Online ISSN : 2314-8969
Print ISSN: 2314-8950
Egy Spine J 16:22-29, 2015
www.esa.org.eg

Partial Radial Nerve Transfer to the Axillary Nerve for Reconstruction of Shoulder Abduction

PARTIAL RADIAL NERVE TRANSFER TO THE AXILLARY NERVE FOR RECONSTRUCTION OF SHOULDER ABDUCTION

Tariq Elemam Awad, MD., Khaled Elsayed Mohamed, MD.
Department of Neurosurgery, Faculty of Medicine, Suez Canal University, Ismailia, Egypt.

Abstract

Background Data: In cases of axillary nerve injury, surgical reconstruction is indicated when no spontaneous recovery is noted after three to six months. Surgical repair has been carried out by neurolysis, a nerve graft or nerve transfer.

Purpose: The aim of this study was to report our results with reconstruction of the axillary nerve by transferring the branch of the triceps lower medial head to the anterior division of the axillary nerve.

Study Design: A descriptive analytic cross section retrospective study.

Patients and Methods: The authors retrospectively reviewed their data archive from 2011 through 2015, and seven patients who were operated on due to complete injury of the axillary nerve either isolated or as part of brachial plexus injury were enrolled in the study. All patients underwent surgical reconstruction by transfer the radial nerve branch from the triceps medial head to the anterior division of the axillary nerve.

Results: There were six men and one woman included in this study, with a mean age of 26 years (range 17–37 years). All patients recovered deltoid function and maintained full active elbow extension. Abduction strength improved from approximately 40% that of the normal side at 90˚ of abduction preoperatively to 60% of normal strength postoperatively. There was improved endurance in abduction from approximately 25% to 65% that of the normal side, which was sufficient to eliminate shoulder pain or fatigability.

Conclusion: Transfer of the radial nerve branch for the lower triceps medial head to the anterior division of the axillary nerve proved to be an effective method of deltoid re-innervation. (2015ESJ101)

Key Words: Axillary nerve, nerve transfer, triceps branch, deltoid palsy.

Received at:
July 2nd, 2015
Accepted at:
September 22nd, 2015

Introduction

A nerve transfer is a surgical technique that may be used when a patient has a nerve injury resulting in complete loss of muscle function or sensation. Nerve transfers involve taking nerves with less important roles and transferring them to restore function in a more crucial nerve that has been severely damaged. The surgeon will use functioning nerves that are close to the target muscle or sensory area.[20]

In cases of axillary nerve injury, surgical reconstruction is indicated when no spontaneous recovery is noted after three to six months.[20] Surgical repair has been carried out by neurolysis, a nerve graft or nerve transfer.[7] Nerve transfer includes diverting the nerve of the long head of the triceps to the anterior branch of the axillary nerve through a posterior approach.[5,17,21] The branch of the long head is short, and occasionally it is necessary to perform substantial proximal dissection (including dividing the teres major) to reach the distal stump of the axillary nerve.[17] The branch of the triceps medial head and anconeus is longer, which facilitates its connection to the axillary nerve.[6]

The aim of this study was to evaluate the results of deltoid function after axillary nerve reconstruction by transfer the radial nerve branch from the triceps medial head to the anterior division of the axillary nerve. Seven consecutive patients with loss of shoulder abduction secondary to axillary nerve palsy or brachial plexus injury were included and analyzed.

Patients and Methods

A total of seven consecutive patients (6 male and 1 female) with loss of shoulder abduction secondary to axillary nerve or brachial plexus injury were surgically treated at Suez Canal University Hospital in the Neurosurgery Department between June 2011 and January 2015. The mean patient age was 26 years (range 17 to 37 years).

All patients had complete injury of the axillary nerve either isolated or as part of brachial plexus injury. All patients underwent surgical reconstruction by transfer the radial nerve branch from the triceps medial head to the anterior division of the axillary nerve. If shoulder dislocation was associated with the injury, reduction and stabilization was performed before nerve transfer.

None of these patients had passive limitations affecting the shoulder. In all patients, preoperative electromyograms indicated a complete axillary nerve lesion with paralysis of all portions of the deltoid. Three months after the patients' injuries, and in the absence of either clinical or electrophysiological recovery of deltoid function, was the indication of nerve transfer.

Surgical Procedure:

We made a 15-cm incision over the posterior arm, beginning at the lateral border of the scapula and running along the posterior margin of the deltoid and the lateral border of the long head of the triceps. (Figure 1a) We identified the upper lateral brachial cutaneous nerve piercing the deep fascia. We incised the fascia over the triceps long head and followed the cutaneous branch proximally to the axillary nerve. We identified the anterior division of the axillary nerve and then separated the triceps long and lateral heads for radial nerve identification. Running on top of the radial nerve and parallel to it, we identified the motor branch to the lower medial head and anconeus. (Figure 1b) Upon electrical stimulation, visible contraction of the anconeus confirmed nerve identity. We dissected the nerve to the lower triceps medial head and anconeus distally, sectioned it, and flipped it 180˚ to coaptate it to the anterior division of the axillary nerve. Microscopic repair was then performed. (Figure 1c)

Postoperative Care:

After surgery, the patients used a sling for ten days, and then were allowed full motion. We saw patients ten and thirty days after surgery, then every three months for a year, and then every six months. The patients received regular physiotherapy, and we strongly recommended exercises such as swimming and weight training.

Preoperative Measurements:

We measured range of shoulder abduction and external rotation using a goniometer. We measured external rotation in the standing position with the elbow flexed and alongside the body. We evaluated elbow extension strength by manual muscle testing. For endurance evaluation, patients were asked to abduct both arms fully and maintain them in this position for as long as they could. This was timed using a stopwatch, and when the affected limb dropped, the patient was instructed to maintain the normal side in the fully abducted position for as long as possible, while still being timed.

For evaluation of deltoid extension lag, we passively extended both shoulders and elbows maximally and asked each patient to hold them in that position. Any incapacity to maintain this position was documented.[12]

For the abduction-in-internal-rotation test, the examiner placed the patient's shoulder internally rotated in maximum abduction with the elbow flexed, after which the patient was requested to maintain this position; incapacity to maintain this position again was Documented.[4]

Postoperative Measurements:

After surgery, we measured abduction strength with the shoulder abducted to 30˚ and 90˚. We measured abduction in internal rotation strength with the shoulder at 90˚ abduction and the elbow flexed to 90˚. We ascertained deltoid bulk recovery by visual inspection with the shoulder abducted and internally rotated. We categorized deltoid bulk as normal, decreased but more than half, or less than half the bulk of the contralateral normal side. We asked patients whether they had shoulder pain (none, moderate, or severe) while raising the limb. We also asked whether they had returned to work, and whether they were satisfied (not satisfied, satisfied, or very satisfied) with the surgical outcome.

Results

A total of seven consecutive patients (six males and one female) with loss of shoulder abduction secondary to axillary nerve palsy or brachial plexus injury were surgically treated in Suez Canal University Hospital in the Neurosurgery Department between June 2011 and January 2015. The mean patient age was 26 years (Range 17-37 years). Patient characteristics and clinical findings are presented in table 1. The mean interval between the accident and surgery was 5.4±1.6 months.

Patient Reports:

All seven patients had sought medical help because of shoulder pain and fatigability while raising the affected limb. Lost motion was a major problem for two patients. Deltoid wasting (aesthetics) was a major problem for five patients and a moderate problem for the remaining two patients. Twelve months after surgery, no patients reported pain while raising the limb. Preoperatively, all reported fatigability with the shoulder fully abducted. These problems were absent at final evaluation. At final follow-up, five patients had recovered deltoid bulk to near normal. The two patients who had recovered less than normal bulk were satisfied with the appearance nonetheless. All seven patients had returned to their former occupation, and all were satisfied with their surgical outcome.

Abduction Strength:

All deltoid muscles scored M4 at 30˚ and 90˚ of abduction at 12 months and at final evaluation. At final evaluation, in abduction and internal rotation, five patients scored M4 and two scored M3

Endurance:

Endurance improved significantly from 64±49.0 seconds preoperatively to 152±87.0 seconds at final evaluation (P=0.02). Endurance recovery averaged 64±18.0% that of the normal contralateral side.

Active Abduction and External Rotation Range of Motion:

Preoperatively, There was a significant decrease in the range of abduction in the affected side (P=0.03). However, all patients could raise the affected limbs above horizontal, and three patients had abnormal range of abduction. Twelve months after surgery, the range of abduction increased significantly (P=0.03). All three patients with incomplete range of abduction recovered values equal to the normal side. At last evaluation, abduction and external rotation range of motion remained unchanged without statistical differences between normal and affected sides (P=0.03)

Elbow Extension Strength (Donor Site Strength):

One month after the nerve transfer, there were no reports of weakness. Elbow strength scored M4 in all patients.

All patients recovered deltoid function and maintained full active elbow extension. Abduction strength improved from approximately 40% that of the normal side at 90˚ of abduction preoperatively to 60% of normal strength postoperatively. There was improved endurance in abduction from approximately 25% to 65% that of the normal side, which was sufficient to eliminate all reports of shoulder pain or fatigability.

Table 1. Patient Characteristics and Clinical Findings in the Study Series

No.	Age/yrs, Sex	Injury Cause	Injury Type	Time to Repair/ mos	Follow Up/ mos	Result
1	17, M	RTA	Isolated axillary nerve palsy	4	14	M4
2	21, M	Fall	Upper trunk plexus injury	6	20	M4
3	29, M	RTA	Isolated axillary nerve palsy	6	36	M4
4	34, M	Traction	Isolated axillary nerve palsy	4	40	M4
5	25, M	RTA	plexus injury	7	48	M4
6	37, F	Fall	Upper trunk plexus injury	5	32	M4
7	19, M	RTA	Isolated axillary nerve palsy	6	25	M4

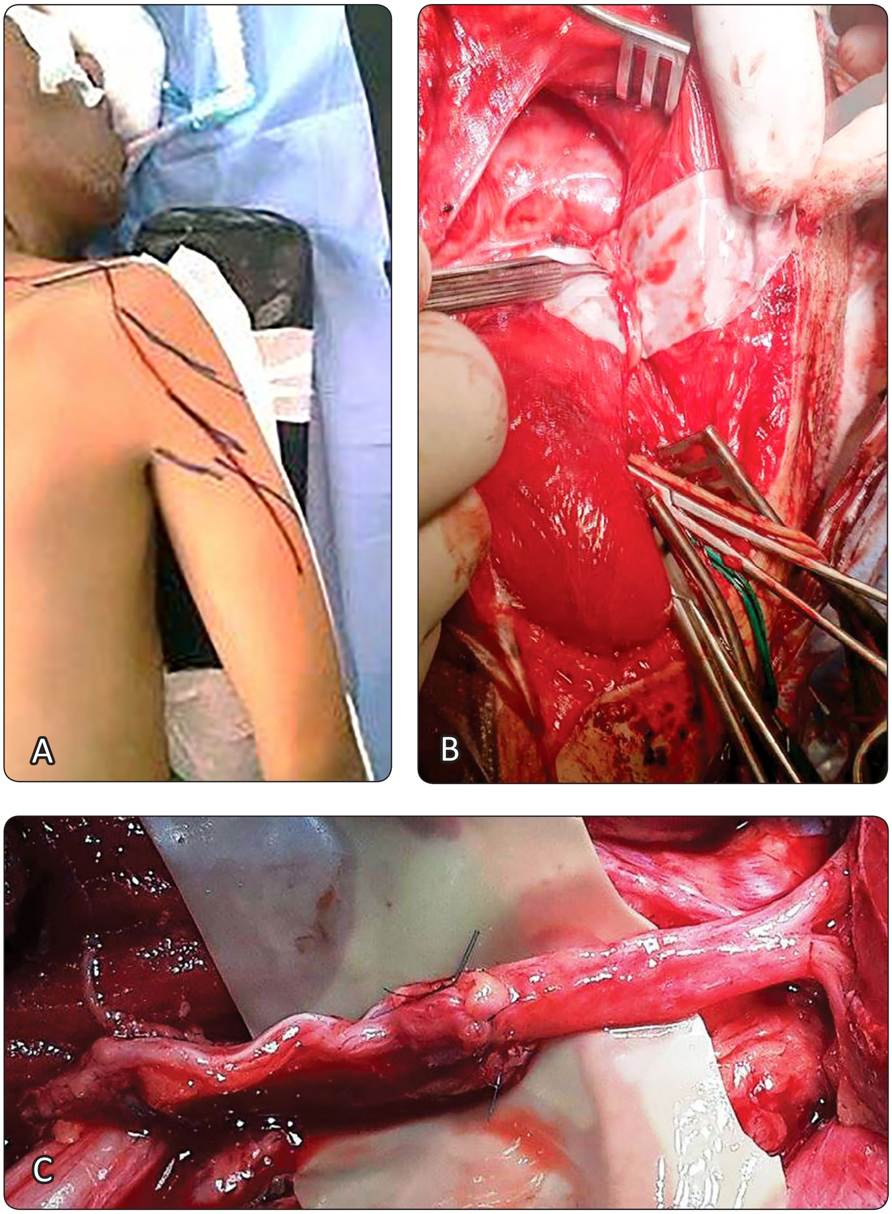

Figure 1. (patients No 2) 21 years old male patient presented absent shoulder abduction. (A) skin incision and operative planning. (B) intraoperative view after the nerve of the medial head of triceps had been diverted upward. (C) microscopic repair.

Discussion

We found that the strength, endurance, and volume of the deltoid consistently improved after surgery, sufficiently to eliminate all reports of shoulder pain or fatigability and to earn high satisfaction with outcome ratings from all patients.

Colbert and Mackinnon[8] proposed using the triceps medial head branch for axillary nerve reconstruction in brachial plexus injuries. From their description, it was not clear whether the donor nerve involved the anconeus branch. The triceps medial head is innervated by two branches. One branch supplies the upper portion, which together with the triceps long head motor branch can be dissected either from a posterior arm approach or from the axilla; this branch follows the ulnar nerve. The other branch supplies the lower portion of the triceps medial head and the anconeus.[6] In proximity of the teres major tendon, the branches to the lateral and long heads emerge from the lateral and medial side of the radial nerve, respectively, whereas the branch to the triceps lower head and anconeus emerge posteriorly.

Viewed from a posterior approach, the course of the lateral and long head motor branches is short and oblique to the radial nerve (Figure 1), whereas the branch to the triceps lower medial head and anconeus passes over the radial nerve and then medially and parallel to it.[6] In half of dissections, the posterior cutaneous nerve of the forearm emerges from the radial nerve together with the branch to the triceps medial head and anconeus branch.[5,6] The average length of the triceps long head motor branch is 3 cm, whereas that of the triceps medial head and anconeus muscle is 9 cm. The diameter, which generally is roughly 2 mm, is similar for the triceps long and lower medial head and anconeus motor branch.[6] The number of myelinated fibers in the branch to the triceps long head is approximately 1, 200, 10 whereas that to the triceps lower medial head and anconeus has not been reported.

In high brachial plexus injuries, where the deltoid is paralyzed but the axillary nerve is anatomically preserved, we prefer to perform reinnervation using the triceps long and/or the upper medial head motor branch dissected via the axilla. This exposure allows for concomitant repair of the musculocutaneous nerve.[2] In isolated axillary nerve injuries, the axillary nerve might be injured at the level of the quadrilateral space, and a healthy distal stump be found only through a posterior arm approach.

Leechavengvongs et al,[16] regularly divided the teres major tendon to enhance exposure of the nerve branch to the long head branch because it is short. Division of the teres major tendon has risks and adds only 1 or 2 cm to the length of the triceps long head motor branch. In brachial plexus injuries, this maneuver may not be necessary because the axillary nerve is not directly involved and can be dissected proximally to include the teres minor branch and thereby extend the length of the recipient nerve stump.[3] However, in isolated axillary nerve lesions, the axillary nerve may be damaged as far distally as its entrance into the deltoid. Extra length of the donor nerve for transfer may be needed. The radial nerve branch to the triceps lower medial head and anconeus is longer, which readily allows for transfer to the axillary nerve terminal divisions. Concomitant lesions of the triceps long head motor branch and axillary nerve can occur.[18,19]

After intraneural dissection and electrical stimulation, those authors found that the triceps long head motor branch most often arose from the axillary nerve rather than from the radial nerve. This explains why the triceps long head motor branch may be affected in patients with an axillary nerve injury.[1] We did not observe total paralysis of the triceps long head, but could not exclude partial injury to the triceps long head motor branch, which not only explains the decreased elbow extension strength we identified preoperatively but also would make the triceps long head nerve a less suitable donor for transfer. Immediately after harvesting the nerve branch to the triceps lower medial head and the anconeus, we observed a 30% decrease in elbow extension strength. Despite this loss of strength, patients did not report a problem. At final evaluation, elbow extension strength matched the normal side. In a few patients, elbow extension was stronger in the affected versus normal side. We believe that this resulted from prolonged rigorous exercise.[1,9,11,13-15]

Concerning distal connection, reconstruction only of the anterior division of the axillary nerve is preferred.[5,17,21] We do not attempt to reinnervate the teres minor or posterior deltoid because adjacent muscles compensate for their lost function.[4,9] When the distal attachment of the nerve branch supplying the triceps long head included all branches to the deltoid, Teissier el al. observed adequate reinnervation only in the posterior deltoid.[21]

We believe that the results of our series support the transfer of the radial nerve branch to the lower triceps medial head and anconeus muscle to the anterior division of the axillary nerve as an effective and reliable method of deltoid reinnervation. The extra length of this motor nerve facilitated direct nerve coaptation.

Conclusion

Transfer of the radial nerve branch for the lower triceps medial head and anconeus to the anterior division of the axillary nerve proved to be an effective method of deltoid reinnervation.

References

1. Basaria S, Wahlstrom JT, Dobs AS: Clinical review 138: anabolic androgenic steroid therapy in the treatment of chronic diseases. J Clin Endocrinol Metab 86(11):5108-5117, 2001
2. Bertelli JA, Ghizoni MF: Nerve root grafting and distal nerve transfers for C5-C6 brachial plexus injuries. J Hand Surg Am 35(5):769-775, 2010
3. Bertelli JA, Ghizoni MF: Reconstruction of C5 and C6 brachial plexus avulsion injury by multiple nerve transfers: spinal accessory to suprascapular, ulnar fascicles to biceps branch, and triceps long or lateral head branch to axillary nerve. J Hand Surg Am 29(1):131-139, 2004
4. Bertelli JA, Ghizoni MF: Abduction in internal rotation: a test for the diagnosis of axillary nerve palsy. J Hand Surg Am 36(12):2017-2023, 2011
5. Bertelli JA, Kechele PR, Santos MA, Duarte H, Ghizoni MF: Axillary nerve repair by triceps motor branch transfer through an axillary access: anatomical basis and clinical results. J Neurosurg 107(2):370-377, 2007
6. Bertelli JA, Santos MA, Kechele PR, Ghizoni MF, Duarte H: Triceps motor nerve branches as a donor or receiver in nerve transfers. Neurosurgery 61(5):333-338; discussion 338e339, 2007
7. Bonnard C, Anastakis DJ, van Melle G, Narakas AO: Isolated and combined lesions of the axillary nerve: a review of 146 cases. J Bone Joint Surg Br 81(2):212-217, 1999
8. Colbert SH, Mackinnon S: Posterior approach for double nerve transfer for restoration of shoulder function in upper brachial plexus palsy. Hand 1(2):71-77, 2006
9. Crouch DL, Plate JF, Li Z, Saul KR: Biomechanical contributions of posterior deltoid and teres minor in the context of axillary nerve injury: a computational study. J Hand Surg Am 38(2):241-249, 2013
10. de Sèze MP, Rezzouk J, de Sèze M, Uzel M, Lavignolle B, Midy D, et al: Does the motor branch of the long head of the triceps brachii arise from the radial nerve? An anatomic and electromyographic study. Surg Radiol Anat 26(6):459-461, 2004
11. Ghizoni MF, Bertelli JA, Grala CG, da Silva RM: The anabolic steroid nandrolone enhances motor and sensory functional recovery in rat median nerve repair with long interpositional nerve grafts. Neurorehabil Neural Repair 27(3):269-276, 2013
12. Hertel R, Lambert SM, Ballmer FT: The deltoid extension lag sign for diagnosis and grading of axillary nerve palsy. J Shoulder Elbow Surg 7(2):97-99, 1998
13. Johansen KL, Mulligan K, Schambelan M: Anabolic effects of nandrolone decanoate in patients receiving dialysis: a randomized controlled trial. JAMA 281(14):1275-1281, 1999
14. Kicman AT: Pharmacology of anabolic steroids. Br J Pharmacol 154(3):502-21, 2008
15. Kuhn CM. Anabolic steroids. Recent Prog Horm Res. 57:411-434, 2002.
16. Leechavengvongs S, Witoonchart K, Uerpairojkit C, Thuvasethakul P: Nerve transfer to deltoid muscle using the nerve to the long head of the triceps, part II: a report

of 7 cases. J Hand Surg Am 28(4):633-638, 2003

17. Lee JY, Kircher MF, Spinner RJ, Bishop AT, Shin AY: Factors affecting outcome of triceps motor branch transfer for isolated axillary nerve injury. J Hand Surg Am 37(11):2350-2356, 2012
18. Rezzouk J, Durandeau A, Vital JM, Fabre T: Long head of the triceps brachii in axillary nerve injury: anatomy and clinical aspects. Rev Chir Orthop Reparative Appar Mot 88(6):561-564, 2002
19. Rezzouk J, Farlin F, Boireau P, Fabre T, Durandeau A: Surgical management of traumatic lesions of the axillary nerve: 83 cases. Chir Main 22(2):73-77, 2003
20. Steinmann SP, Moran EA: Axillary nerve injury: diagnosis and treatment. J Am Acad Orthop Surg 9(5):328-335, 2001
21. Teissier P, Lazerges C, Marès O, Bosch C, Chammas M: Nerve transfer in isolated deltoid palsy: branch of the long head of the triceps to the axillary nerve. Chir Main 31(5):239-243, 2012
22. Witoonchart K, Leechavengvongs S, Uerpairojkit C, Thuvasethakul P, Wongnopsuwan V: Nerve transfer to deltoid muscle using the nerve to the long head of the triceps, part I: an anatomic feasibility study. J Hand Surg Am 28(4):628-632, 2006

Address reprint request to:	**Tariq Elemam Awad, MD.** Department of Neurological Surgery, School of Medicine, Suez Canal University Hospital, Ismaillia, Egypt 15213. - Email: Tariqelemam@yahoo.com

الملخص العربي

إعادة إعمار حركة إبعاد الكتف بنقل جزء من العصب الكعبري إلى العصب الإبطي

البيانات الخلفية: في حالة الإصابة للعصب الإبطي وعدم التمكن من إبعاد الكتف لمدة ثلاثة شهور من العلاج التحفظي يوصى بإجراء التدخل الجراحي لنقل جزء من العصب الكعبري للعصب الإبطي.

الغرض: توضيح النتائج الجراحية لجراحة نقل جزء من العصب الكعبري إلى العصب الإبطي في حالات إصابة العصب الإبطي.

تصميم الدراسة: دراسة لحالات أكلينيكية على ٧ مرضى يعانون من إصابة العصب الإبطي.

الطرق والمرضي: تم إجراء نقل جزء من العصب الكعبري إلى العصب الإبطي في حالات إصابة العصب الإبطي. وتم مقارنة حالة المريض قبل وبعد الجراحة بتقييم قوة العضلات وتعافي حركة الكتف.

النتائج: عانى ٧ مرضى من ضعف في حركة أبعاد الكتف نتيجة إصابة العصب الإبطي. (٦ رجال وامرأة واحدة) متوسط العمر ٢٦ سنة. وبعد الجراحة أظهر جميع المرضى تحسن ملحوظ في قوة إبعاد الكتف وكذلك في حجم عضلات الطرف العلوي المصاب.

الاستنتاج: نقل جزء من العصب الكعبري إلى العصب الإبطي في حالات إصابة العصب الإبطي يحتفظ بنسبة نجاح عالية في الشفاء.