive movement of the elbow; patients with chronic illness, steroid dependent patients (Asthmatic, Joint pain patients), and renal failure patients.

Table 2

Grade	5	Normal Power
Grade	4	Active Movement Against Gravity With Resistance
Grade	3	Active Movement Against Gravity Without Resistance
Grade	2	Active Movement With Gravity Eliminated
Grade	1	Only A Trace Or Flicker Of Movement
Grade	0	No Movement

SURGICAL TECHNIQUE

In the surgical procedure the patient is placed in the horizontal supine position with the upper limb in external rotation and slightly flexed on a "hand table". The upper limb is exsanguinated with an elastic band and pneumatic tourniquet applied. The incision is started in the medial part of the arm approximately eight centimeters proximal to the medial epicondyle, extending distally, passing over the medial epicondyle and continuing towards the forearm lengthwise in relation to the pronator teres muscle. This was followed by the opening of the forearm muscle fascia, with dissection and identification of the Ulnar nerve up to its branches to the flexor musculature, we make the good excursion of Ulnar nerve after its release from FCU so that no tension should be maintained on it while transposing it anteriorly as well as we isolated median nerve and tag it with loop. The medial epicondyle osteotomy was performed with an oscillating saw respecting the location of the medial collateral ligament of the elbow. The dimension of the epicondyle fragment accompanying the muscle mass measures approximately 1cm in depth and 2cm in width. After isolating the brachial artery and the median nerve with its branches to the round pronator muscle and superficial flexor muscle of the fingers, the musculature was released enough to shift the epicondyle fragment and the entire origin of the flexor-pronator muscles proximally. The bone fragment is fixed approximately five centimeters proximal and radial wise to the distal edge of the humerus. The humerus and the fragment were irrigated with blood for the fragment to be fixed. The elbow was flexed 110-120 degrees for fixation of the fragment with a malleolar screw. The fixation position in the humerus was chosen as radially as possible, decreasing the pronating action of the transfer. The planes of soft parts were brought together and the limb was immobilized with a long upper limb plaster cast at 110-120 degrees of elbow flexion with forearm supination.

Functional Outcome

Actual change of movement (Flexion improved) at elbow joint measured with the goniometer as explained below.

Goniometry

Goniometry was performed using a standardized goniometer before and after the operation. The active range of motion of the elbow was evaluated with measurements in degrees (flexion and extension).

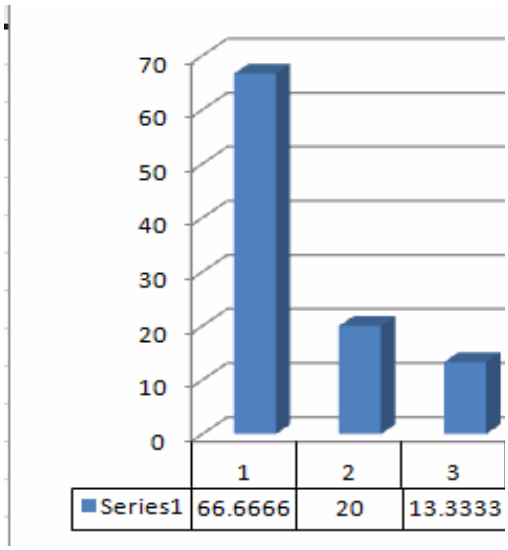
Degree of muscle strength (TMM)

The muscle test is an important part of the physical exam, providing information on the degree of muscle strength that the patient is capable of reaching. This evaluation was carried out to scale the evolution of elbow flexion force. Muscle strength was scaled as shown in following table.2

RESULTS

We operated 15 patients and average age at which patients presented was 23.2% in which male patients were 86.66% and female patients were 13.33%, The percentage of C5-C6 was 86.66% while average time elapsed since injury was 20.5 months. We followed the patients on average of for 1.75 years. The Percentage of very Good Patients is 66.66% and good is 20%. The overall results were very good to good showing the success of the procedure and increased flexion range of motion of elbow from flail to very good which is explained in study variables (change) and most of them were satisfied from the results of the surgery. We did have complications but not much serious as one of our patients developed numbness of ulnar nerve and few developed pronation contracture and one patient got

detachment of bony fragment. The Vertical Axis shows Percentage of success from very good to mild while horizontal axis shows the functional outcome in term of how much very good, good and mild as shown in Graph.1 below



(Graph. 1)

Fig. 1: Young male 19 years of age presented with injury to C5 and C6. Results After 1 year follow up were very good.

Fig. 2: Middle age man 46 years of age presented after RTA with injury to C5-C6 with good hand function operated after 3 years. Functional outcome was very good.

Table 3: Data on the flexorplasty

Case No.	Elbow flexors power E	Length of follow up	Associated procedures	Results	Complications
1	0	2y	Saha'procedure	VG	No
2	0	1.5y	Wrist arthrodesis and saha's proceed	VG	Pc
3	1	1y	Saha'procedure	G	No
4	0	1.3y	Saha'procedure	VG	No
5	0	2y	Saha'procedure	VG	No
6	0	3y	Saha'procedure	G	NP
7	0	1y	Saha'procedure	VG	Pc
8	0	2y	Wrist arthrodesis, Saha's procedure	VG	NO
9	0	2y	Saha'procedure	VG	NO
10	0	2.5y	Saha'procedure	M	NO
11	0	1y	Saha'procedure	VG	EEL
12	1	3y	Saha'procedure	VG	Nt,ng
13	0	2y	Saha'procedure	VG	EEL
14	0	1y	Saha's procedure	G	RF
15	0	1y	Wrist arthrodesis Saha'procedure	M	No

Strength rated on a scale of 0 to 5, nl: neurolysis; ng: nerve grafting;, nt: neurotization, VG: very good; G: good; M: mild; F: fair, NP: nerve parenthesis, Pc: Pronation contracture, EEL: Elbow Extension Loss, RF: refixation of lose fragment

DISCUSSION

The increase in the incidence of plexus lesions caused by motorbike accidents makes every orthopedic surgeon to think about to have a proper law and order for biker and to educate the community for safety measures and consequences of brachial plexus injuries and its fatal outcome until if not intervened properly whether primary or secondary reconstruction. Here we discuss about secondary reconstruction only in term of reconstruction via tendon transfer in otherwise flail elbow. A fact that increases the importance of studies targeting their recovery. Modified Steindler surgery is indicated in patients that do not have functional elbow flexion strength with normal or near normal hand function. We operated on those patients with flail elbow with functional hand and flexor-pronators muscles with strength of at least M4 (MRC) [20,21].

While reviewing the literature, there are various methods to restore elbow flexion, which are well documented, in the medical literature. These reconstructive procedures include proximal transfer of the forearm flexor-pronator or wrist extensor mass [1], anterior transfer of the triceps tendon [22,23,24], pectoralis major transfer [25,26,27], latissimus dorsi transfer [28,29,30], transfer of the flexor carpiulnaris [31], transfer of the sternocleidomastoid with or without shoulder arthrodesis [32] and free muscle transfer [33].

Complication do happens, in our series one patient got a screw pullout but re-fixation was done, fortunately, his functional outcome was very good as shown in case 14. Few other developed pronation contracture but it was supple in nature and one patient developed Ulnar nerve neuroprexia. In general, this is excellent procedure to restore elbow flexion. Proximal advancement of the forearm flexor/pronators muscle group should be considered as the initial treatment in all patients because of its familiarity by many surgeons and minimal donor site deficit but care must be taken while fixing the screw, we usually bring it 5-6 cm proximal to elbow joint and to slight radial side to prevent pronation contracture but common issues in our series was pronation contracture and nerve neuroprexia. According to Segal, Seddon, and Brooks [34], when the pattern of paralysis is such that a free choice of procedures is possible, the Steindler flexorplasty is preferable. Carroll [35] advises against transferring a muscle arising from the medial epicondyle to restore hand function until after any indicated flexorplasty has been done and the strength and function of the transferred muscles have been regained. A modified Steindler flexorplasty was used by Chen W [36] to restore elbow flexion in 8 patients with post-traumatic flail elbow and the results were not

compromised in patients whose flexor tendons had been transferred for wrist and finger extension. Brunelli GA [37] recommended a modified Steindler procedure to restore elbow flexion. The modifications were designed to avoid the phenomenon of the patient having to make a fist in order to obtain elbow flexion (Steindler's effect). According with the authors, Steindler flexorplasty is indicated in upper plexus lesions (C5-C6); other transfers are more appropriate for lower plexus palsies.

There is general agreement regarding the efficacy of the Steindler flexorplasty. Despite varying criteria, a number of authors [1-6] has reported a 70 to 90 per cent success rate with this procedure. We agree that it is the procedure of choice for a patient who has paralysis of the biceps brachii and brachialis, a functional hand, and sufficient forearm flexor power to warrant transfer because in our series we also got very good to good results in 66.66% and 20% respectively. One patient was fallen in mild category but he was using his hand for daily activities of life and was satisfied with the surgery results and we advised him to have exercises against resistance and with weight lifting as tolerated.

CONCLUSION

Steindler Elbow Flexoplasty is good and effective procedure in improving the range of motion at elbow joint in traumatic brachial plexus injuries (C5-C6-C7/C5-C6 deficit).

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