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ORIGINAL ARTICLE

FUNCTIONAL OUTCOME OF OBERLIN PROCEDURE

RESULTADO FUNCIONAL DA CIRURGIA DE OBERLIN

Fernando Antonio Silva de Azevedo Filho[1], Yussef Ali Abdouni[1], Guilherme Ogawa[1], Cloud Kennedy Couto de Sá[2], Antonio Carlos da Costa[1], Patrícia Maria de Moraes Barros Fucs[1]

1. Irmandade da Santa Casa de Misericórdia de São Paulo, Department of Orthopedics and Traumatology, São Paulo, SP, Brazil.
2. Hospital Geral Ernesto Simões Filho, Salvador, BA Brazil.

ABSTRACT

Objective: To evaluate the functional outcome of patients with traumatic brachial plexus injury undergoing the Oberlin procedure. Methods: Eighteen patients were assessed, comprising 17 men (94.4%) and 1 woman (5.6%), mean age 29.5 years (range 17-46 years), with upper traumatic brachial plexus injury (C5-C6 and C5-C7). We assessed active range of motion of the elbow, elbow flexion muscle strength and hand-grip strength, and applied the DASH (Disabilities of the Arm, Shoulder and Hand) questionnaire. Results: Four patients (22.2%) did not achieve effective elbow flexion strength (BMRC Grade 3). Mean active range of motion was 100.2º (±45.6º), and we observed a mean percentage of strength recovery relative to the contralateral limb of 35.5% (0-66.3%). Elbow flexion ($p = 0.0001$) and hand-grip ($p = 0.0001$) strength levels were lower on the affected side. Conclusion: The surgical technique described by Oberlin for brachial plexus injuries proved effective for restoring elbow flexion and produced no functional sequelae in the hand. Bicep strength outcomes were better when surgery was performed within 12 months of injury. ***Level of evidence II, retrospective study.***

Keywords: Brachial Plexus. Nerve Transfer. Muscle Contraction.

RESUMO

Objetivo: Avaliar o resultado funcional dos pacientes com lesão traumática do plexo braquial submetidos à cirurgia de Oberlin. Métodos: Foram analisados 18 pacientes, sendo 17 homens (94,4%), com idade média de 29,5 anos (17 a 46 anos), com lesão traumática alta do plexo braquial (C5-C6 e C5-C7). Avaliamos a amplitude de movimento ativa do cotovelo, a força muscular de flexão do cotovelo e a força de preensão palmar, e aplicamos o questionário Disabilities of the Arm, Shoulder and Hand (DASH). Resultados: Quatro pacientes (22,2%) não obtiveram força eficaz de flexão do cotovelo BRMC (Grau 3). A amplitude de movimentação ativa apresentou média de 100,2º (± 45,6º) e observamos média de 35,5% (0 a 66,3%) de percentual de recuperação da força em relação ao membro contralateral. Foi observada menor força de flexão de cotovelo ($p = 0,0001$) e de preensão manual ($p = 0,0001$) no lado acometido. Conclusão: A cirurgia descrita por Oberlin para lesões do plexo braquial mostrou-se eficiente para a restauração da flexão do cotovelo e não deixou sequelas funcionais para a mão. Os resultados para a força do bíceps são melhores nas cirurgias realizadas com menos de 12 meses de lesão. ***Nível de evidência II, estudo retrospectivo.***

Descritores: *Plexo Braquial. Transferência de Nervo. Contração Muscular.*

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INTRODUCTION

The incidence and severity of brachial plexus injuries has increased worldwide.[1] In the vast majority of cases, these injuries are caused by high-energy trauma. The increase in cases is directly associated with the growing number of motorcycle accidents involving young, economically active individuals, resulting in limitation both for activities of daily living and the occupational sphere.[1-5]

These injuries are usually classified according to the level of the injury into upper (injury of C5-C6 or C5-C6-C7 roots), lower (C8-T1) or total, affecting all roots of the brachial plexus.[4] Upper trunk (C5-C6) involvement results in significant disability, with loss of shoulder function (abduction and external rotation), elbow flexion and forearm supination.Involvement of theC7 root can lead to further deficits including wrist and elbow extension.Total injuries affect upper limb function completely.[1,6,7] The severity of these injuries range from neuropraxia (generally exhibiting spontaneous resolution) to complete injury due to avulsion, with no prospect of recovery.[6]

For patients with palsy of the upper roots of the brachial plexus (C5-C6 or C5-C7), the priority of first restoring elbow function, followed by shoulder abduction and external rotation, is well established in the literature.[2,4,8]

The strategies for brachial plexus repair consist of surgical exploration followed by reconstruction using nerve grafts.[6] This approach is reserved only for post-ganglionic injuries.In pre-ganglionic injuries involving root avulsion, the proximal root stumps are unavailable for grafting and surgical repair is based on nerve or tendon transfers.[2,6,9-12]

Evidence suggests that the outcomes of nerve transfers, also defined as neurotizations, are better than results attained for tendon transfers.[8,11-13] Neurotizations performed using nerves from the brachial

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Work conducted at the Irmandade da Santa Casa de Misericórdia de São Paulo, São Paulo, SP, Brazil.
Correspondence: Fernando Antonio Silva de Azevedo Filho. Rua Rodrigues Dórea, 250, Torre Atlântico, ap 904, Salvador, BA, Brazil. 41750-030. azevedofilho@gmail.com

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plexus are called intraplexial, whereas situations in which the donor site is not part of the brachial plexus are referred to as extraplexial. Transfer of a nerve entails total or partial resectioning of a healthy nerve and suturing it to the end of a paralyzed nerve.In cases of total resectioning of the donor nerve, it is important to bear in mind that this involves potentially sacrificing the function that the nerve hitherto performed, resulting in permanent sequelae.Partial use of the donor nerve, in the form of single fascicles, spares most of the nerve, preserves motor and sensory function of the donor nerve, whilst also allows the reconstruction to attain acceptable functional levels.[14] The neurotization techniques significantly improve the outcomes of surgical management of upper brachial plexus injuries.[15] More specifically, for restoring elbow flexion (priority in reconstruction), the literature reports use of the intercostal nerve, spinal accessory nerve (cranial nerve pair XI), phrenic nerve or fibers in the ulnar nerve, as donor sites, which are transferred to the musculocutaneous nerve to reinnervate the brachial biceps muscle.[13] Recent studies have shown superior results for elbow flexion when fascicles of the ulnar nerve are employed as the donor nerve.[6,8] The technique described by Oberlin et al.[16] (1994) uses a predominantly motor fascicle of the ulnar nerve which is transferred and sutured at the motor branch to the biceps. Attaining satisfactory results using this technique hinges on several factors, such as nerve suturing occurring at a healthy, uninjured area with lower fibrosis compared to the injury site; use of a single suture, without the need for nerve grafting; a short distance for axonal regeneration to reach the target muscle; and use of a well-vascularized nerve for the transfer.[6,8,11,15] This is a procedure which causes no morbidity at the donor site.[13,16,17] The objective of the present study was to assess the functional outcome of traumatic brachial plexus injury patients submitted to surgery using Oberlin´s procedure.

MATERIALS AND METHODS

A cross-sectional study of patients of the Outpatient Clinic of the Hand Surgery and Microsurgery Group of the Santa Casa de Misericórdia de São Paulo Hospital was conducted to assess outcomes of the Oberlin surgical procedure for brachial plexus injury. The study included patients with upper brachial plexus traumatic injuries at levels C5-C6 and C5-C6-C7; aged > 15 years; submitted to the Oberlin procedure, in association or otherwise with other concomitant brachial plexus procedures (reconstructions with grafts, intraplexial or extraplexial neurotizations such as: accessory nerve transfer to the suprascapular nerve of the motor branch of the triceps muscles to the axillary nerve) and who were followed up post-operatively for at least six months.Patients diagnosed with obstetric palsy, pediatric patients, as well as those with lower and total brachial plexus injury, were excluded from this investigation. The following clinical aspects were assessed:age, gender, side affected, handedness, work activity prior to accident, type of accident, time elapsed (in months) between the trauma event and the surgery performed by the fast-track specialized team, presence of associated injuries and level of neural injury (trunks affected) as determined by physical examination and initial surgical findings. The active range of motion of the elbow, elbow flexion muscle strength, hand-grip strength and results on the DASH (Disabilities of the Arm, Shoulder and Hand) questionnaire were assessed.[18] Free active range of motion was measured using a goniometer, with the patient in a standing position. The goniometer was placed on the sagittal plane centered over the elbow joint and, starting from the point of maximum extension, the patients was instructed to perform maximum flexion, with the reading taken in degrees. Elbow flexion muscle strength was measured in two ways: using the British Medical Council scale and by dynamometer. For the scale assessment, the patient was instructed to assume a sitting position, with trunk upright to prevent compensatory movements during the exam.The examiner stabilized the proximal region by providing the necessary support.Strength was graded as M0, no muscle contraction; M1, trace of contraction; M2, active movementwith gravity eliminated; M3, active movement against gravity; M4, active movement against resistance; M5, normal strength.A result below M3 was considered poor and these patientswere not subsequently submitted to the dynamometry tests.

The dynamometry assessment was done according to the recommendations of the American Society of Exercise Physiologists, as described by Brown.[19] Elbow flexion strength was measured in kilograms (Kgf) using a model 01163 Lafayette® Hand Held Dynamometer (Manual Muscle Test - MMT) consisting of two adjustable rigid straps, one end of which was affixed to the floor using a suction cup while the other end was attached to the patients hand.The patient remained in a sitting position holding the elbow at 90º alongside the body and with forearm in supination.The device was adjusted to patient height. Three consecutive measurements were made at 30-second intervals of 5-second contractions.An average of the three readings taken was calculated.The value obtained was compared with the force of the contralateral side, measured in the same manner as the affected limb. Hand-grip strength was quantified using a Jamar Plus® dynamometer. The test was performed in the sitting position with the elbow flexed at 90º.The examiner stabilized the patient´s wrist during the test, and patients were encouraged to exert the maximum grip-strength possible.Three measurements were made for each limb at 30-second intervals.The mean of these measurements in kilograms (Kgf) was used for the analysis, comparing the values obtained for each limb. The data gathered were stored on the Excel program for Windows and then compared and analyzed using the SPSS statistics program V20 for Windows.The elbow flexion and hand-grip strength data were first tested for normality and logarithmic transformations applied when appropriate.Mean values for normal and affected sides were then compared after neurotization using the paired *t*-test, with an alpha < %5 considered significant.All analyses were carried out using the Statistical Package for the Social Science for Windows (SPSSW) – version 15.0. The data were expressed as mean ± standard deviation. This study was approved by the Ethics Committee for Analysis of Research Projects (CAPPesq) (number 10179316.7.0000.5479). All patients signed an informed consent form after receiving a detailed explanation.

RESULTS

A total of 18 patients were analyzed.The patient group comprised 17 men (94.4%) and 1 woman (5.6%), with a mean age of 29.5 years (range 17-46 years).With regard to the trauma mechanism, most cases involved motorcycle accidents (17 individuals, 94.4%).The distribution of affected side, left or right, was similar in the sample studied, and 8 patients (44.4%) had other associated injuries.The analysis of injury level revealed predominantly C5-C6 injuries (13 cases) (72.2%) followed by C5-C7 injuries (5 cases)(27.8%).Time elapsed between trauma and performance of the surgical procedure ranged from 3 to 17 months, with a mean interval of 9.2 months. (Table 1)

Four patients (22.2%) did not attain effective elbow flexion strength (MRC Grade 3), mean active range of motion was 100.2º (±45.6) and mean percentage recovery of strength relative to the contralateral limb was 35.5% (0-66.3%).Mean score on the DASH was 37.87 (range 14.2-79.0). Three patients showed no improvement after the surgical procedure. (Table 2)

Elbow flexion (p= 0.0001) and hand-grip (p= 0.0001) strength was lower on the injured side submitted to neurotization, compared with the normal contralateral side.

Table 1. Clinical data.

Patient	Age	Sex	Handedness		Side affected	Trauma mechanism	Time elapsed to surgery (M)	Associated injuries	Level of injury
			Before	After					
1	17	M	R	L	Right	Motorcycle	15	None	C5-C7
2	27	M	R	R	Right	Motorcycle	12	None	C5-C6
3	46	M	R	R	Left	Motorcycle	8	None	C5-C6
4	38	F	R	R	Left	Fall from height	14	None	C5-C7
5	27	M	R	R	Left	Motorcycle	10	Humeral fracture	C5-C7
6	28	M	R	R	Left	Motorcycle	6	Fractures to foot, radius and femur	C5-C6
7	39	M	R	L	Right	Motorcycle	16	None	C5-C6
8	37	M	R	R	Left	Motorcycle	6	Fracture to radius	C5-C6
9	17	M	R	R	Left	Motorcycle	3	Fracture to scapula and rib	C5-C6
10	26	M	R	L	Right	Motorcycle	3	Tibia fracture	C5-C6
11	20	M	R	L	Right	Motorcycle	7	Clavicle fracture	C5-C6
12	37	M	R	R	Left	Motorcycle	16	Rib and cervical vertebrae fractures	C5-C7
13	35	M	R	R	Left	Motorcycle	17	None	C5-C6
14	24	M	R	R	Right	Motorcycle	6	None	C5-C6
15	27	M	R	L	Right	Motorcycle	6	None	C5-C6
16	25	M	R	L	Right	Motorcycle	5	None	C5-C6
17	37	M	R	R	Left	Motorcycle	9	Clavicle and wrist fracture	C5-C7
18	24	M	R	R	Right	Motorcycle	6	None	C5-C6

Table 2. Quantitative variables.

Patient	ROM (degrees)	Elbow				Grip		DASH
		MRC	Dynamometry(Kgf)		Strength (%)	Jamar (Kgf)		
			R	L		R	L	
1	130	3	11.3	29.3	38.6	21.3	38.0	51.6
2	100	3	13.0	36.5	35.6	42.7	54.7	27.3
3	132	4	26.7	17.7	66.3	50.0	14.0	22.3
4	14	2	12.7	0.0	0.0	34.0	6.7	79.0
5	100	3	31.7	7.9	24.9	49.3	22.0	39.1
6	130	4	33.2	20.0	60.2	48.6	21.3	35.1
7	0	2	0.0	31.7	0.0	21.0	41.3	30.8
8	130	4	30.9	14.3	46.3	34.0	11.3	30.0
9	110	4	29.0	13.0	44.8	38.6	18.3	22.5
10	150	4	4.2	11.1	37.8	37.0	46.0	30.0
11	130	3	3.6	11.3	31.9	26.3	38.6	34.1
12	10	2	12.0	0.0	0.0	39.3	2.0	58.3
13	80	2	20.3	0.0	0.0	34.0	12.0	60.0
14	100	4	10.3	27.6	37.3	38.0	42.0	34.1
15	128	4	12.0	20.7	58.0	34.0	51.3	28.0
16	130	4	23.0	37.3	61.7	22.6	40.3	33.3
17	120	3	32.5	10.7	32.9	36.6	11.3	52.0
18	110	4	21	33	63.63	38.0	47.0	14.2

DISCUSSION

Neurotizations or nerve transfers represent a favorable treatment option for brachial plexus injuries. In root avulsion injuries, the Oberlin procedure used alone has shown better outcomes than tendon transfers[11-13] or nerve grafting in reparable injuries.[6]

Factors determining improved outcomes include the proximity of the donor nerve to the motor end plate of the recipient muscle, and thus shorter reinnervation time; the need for only a single anastomosis as opposed to the two required for nerve grafting; and the more anatomic force vectors, contractile capacity and tension of the muscle previously determined for the primary motion compared to the reorientation and new characteristics of a muscle involved in a tendon transfer.[6,7,9,11,12]

Given the factors outlined above, allied with advances in dissection techniques, electrostimulation to select the best fascicle, magnification of the surgical field of view and improved neurorrhaphy techniques, nerve transfers are becoming the treatment of choice for nerve injuries.[11-13]

The results of the presentstudy are similar to those reported in the literature for recovery of elbow flexion strength after the Oberlin procedure (77.7% ≥ MRC grade 3 and 50% ≥ MRC grade 4),[2,7,14,20] yet worse than some studies reporting 90-100% successful outcomes.[1,13,21] This disparity appears to be related to the fact that delayed surgical treatment – longer than 12 months after injury – is associated with poorer outcomes[2,6,8,17,21] where 5 patients (27.8%) in the present sample had a time elapsed between injury and surgery of over 12 months.

Comparison of elbow flexion strength relative to the contralateral limb (35.5% of the unaffected limb), although statistically meaningful in terms of strength loss, showed similar results to those found in previous studies.[4,15]

Success of the Oberlin procedure hinges largely on the characteristics of the donor nerve.In theory, this should be specifically motor, close to the recipient motor end plate and the dysfunction caused by resection should be acceptable or compensated by other muscles.The use of an ulnar nerve fascicle potentially satisfies all these criteria.Previous studies have shown no loss of function in the affected hand submitted to surgery. Indeed, the operated hand sometimes shows improved grip strength scores after the surgery.[1,2,9,13,14,17] In the present study, mean grip strength was 22.2 kg (2-42.7) which, although demonstrating a statistically significant loss of strength, mirrors results of previous studies.[7,9] Despite the loss of grip strength seen in the present study, overall hand function was unaffected.This result is corroborated by the patients´ perceived functional deficit as assessed by the DASH score (37.87), which is in line with previously reported results.[15,21]

CONCLUSION

The surgical technique described by Oberlin for brachial plexus injuries proved effective for restoring elbow flexion and produced no functional sequelae in the hand.

Bicep strength outcomes were better when surgery was performed within 12 months of injury.

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