TRANSFER OF LATISSIMUS DORSI TO REPLACE A PARALYSED ANTERIOR DELTOID

A NEW TECHNIQUE USING AN INVERTED PEDICLED GRAFT

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A new method of replacement for the paralysed anterior deltoid is described. The latissimus dorsi with its neurovascular pedicle is freed and rotated, and then placed over the anterior part of the paralysed muscle. The lever arm of the transposed muscle is as long as that of the deltoid, and the muscle volume is enough to restore the natural contour of the shoulder.

We report operations on 10 patients with shoulder palsy, eight caused by brachial plexus injury and two by resection of a neurilemmoma of the plexus. In six cases, active flexion to over 90° was achieved. At least one of the rotator cuff muscles or the long head of biceps should have some active function if good results are to be obtained.

Many types of reconstructive operations have been reported for deltoid paralysis. Transfer of the trapezius has been the treatment of choice (Bateman 1955; Saha 1967; Ingram 1980), but it is difficult to obtain an adequate lever arm for the transferred muscle to act as a prime mover for elevation, and it does not restore the contour of the deltoid. In addition, resection of the acromion in cases with paralysis of both the deltoid and the rotator cuff muscles decreases the stability of the humeral head. Having had success with six cases of transfer of the latissimus dorsi on a neurovascular pedicle for the restoration of elbow flexion (Schottstaedt, Larsen and Bost 1955; Itoh et al. 1982), one of the authors (YI) has developed a technique which uses the latissimus dorsi to replace some of the functions of a paralysed deltoid.

Surgical anatomy. The latissimus dorsi is a large triangular muscle innervated from C6, 7 and 8 roots via the thoracodorsal nerve which branches from the posterior cord of the brachial plexus. The blood supply of the muscle is Type IV in the classification of Mathes and

Fig. 1

Diagram of the position of the patient and the incisions. 1, A long incision over the anterior border of the latissimus dorsi, extended up to the inferior part of the deltopectoral groove. 2, An anterolateral incision over the distal deltoid and its insertion. 3, A curved incision along the acromion and the distal third of the clavicle.

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Nahai (1981); it has a single main feeder. This is the subscapular artery and when its main division, the

Fig. 2

Dissection of the latissimus dorsi. The muscle is freed, preserving the neurovascular bundle, by detaching the humeral insertion and dividing fleshy muscle. Note the two marker sutures placed 10 cm apart as a record of its resting physiological tension (PM, pectoralis major; SA, serratus anterior; LD, latissimus dorsi).

Fig. 3

Rotation and transposition of the latissimus dorsi. The freed muscle is inverted and rotated through 180° to leave the neurovascular bundle in a superficial position. The muscle is then passed behind the pectoralis major and out through the deltopectoral part of the incision (DLT, deltoid).

Fig. 4

The transposed muscle is placed in a wide subcutaneous tunnel between the second and third incisions. Its flat insertion is buried and sutured into the insertion of the deltoid. Then the fleshy proximal portion is pulled up through the tunnel and sutured at its correct physiological tension (TRZ, trapezius).

circumflex scapular artery, is ligated deep in the axillary fossa, a 12 cm vascular pedicle can be obtained. Small branches to the muscle from the lateral thoracic and intercostal arteries may safely be ligated without endangering its viability. The neurovascular bundle enters the latissimus dorsi near its anterior margin some 10 to 15 cm below its humeral insertion.

METHODS

Technique of operation. With the patient in a lateral position, the upper limb, shoulder, pectoral region and back are prepared and three skin incisions are made (Fig. 1):

1. Laterally along the length of the anterior border of the latissimus dorsi extended to the lower half of the deltopectoral groove.
2. Anterolaterally exposing the anterior half of the lower deltoid.
3. Along the acromion and the distal third of the clavicle.

The anterior border of the latissimus dorsi is then elevated from the chest wall, undermining loose areolar tissue to expose and preserve the neurovascular bundle, which is left attached to the muscle. The bundle should not be completely stripped, but retain a covering of the adipose tissue which surrounds it. It is followed proximally, and the communicating branch to the lateral thoracic vessels and the circumflex scapular vessels are ligated. At this stage, the neurovascular pedicle should be 10 to 12 cm long.

The subcutaneous tissue over the latissimus dorsi is

cleared for about 20 cm downwards from the humeral insertion, a length sufficient to cover the paralysed deltoid. The resting tension of the muscle is indicated by two marker sutures which are placed 10 cm apart on the anterior margin of the muscle (Fig. 2).

The muscle is then freed from the lower angle of the scapula and separated from the teres major with care to avoid damage to the thoracodorsal vessels which lie just beneath the two muscles. Minor feeding vessels from the intercostal arteries are ligated, the humeral insertion is divided and the muscle is cut from the dorsolumbar fascia near its origin so as to leave at least 20 cm length from its insertion. The entire muscle is then freed, preserving its neurovascular bundle (Fig. 2).

A wide tunnel is prepared behind the humeral insertion of the pectoralis major up to its upper margin and the retropectoral fascia is incised to allow the latissimus dorsi to be passed posterior to pectoralis major. In three early cases, the neurovascular bundle was routed anteriorly round the lower edge of the pectoralis major muscle; this detour produced some stretching of the bundle.

Through the anterolateral incision on the proximal third of the upper arm, the distal portion of the deltoid and its insertion is exposed. A wide tunnel is then prepared by subcutaneous dissection through to the deltopectoral part of the first incision. From the third incision, on the acromioclavicular line, a wide triangular subcutaneous tunnel is prepared over the anterior half of the deltoid.

Table I. Details of 10 patients having latissimus dorsi transfer for paralysis of the deltoid

Case number	Age (years)	Sex	Cause of paralysis	Interval before transfer (months)	Pre-operative muscle power				Follow up (months)	Postoperative range of shoulder movement in degrees			Comment
					Deltoid	Latissimus dorsi	Infraspinatus	Biceps		Flexion	Abduction	Extension	
1	56	F	Resection of neurilemmoma	37	1	4+	2	0	16	150	60	0	Steindler
2	57	M	Resection of neurilemmoma	24	0	4	0	2	15	110	40	0	Steindler
3	21	M	Brachial plexus injury	15	0	4	2	4	17	125	50	0	
4	21	M	Brachial plexus injury	7	0	4	0	3	12	160	70	20	Partial recovery of axillary nerve
5	28	M	Brachial plexus injury	9	0	4-	0	0	14	90	20	0	Steindler
6	32	M	Brachial plexus injury	16	0	4	0	0	12	70	20	0	Infection
7	33	M	Brachial plexus injury	8	0	4-	1	0	7	80	30	0	Neurolysis of brachial plexus
8	22	M	Brachial plexus injury	14	0	4-	0	0	11	90	45	0	Steindler
9	35	M	Brachial plexus injury	16	0	4-	0	0	14	80	20	0	Fracture dislocation of shoulder; musculocutaneous nerve graft
10	18	M	Brachial plexus injury	6	0	3	0	0	15	60	20	0	Steindler*

* Also had cervical cord injury and head injury with hemiparesis (transfer not the correct procedure)

The freed latissimus dorsi graft is rotated through 180° on the axis of the neurovascular bundle, the broad origin of the muscle being turned cephalad with the thin flat insertion distally. After this, the muscle is rotated in another plane so that the neurovascular bundle, which originally entered the deep surface of the muscle, now enters its anterior surface.

The rotated and inverted muscle is then passed through the tunnel behind the pectoralis major to the deltopectoral part of the exposure (Fig. 3) and its flat humeral end is passed down to the region of the deltoid insertion. The broad muscular end is pulled through the subcutaneous tunnel to the acromioclavicular incision. Great care is taken to prevent excessive tension or torsion of the neurovascular bundle, which should lie anterolaterally along the upper border of pectoralis major (Fig. 4).

The flat tendon which was originally the humeral insertion is buried and sutured to the insertion of the deltoid with tough non-absorbable sutures. The broad muscular origin of latissimus dorsi is anchored to the periosteum of the acromion and distal clavicle or to the insertion of the trapezius under normal tension when the upper arm is held at 70° to 80° of flexion. To secure a good operative field, the shoulder should be held depressed while maintaining this angle of flexion. Correct physiological tension is ensured by keeping the two marker sutures 10 cm apart (Fig. 4).

A suction drain is used at the donor site. After skin

closure, the arm is kept in its flexed position by an aeroplane splint or a shoulder spica cast which has been prepared before operation.

Postoperative management. Immobilisation of the shoulder at 70° to 80° of flexion is maintained to prevent tension at the anchor sites, the spica cast or splint being retained for eight weeks. After removal of the cast, active flexion exercises are started, using a large piece of foam rubber between the upper arm and chest wall to support the limb. The foam rubber is used for two weeks.

The latissimus dorsi normally adducts the humerus, and the deltoid is a prime mover for flexion and abduction, but the change in function occurs as smoothly as in tendon transfers in the hand. The patient is instructed to palpate the transferred muscle while contracting all the shoulder muscles voluntarily, and he learns by repetition to contract the transferred muscle. This simple biofeedback exercise is very easy and effective.

PATIENTS

Twelve patients with complete paralysis of the deltoid have had this operation since 1982. Of these, 10 have been followed up for more than four months. The cause of the paralysis was brachial plexus injury in eight cases and operation for neurilemmoma of the brachial plexus in two. The pre-operative states of the shoulder muscles are shown in Table I. The power of the latissimus dorsi

Fig. 5

Fig. 6

Case 1. Figure 5 – A 56-year-old woman with complete palsy of the shoulder and elbow flexors caused by the excision of a neurilemmoma of the right brachial plexus three years earlier. Steindler's elbow flexorplasty had been performed one year after the original palsy; she had only 30° of shoulder flexion. Figure 6 – Sixteen months after reconstruction there was good flexion of the shoulder and improved contour of the shoulder.

Case 3. Figure 7 – A 21-year-old man who had sustained a left upper brachial plexus injury in a motorcycle accident 15 months before latissimus dorsi transfer. Seventeen months after operation he had flexion to 125°.

Fig. 7

before operation was MRC Grade 4+ in one case, 4 in four, 4- in four and 3 in one. The interval between paralysis and the reconstruction ranged from six months to three years (average 15.2 months). In five cases, a modified Steindler flexorplasty of the elbow was performed before, after or concurrently with the latissimus dorsi transfer.

RESULTS

In six of the 10 cases, active flexion to more than 90° was achieved, and in all 10 cases a good deltoid contour was regained. All but one of the nine patients with Grade 4 power of the latissimus dorsi regained good flexion, the one exception having deep infection with partial necrosis of the transferred muscle which limited shoulder flexion to 70°. In cases 1,2,3 and 4, in which some power had been preserved in the rotator cuff and/or the long head of the biceps, flexion of more than 110° was obtained. This seemed to be due to the stabilising effect on the shoulder of these muscles. In cases in which the rotator cuff muscles and biceps had been completely paralysed, the shoulder flexion was only 90° or less, and it seems that rotator cuff reconstruction (Saha 1967) should have been employed simultaneously in these cases.

CASE REPORTS

Case 1. A 56-year-old woman had complete paralysis of the deltoid and biceps brachii after excision of a neurilemmoma of the right brachial plexus three years earlier. A modified Steindler's elbow flexorplasty had been performed, and her latissimus dorsi was graded 4+, triceps brachii 5, infraspinatus 2, biceps brachii 0 and wrist extensors 4+ (Fig. 5). Sixteen months after transfer of the latissimus dorsi, she had regained good shoulder flexion of 150° (Fig. 6), and abduction of 60°, but extension was impossible because of complete paralysis of the posterior deltoid.

Case 3. A 21-year-old man suffered a partial left brachial plexus injury as well as fractures of the skull, femur, tibia and fibula in a motorcycle accident. Fifteen months after injury, the muscle power was deltoid 0, infraspinatus 2, biceps brachii 4 and latissimus dorsi 4. Three months after latissimus dorsi transfer he could flex his shoulder to 80°, and 17 months after reconstruction he had 125° flexion, 50° abduction with adequate power (Fig. 7) and restoration of good shoulder contour.

Case 10. In an 18-year-old man brachial plexus paralysis was complicated by both cervical cord injury and hemiparesis from head injury. The power of the latissimus dorsi was Grade 3 and flexion after operation was limited to 60°, but pre-operative subluxation of the shoulder joint had been improved.

DISCUSSION

The humeral head has a dual musculotendinous support: the rotator cuff muscles and the broad strong deltoid. The anterior part of the deltoid is the most important muscle for forward elevation at the shoulder. In cases of suprascapular nerve palsy or major tear of the rotator cuff, elevation of the arm is possible, although not complete, if the acromion and the long head of the biceps are intact. Isolated deltoid palsy is rare and more commonly associated with paralysed rotator cuff muscles (Petrucchi, Morelli and Raimondi 1982).

Reconstruction for extensive shoulder girdle palsy is very difficult. Not only prime movers, but also the head stabilising and/or depressor muscles need reconstruction if good elevation of the arm is to be achieved (Saha 1967; Ingram 1980). However, the powerful prime mover is the most important muscle. Bateman (1955) and Saha (1967) employed the trapezius as a motor source, but this provides a lever arm which is shorter than that of the normal deltoid (Fig. 8A), and if the acromion is resected to allow the trapezius to be anchored to the neck of the humerus, rotator cuff reconstruction is indispensable to prevent superior subluxation of the humeral head.

Fig. 8

The lever arm of the reconstructed prime mover. *A*, Bateman's and Saha's trapezius transfers. R_1 is the short lever arm acting on the glenohumeral joint. *B* shows the broad covering of the humeral head provided by the latissimus dorsi after the new operation. This helps to stabilise the glenohumeral joint and provides a longer lever arm, R_2 .

In the latissimus dorsi transfer we have described, the lever arm is as long as that of the deltoid, and the muscle volume and width are sufficient to cover and stabilise the humeral head (Fig. 8B), while the strength of the transferred muscle is sufficient for the normal activities of daily living.

We can recommend this procedure not only for the paralysed deltoid, but also for use in reconstructive surgery after wide resection of the proximal humerus and its muscles for malignant tumour.

Conclusions. This new method of replacing the paralysed anterior deltoid has achieved good results in cases which have retained even weak muscle power in the rotator cuff muscles and/or the long head of the biceps. It has a number of advantages: the transferred latissimus dorsi provides an adequate motor source, the lever arm is enough to provide shoulder flexion, preservation of the acromion helps to stabilise the humeral head and the deltoid contour of the shoulder is restored.

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