



Original Article

Correlation between the elbow flexion and the hand and wrist flexion after neurotization of the fascicles of the ulnar nerve to the motor branch to the biceps[☆]



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ABSTRACT

Objective: Gain in elbow flexion in patients with brachial plexus injury is extremely important. The transfer of a fascicle from the ulnar nerve to the motor branch of the musculocutaneous nerve (Oberlin surgery) is a treatment option. However, in some patients, gain in elbow flexion is associated with wrist and finger flexion. This study aimed to assess the frequency of this association and the functional behavior of the limb.

Methods: Case-control study of 18 patients who underwent the Oberlin surgery. Group 1 included patients without disassociation of range of elbow flexion and that of the fingers and wrist; Group 2 included patients in whom this disassociation was present. In the functional evaluation, the Sollerman and DASH tests were used.

Results: It was observed that 38.89% of the patients did not present disassociation of elbow flexion with flexion of the wrist and fingers. Despite the existence of a favorable difference in the group with disassociation of the movement, when the Sollerman protocol was applied to the comparison between both groups, this difference was not statistically significant. With the DASH test, however, there was a statistically significant difference in favor of the group of patients who managed to disassociate the movement.

Conclusion: The association of elbow flexion with flexion of the wrist and fingers, in the group studied, was shown to be a frequent event, which influenced the functional result of the affected limb.

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Correlação da flexão do cotovelo com a flexão da mão e do punho após neurotização dos fascículos do nervo ulnar para ramo motor do bíceps

R E S U M O

Palavras-chave:

Plexo braquial/lesões
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Objetivo: O ganho da flexão do cotovelo em pacientes com lesão no plexo braquial é de suma importância. A cirurgia de transferência de fascículo do nervo ulnar para ramo motor do nervo musculocutâneo (cirurgia de Oberlin) é uma opção de tratamento. Contudo, o ganho da flexão do cotovelo, em alguns pacientes, vem associado à flexão do punho e dos dedos. O objetivo deste trabalho é avaliar a frequência dessa associação e o comprometimento funcional do membro.

Métodos: Estudo tipo caso-controle de 18 pacientes submetidos à cirurgia de Oberlin. No Grupo 1 foram incluídos os pacientes que não apresentavam dissociação do ganho da flexão do cotovelo com a dos dedos e do punho; no Grupo 2, os pacientes em que havia dissociação. Os testes de Sollerman e *Disabilities of the Arm, Shoulder and Hand* (Dash) foram usados na avaliação funcional.

Resultados: Observou-se que 38,89% dos pacientes não dissociavam flexão de cotovelo de flexão de punho e dos dedos. Apesar de existir uma diferença favorável ao grupo que dissociava o movimento quando aplicado o protocolo de Sollerman na comparação entre os pacientes dos dois grupos, essa não se mostrou estatisticamente significativa. Já no teste Dash, observou-se diferença estatisticamente significativa, favorável ao grupo de pacientes que conseguiu dissociar o movimento.

Conclusão: A associação da flexão do cotovelo com a flexão de punho e dos dedos no grupo estudado mostrou ser um evento frequente, teve influência no resultado funcional do membro acometido.

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Introduction

Brachial plexus injury has received special attention in the last decades because it mainly affects young patients. Treatment of these injuries is challenging.^{1,2} Currently, the leading cause of brachial plexus injury is a result of high energy trauma in traffic accidents and main victims are motorcyclists.^{3,4} The injury occurs by a traction force applied in the shoulder and neck areas, leading to temporary or permanent loss of movement and of upper limb sensitivity.

As recommended by Hentz and Doi,⁵ restoring active elbow flexion in brachial plexus injuries is a priority, regardless of the type of injury. To achieve this goal, several surgical approaches have been described.

Initially, neurological procedures should be prioritized, through nerve reconstruction with or without grafts and nerve transfers (neurotization).^{5,6} The first report of neurotization using a motor fascicle of the ulnar nerve was published in 1994 by Oberlin et al.,⁷ for elbow flexion gains. This procedure consists of transferring a motor fascicle from the ulnar nerve to the biceps motor branch. In general, a fascicle related to the flexor carpi ulnaris and flexor digitorum is chosen, to avoid denervation of the intrinsic muscles of the hand. The Oberlin procedure gained notoriety due to excellent results in elbow flexion, tested and demonstrated by several authors. Currently, it is routinely used in high partial lesions of the brachial plexus, i.e., lesions that do not affect the roots of C8 and T1, which account for approximately 40% of the lesions.^{8,9}

In the literature, the assessment of elbow flexion gain after nerve reconstruction has been done mostly by using the British Medical Research Council (BMRC) scale. This type of evaluation, although widely used, provides little or no information about the quality of muscle recovery in terms of functionality in work life.^{7,10,11}

In the evaluation of the present patients, who presented recovery of elbow flexion with force greater or equal to M3 after Oberlin surgery, we observed that some patients presented flexion of the elbow associated with flexion of the wrist and fingers. Despite the effectiveness of elbow flexion, this co-contraction phenomenon leads to flexion of the fingers and wrist, which damages the limb's functionality, especially for the execution of grip movements.

Therefore, this study aimed to assess the frequency with which co-contraction of the elbow flexion/wrist and fingers flexion occurs and its functional repercussions.

Material and methods

Patient records with high brachial plexus lesions who were submitted to distal neurotization by the Oberlin technique, associated or unassociated with the C7 root lesion, were analyzed. Only patients who had elbow flexion with a motor force degree greater or equal to 3 on the BMRC scale were included in this study. Minimum follow-up time was at least 12 months after Oberlin surgery.

Table 1 – Result in kgf of the hand grip.

	Affected side	Non-affected side	p-Value
Lateral pinch + SD	6.42 ± 3.0	10.1 ± 2.3	0.002
Pulp pinch + SD	3.44 ± 1.7	5.77 ± 1.5	0.004
Three-digit pinch + SD	4.89 ± 2.52	7.77 ± 2.2	0.002

SD, standard deviation; kgf, kilogram force.

Patients who presented the following characteristics were excluded from the study:

- Bilateral brachial plexus injury
- Associated humeral fracture
- Those who did not achieve elbow flexion force greater than or equal to 3 on the BMRC scale.

Patients were divided into two groups:

- Group 1: those not able to dissociate the movement of elbow flexion with the movements of wrist and fingers flexion;
- Group 2: those able to dissociate the movement of elbow flexion with the movements of wrist and fingers flexion;

Patients' epidemiological data, date of accident, date of surgery, trauma mechanism, age at time of injury, sex, surgical procedures, type of injury, and injured side were collected.

Patients were assessed for grip strength and the DASH protocol was applied,^{12,13} which aims to measure symptoms and function in individuals with musculoskeletal pathologies in the upper limbs, with a focus on physical function, highlighting subjective aspects; the Sollerman et al. test,¹⁴ which measures the grip movements required for certain ADLs, has a more objective character.

The DASH score contains 30 items regarding the health status of the individual, highlighting difficulties in the performance of physical activities, severity of symptoms, and impact on social conditions. Each item in the DASH has five response options, ranging from 0 (no difficulty or symptom) to 5 (inability to perform the task or extreme symptom severity). Total DASH score ranges from 0 to 100; it is calculated by adding the score of each item, subtracting 30, and dividing the score by 1.2.

The Sollerman score takes into account the time required, the level of difficulty presented, and the quality in which the task is performed, using the correct hand grip position. Patients are scored on a five-point scale: from 0 (task cannot be performed at all) to 4 (task is completed without any difficulty within 20 s and with the prescribed hand grip of normal quality). The total score (0–80) is created by the sum of the scores of the different subtests.

Data were stored in an Excel spreadsheet and imported into SPSS v. 23 software for Mac. Continuous data were described as means and their respective standard deviations and tested for normality using the Kolmogorov–Smirnov test. Categorical data were described as absolute numbers and their respective proportions. For the parametric data, Student's t-test was used, and for non-parametric data, the Mann–Whitney test. For associations between categorical data, chi-squared test

was used. Statistically, an alpha less than or equal to 0.05 was accepted as statistically significant.

The study was approved by the Research Ethics Committee, under No. 47713615.2.0000.0068.

Results

Twenty-five medical charts of patients who agreed to participate in the study after the Oberlin procedure were collected. Of these, seven did not meet the inclusion criteria, due to lack of flexion force, and were excluded. The remaining 18 patients underwent the DASH and Sollerman tests.

Mean age of patients was 28.9 ± 8.3 years; 17 were males and one, female. Ten (55.6%) presented lesions of the C5–C7 roots and eight (44.4%), lesions of the C5–C6 roots.

Main trauma mechanism was motorcycle accident, observed in 94.4% of patients; a different trauma mechanism was observed in only one patient (5.6%), fall from a bicycle. Brachial plexus injury occurred mainly on the left side (77.8%).

In the comparative evaluation of different types of grip between the affected and normal sides, significant differences were observed, as shown in Table 1.

It was observed that patients took 6.63 ± 3.63 min to complete the Sollerman test on the affected side and 3.63 ± 1.8 min on the non-affected side. The final mean result of the protocol was on average 74.83 (95% CI: 70.4–79.2) points on the non-affected side, with a standard deviation of 8.87 points. The affected side presented a mean of 62.55 (95% CI: 54–71) points, with a standard deviation of 17.17 points.

The DASH test was applied only in the injured limb; the mean score was 51.28 ± 18.3 points.

Of the 18 patients who underwent functional evaluation, seven (38.89%) were not able to dissociate the flexion movement of the elbow from the flexion movements of the wrist and fingers (Group 1) and 11 (61.11%) were able to dissociate these movements (Group 2).¹⁵ Five patients from Group 1 and five from Group 2 presented injury at C5, C6, and C7.

Mean time between injury and surgery were 6.8 ± 2.0 months for patients in Group 2 and 7.6 ± 2.6 months for Group 1, which did not differ significantly.

Results of the evaluation of the different types of hand grip between Group 1 and Group 2 are described in Table 2.

In the Sollerman test, the patients in Group 1 presented a mean of 54.42 (95% CI: 32.18–76.66) points, with a standard deviation of 24 points, while the patients in Group 2 presented a mean of 67.72 (95% CI: 61–73) points, with a standard deviation of 8.87 points; however, this difference was not statistically significant ($p=0.173$; Table 3).

Table 2 – Result in kgf of the hand grip, with or without dissociation.

	Group 1	Group 2	p-Value
Lateral pinch + SD	5.97 ± 3.6	6.72 ± 2.7	0.626
Pulp pinch + SD	3.57 ± 2.0	3.36 ± 1.5	0.807
Three-digit pinch + SD	4.41 ± 2.3	5.20 ± 2.7	0.536

SD, standard deviation; kgf, kilogram force.

The DASH test presented a mean score of 65.3 (95% CI: 55–74) points for Group 1, with a standard deviation of 10.3 points, while Group 2 presented a mean of 43.25 (95% CI: 31.6–54.9) points, with a standard deviation of 17.3 points ($p=0.008$). Regarding these data, a statistically significant difference was observed (Table 3).

Table 3 presents the results of the Sollerman and DASH scores, in which a significant difference between the groups was observed only for the latter score.

Discussion

The increased number of motorcycle accidents observed in recent statistics is associated with a change in habits of society, in which the use of motorcycle combines low purchase and maintenance costs with the perspective of more agile mobility in big cities.

In agreement with the literature,^{3,4,13} the present study population had a profile of young patients (mean 29 years) and predominantly male. Motorcycle accident was shown to be the major causal factor (94%) of brachial plexus injuries, in line with the increased use of this type of transportation.

When treating a patient with brachial plexus injury, it is necessary to establish priorities in the order of reconstruction, considering that there are often few treatment options, which should be used according to the judgment of functional importance. The literature indicates a tendency to prioritize shoulder and elbow reconstruction, and especially elbow flexion, which has a primary function mainly in high brachial plexus lesions (C5/C6/C7), where the functional hand, in order to be useful, requires the elbow flexion movement so that it can reach objects.⁵

In the cases of high brachial plexus lesion, it is possible to use a fascicle of the ulnar nerve for neurotization in the musculocutaneous nerve, as described by Oberlin; this procedure has excellent results, as attested by numerous studies, with a success rate of 85–93%, with return of strength greater than or equal to M3.^{1,6}

Considering the evaluation of the different types of hand grip between the affected side and the normal side, a worsening of the strength in the former (40–50%) was evident. When applying Sollerman test,¹⁴ paired, in both sides of the same

patient, a significant difference was observed in the time to execute the hand grips (6.63 ± 3.63 min on the affected and 3.63 ± 1.8 min on the non-affected side), as well as a more favorable final score on the non-affected side. One possible explanation for this fact is that, even in a high plexus lesion, there may be some degree of impairment of the innervation of the median nerve and even of the ulnar nerve, due to the contribution of different levels of roots in the formation of these nerves. Therefore, the hand strength of the affected side should be considered, a priori, as inferior to that of the normal side.

In turn, the DASH score characterizes the overall function of each patient, which is reduced in relationship to that the normal population, with a mean of 51 points (variation of 18), an expected fact due to the evident functional impairment of the affected side.

Regarding the primary objective of the present study, we observed that almost 39% of the patients who recovered elbow flexion through the Oberlin surgery presented the association of this movement with flexion of the wrist and fingers. The remainder (61%) were able to dissociate both movements. Considering the minimum post-Oberlin follow-up time of one year, the authors believe that the event of non-dissociation of movement between the elbow and the hand/wrist was quite high in the present sample, and therefore deserves attention in relation to its possible causes, forms of treatment, and prevention.

One of the factors that could influence the occurrence of non-dissociation of movement (elbow/hand) would be the time between the injury and the Oberlin surgery, as well as the homogeneous distribution of cases that included C7 or not in both groups. However, a balance of these possible confounding factors was observed in the groups studied.

In the comparative functional assessment of both groups, we observed that the Sollerman test presented a trend of better results in patients who could dissociate movement (Group 2), but this difference was not statistically significant. It is noteworthy that this test basically assesses the different hand grips, rather than the function of the limb as a whole. Therefore, the observed lack of difference may be due to the inadequacy of this test to answer the question posed by this study.

Table 3 – Result, in points.

	Group 1	Group 2	p-Value
Sollerman	54.42 ± 24	67.72 ± 8.87	0.173
DASH	65.3 ± 10.3	43.25 ± 17.73	0.8

DASH, Disabilities of the Arm, Shoulder and Hand.

The DASH score indicated a statistically significant difference, favorable to Group 2, despite the small number of patients. That is, in this test, the dissociation of movement (elbow/hand) was shown to be an important factor for the functional gain of the affected limb as a whole. This finding seems intuitive, since in most hand movements, such as when approaching a lock to open a door, the required movement is that of elbow flexion, combined with first the extension of the wrist and fingers, then the gripping movement.

Patients from Group 1 were only able to grab an object when the forearm was supported and the elbow relaxed, thus allowing hand grip. Regardless of the functional tests used, a fundamental difference was observed between the two groups, characterized by the need for elbow support for gripping in Group 1, which was not observed in Group 2. When assessing the function of the elbow and of the hand in isolation, similar results were observed between the two groups. However, when considering the function of the limb as a whole, a significant difference was observed between the two groups, evidenced by the DASH score.

Regarding the difference observed between both tests used in the functional assessment of the affected limb, it is noteworthy that the Sollerman test focuses on the specific evaluation of the different hand grips, differently from the DASH test, in which the score takes into account the functional aspect of the limb as a whole, in addition to having demonstrated a significant difference between the two groups evaluated. The authors believe that since the present study assessed the synchronism of two distinct movements topographically, the DASH score is more accurate to reflect the quality of the affected limb function.

While the result with Oberlin surgery is quite satisfactory in terms of elbow flexion gain, the present study demonstrated that a significant number of patients (39%) could not perform this dissociation. This data should be considered when evaluating the results of the Oberlin surgery, since it compromises the function of the affected limb as a whole.

The authors believe that some factors may influence the presence or absence of elbow/hand dissociation after Oberlin surgery, such as the patient's level of education and his/her adherence to the rehabilitation protocol. In the present study, patients were submitted to a standard rehabilitation protocol for elbow flexion gain; in theory, they should respond in a similar way to the process of movement dissociation.

Most of the studies that reported the results of Oberlin surgery only described the results of elbow flexion gain. However, based on the present study, the functional gain of the affected limb should be assessed in a global way and thus include the presence or absence of movement dissociation, which, as demonstrated, has a direct influence on the final functional outcome of the patient. The authors believe that further studies should be conducted in order to identify the possible causal factors for the movement association event (elbow/hand), so that prophylactic actions can be taken in order to avoid this adverse effect.

As a limitation of the present work, the small sample size is noteworthy. However, this observation of the association of the elbow flexion movement with the flexion of the wrist and the fingers has been a constant finding in the authors' daily

practice, which necessitated a study to indicate the frequency of this event and therefore act effectively in its solution.

The treatment of patients with brachial plexus injury requires specific therapeutic decisions that, due to the scarcity of options, should be used carefully, which implies having a correct evaluation of their results for a more effective treatment. Oberlin surgery is undoubtedly excellent for gaining elbow flexion; it will be even better if the undesirable association of elbow flexion with flexion of the wrist and fingers can be successfully avoided in the future.

Conflicts of interest

The authors declare no conflicts of interest.

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