Glenohumeral arthrodesis in upper and total brachial plexus palsy

A COMPARISON OF FUNCTIONAL RESULTS

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We have compared the functional outcome after glenohumeral fusion for the sequelae of trauma to the brachial plexus between two groups of adult patients reviewed after a mean interval of 70 months. Group A (11 patients) had upper palsy with a functional hand and group B (16 patients) total palsy with a flail hand.

All 27 patients had recovered active elbow flexion against resistance before shoulder fusion. Both groups showed increased functional capabilities after glenohumeral arthrodesis and a flail hand did not influence the post-operative active range of movement. The strength of pectoralis major is a significant prognostic factor in terms of ultimate excursion of the hand and of shoulder strength. Glenohumeral arthrodesis improves function in patients who have recovered active elbow flexion after brachial plexus palsy even when the hand remains paralysed.

The operative treatment of severe traction injuries to the supraclavicular brachial plexus in adults remains a difficult challenge. The functional results of direct nerve repairs to the shoulder are less predictable than those for the elbow.[1-4] The place of surgery in the management of the flail shoulder is still under debate.[4-11] The few previous reports of shoulder arthrodesis in cases of brachial plexus palsy suggest that hand function is a major determinant of outcome.[8,12-16]

The main aim of this retrospective review was to compare the functional outcome and shoulder strength of two groups of patients who had undergone glenohumeral fusion. Both had upper brachial plexus palsy, one with functional hands and the other with flail hands. The second aim was to determine whether glenohumeral arthrodesis was functionally worthwhile in patients who had recovered active elbow flexion with a remaining paralytic hand.

Patients and Methods

Between 1978 and 1998 we performed glenohumeral arthrodesis on 29 patients who had sequelae of post-traumatic supraclavicular brachial plexus palsy. One patient was lost to follow-up and one died. The remaining 27 were reviewed. There were 25 men and two women with a mean age at shoulder fusion of 25 years (17 to 37). Ten patients had paralysis on the right side and 17 on the left. The dominant arm was involved in 11 patients. Two types of supraclavicular brachial plexus injury were identified. Group A consisted of one woman and ten men with a mean age of 25 years (18 to 37) of whom five had lesions of C5 and C6 and six lesions of C5, C6 and C7. Group B comprised one woman and 15 men with a mean age of 24.7 years (17 to 35) who had lesions of C5 to T1. There was avulsion of C5 and/or C6 in 14 patients (five of group A, nine of group B).

All 27 patients recovered active elbow flexion against resistance after either spontaneous recovery (1 patient), nerve repair only (20), nerve repair and conventional tendon transfer (3) or free transfer of vascularised gracilis muscle innervated by intercostal nerves (3).

Eleven patients had undergone suprascapular nerve repair which failed in all with a muscle power of MRC grade 2 or less. Seven had a direct transfer of the inferior branch of the spinal accessory nerve and four had nerve grafting to the suprascapular nerve. A double-level lesion of the suprascapular nerve, an unsuspected root avulsion or a rupture of the nerve suture may explain these results. In the other 16 patients, no procedure had been performed on the axillary or suprascapular nerves. Examination of the shoulder before surgery showed muscle power graded at 4 or 5 in 21 patients for the superior head of trapezius (nine of group A, 12 of group B) and in 25 patients for serratus anterior (ten of group A,

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15 of group B). Examination also showed power of the superior head of pectoralis major of 3 or more in six patients (four of group A, two of group B) and of the inferior head of pectoralis major in 17 (ten of group A, seven of group B).

Nineteen of the patients complained of mild to moderate pain from deafferentation of the arm and nine had pain in the shoulder due to inferior glenohumeral subluxation. Before shoulder fusion, 22 patients could not use their arm (six in group A, 16 in group B), and 12 had their upper limb in a sling (three in group A, nine in group B).

In all cases glenohumeral fusion was indicated because of joint instability and an inability to use the affected arm for everyday activities. The mean time between injury and glenohumeral fusion was 36 months (20 to 110) for group A and 31 months (15 to 49) for group B. In the 17 patients who had undergone nerve repair the time interval between this procedure and shoulder fusion was 30 months (14 to 104) for group A and 20 months (10 to 44) for group B.

Operative technique. A posterior approach was used in all patients. Internal fixation with screws followed by immobilisation in a cast was performed on six patients (three in group A, three in group B), and a Hoffmann external fixator was used in conjunction with internal fixation using screws[17] on 21 patients (eight in group A, 13 in group B). No supplementary bone graft was used. Rehabilitation was begun following removal of the cast after a mean of 2.5 months (1.5 to 4.5) or at the second post-operative week in the case of internal osteosynthesis in combination with external fixation which was retained for a mean of 69 days (2.0 to 3.0 months).

Post-operative assessment. In both groups the level of pain determined by a visual analogue scale, the position of fusion, the range of movement, hand excursion, strength, daily activities, return to work, functional abilities for sport and patient satisfaction were compared.

In order to determine the position of fusion in abduction the angles between the upper arm and the medial border and the plane of the scapula were used. The position in flexion was given by the angle between the coronal plane of the body and the axis of the arm. Internal and external rotation were measured from the sagittal plane with the arm at the side and the elbow flexed at 90°.

The humerothoracic ranges of movement in flexion, extension, abduction and internal and external rotation were measured by a single observer (JNG) using a goniometer. The anatomical neutral position was defined as the unelevated position of the humerus, parallel to the thoracic spine, with the arm at the side, the elbow flexed at 90° and the forearm in the sagittal plane. The landmarks used were the axis of the upper arm, the coronal plane and the sagittal plane of the body passing through the axis of the spine. The sum of the measurements represents the scapulothoracic active range of movement. For each patient, the numerical mean of three measurements of isometric strength at 0° (neutral position) was calculated in flexion, abduction and internal and external rotation using the Isobex 2.0 (Cursor AG Muristrasse, Bern, Switzerland).[18]

Hand excursion was assessed by the ability to reach the mouth, the forehead, the nape of the neck, the front pocket, the ipsilateral buttock and the perineum.

The ability of the patients to perform a bimanual activity, using the brachiothoracic grasp or tray-holding position was assessed as well as the use of the affected hand as a paperweight and sleeping on the fused upper limb.

Statistical analysis. The distribution of numerous variables and discrete numeric variables (ordinal scale) was not normal. Comparison of variables was performed using a non-parametric method, the Mann-Whitney U test. A 1% level of significance was used throughout the study considering the number of patients in each group.

Results

The mean post-operative follow-up for group A was 70 months (12 to 188) and for group B, 72 months (6 to 188). At follow-up there was solid union at the site of glenohumeral arthrodesis in all patients. No significant differences were found between group A and group B with regard to the age of the patients, gender ratio, the time interval between trauma and nerve repair or shoulder fusion and post-operative follow-up.

Complications. These occurred in six patients. Two had nonunion requiring reoperation with bone grafting, which resulted in fusion. Three sustained a fracture of the humerus just below the site of arthrodesis during the first six months after operation and one had a benign pin infection.

Pain. After operation, group A had a mean pain rating of 3.3 (0 to 8) and group B of 4.4 (0 to 7.6). Shoulder fusion did not influence pain due to deafferentiation. Pain resulting from inferior subluxation of the glenohumeral joint had disappeared in each of the six affected patients. There was no pain due to stress on the periscapular muscles at follow-up.

Position of fusion. The positions in flexion and abduction of the two groups were similar (group A, mean flexion 21°, mean abduction 24°; group B, mean flexion 27°, mean abduction 31°) (Table I). However, the mean angles of internal rotation were smaller for the group with sequelae of upper plexus palsy (mean internal rotation 14°) than for those with total plexus palsy (mean internal rotation 28°) (Table I).

Range of movement. After operation, patients with an upper plexus lesion and those with a total lesion showed no difference in the active range of movement in terms of flexion.

Strength of the shoulder. Patients with upper plexus palsy showed greater values for strength in abduction, adduction and external and internal rotation (Table I).

Strength of elbow flexion. After shoulder fusion, all 27 patients noted a subjective improvement in the strength of elbow flexion. However, the two groups were not significantly different.

Table I. Comparison of clinical details after shoulder arthrodesis between the patients having sequelae of upper brachial plexus lesion and those having sequelae of a total brachial plexus lesion. Hand excursion represents the mean sum of capabilities, of hand excursions

	Group A† mean (SD)	Group B† mean (SD)	p value
Position of fusion (°)			
Flexion	21 (9)	27 (18)	0.57
Abduction	24 (5)	31 (13)	0.09
Internal rotation	14 (14)	28 (24)	0.03
AROM* (°)			
Flexion	61 (17)	62 (14)	0.86
Abduction	59 (18)	63 (14)	0.69
Extension	14 (10)	12 (17)	0.86
External rotation	7 (12)	-9 (22)	0.06
Internal rotation	42 (20)	45 (27)	0.18
Strength (kg)			
Shoulder			
Flexion	11 (5)	7 (4)	0.03
Abduction	12 (5)	7 (4)	0.004‡
Adduction	14 (6)	5 (3)	0.0008‡
External rotation	6 (2)	2 (2)	0.002‡
Internal rotation	11 (6)	3 (3)	0.0003‡
Elbow flexion	9 (9)	4 (4)	0.07
Total hand excursion	5 (3/7)	3 (1/6)	0.01‡

* active range of movement
† Group A, upper plexus palsy; Group B, total plexus palsy
‡ $p < 0.01$

Hand excursion. For group A, with an upper plexus lesion and a functional hand, recovery of the ability to reach the mouth was noted in all 11 patients, to reach the forehead in ten, the nape of the neck in five, the front pocket in nine, the contralateral axilla in eight and the ipsilateral buttock in four. In group B only three could reach the forehead and one the nape of the neck, while 13 were able to reach the mouth.

Relationship between hand excursion, active range of movement, strength and grading of the muscle power of the shoulder girdle. A statistically significant difference in terms of grading of the muscle power at the shoulder girdle between the groups was found only for the superior and the lower heads of pectoralis major. This was not found when comparing the upper head of trapezius and the serratus anterior. We therefore studied the influence of the muscle power of the superior and inferior heads of pectoralis major on the active range of shoulder movement, strength and hand excursion (Table II). The function of pectoralis major was considered to be useful if its muscle grading was at 3 or more.

This level of power of the inferior head of pectoralis major was observed in combination with increased hand excursion in internal rotation and increased strength of adduction of the shoulder. The strength of abduction and internal rotation, and the active range of movement of the shoulder increased when the upper head of pectoralis major had a power of 3 or more (Table II).

Daily activities. In group A, all patients had recovered bimanual activity and brachiothoracic grasp. Of the seven patients affected on their dominant side, only five with lesions of the upper brachial plexus were able to write. All patients could use the hand as a paperweight and six in group A could use their affected upper arm to eat. The tray-holding position or the brachioantibrachial hook grip was used by eight patients. In group B, all patients except one had recovered their brachiothoracic grasp and seven could perform bimanual activity. The tray-holding position or the brachioantibrachial hook grip was used by nine. Fourteen could use the hand as a paperweight. Nineteen of the 27 patients could sleep on the fused upper limb (eight in group A and 11 in group B).

Return to work. In group A, seven patients had been manual workers before their injury. Of these four had returned to their previous job after fusion, and three were still out of work. Of the four patients in group A who had not been manual workers before injury, one is now a manual worker and one is still out of work. In group B, among the three manual workers before injury, one has returned to his previous job. In this group only two patients are still out of work.

Table II. Statistical comparison (mean, SD) between muscle grading of the superior and inferior heads of pectoralis major and active range of movement of the shoulders, strength and hand excursion

	Muscle grading of the superior head					
	M < 3 (n=21)	M ≥ 3 (n=6)	p value	M < 3 (n=10)	M ≥ 3 (n=17)	p value
Active range of movement (°)						
STARM*	167 (35)	213 (41)	0.014	166 (45)	183 (38)	0.18
Total rotation	35 (17)	62 (15)	0.004†	40 (17)	42 (22)	0.58
Strength (kg)						
Flexion	8 (4)	13 (5)	0.04	8 (4)	10 (5)	0.25
Abduction	8 (5)	12 (3)	0.01†	8 (5)	9 (5)	0.58
Adduction	7 (5)	13 (7)	0.04	3 (2)	11 (6)	0.0008†
External rotation	3 (2)	6 (3)	0.02	2 (2)	5 (2)	0.01†
Internal rotation	5 (4)	12 (7)	0.009†	3 (1)	8 (6)	0.02
Total hand excursion	4 (2)	4 (2)	0.66	2 (1)	4 (2)	0.003*

* Scapulothoracic active range of movement
† <0.01 significant

Functional ability to perform sport. Seven patients of the 27 now regularly take part in sport (two in group A and five in group B).

Patient satisfaction. After glenohumeral fusion, subjective improvement was felt by 26 of the 27 patients. In group A nine of the 11 patients with an upper plexus lesion and in group B five of the 16 patients with a total brachial plexus lesion had a high rate of satisfaction. Two patients in group A and ten in group B had a moderate degree of satisfaction. One patients in group B had no subjective improvement.

Discussion

After severe brachial plexus palsy involving the shoulder, the major determinants for outcome following shoulder arthrodesis[8,16,19] are hand function, the position of fusion, especially the position of internal rotation,[20] and pain. Our series shows that a non-functional hand is not a limiting factor for the recovery of a satisfactory active range of movement after glenohumeral fusion.

It has been suggested that glenohumeral arthrodesis is functionally worthwhile for patients with almost fully preserved or restored function of the hand.[10] In our study all patients with lesions of the upper plexus were at least able to perform bimanual activities and activities requiring dexterity with their affected upper limb. In those with total plexus palsy, the stability, the active range of movement and the strength given by shoulder fusion allowed patients to perform bimanual activities in seven of 16, or to carry objects with their affected arm. Thus, 14 of the 16 patients in group B were able to hold a sheet of paper in place while writing, and 15 used their brachiothoracic grasp. None of the patients in group B had this ability before shoulder arthrodesis despite the recovery of active elbow flexion against resistance. In both groups, the stability, the active range of movement and strength given by shoulder fusion may be considered to be determining factors to explain the high rate of return to work.

Despite poor hand function, patients with a total brachial plexus palsy and recovery of active elbow flexion, showed increased functional capabilities after glenohumeral arthrodesis. Poor hand control or a flail hand in patients with a total palsy did not influence the quality of the results in terms of active range of movement compared with those who only had an upper plexus lesion. The strength of pectoralis major appeared to be a more determining factor which may explain differences in terms of hand excursion and shoulder strength. Reinnervation of pectoralis major during direct nerve repair in the case of the total brachial plexus palsy should be considered in order to improve the future function of the scapular girdle after a secondary shoulder fusion.

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