TRICEPS TO BICEPS TRANSFER FOR
ESTABLISHED BRACHIAL PLEXUS PALSY

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From the Derbyshire Royal Infirmary

We have reviewed seven patients who had triceps transfer after an old brachial plexus injury. All patients had a useful functional improvement with a good range of powerful elbow flexion; five patients could manage to bring their hand to their mouth. The basis of patient selection and the relative advantages of triceps transfer are discussed.

Inability to flex the elbow is a major disability, particularly in a patient with a functioning hand. Patients with permanent loss of C5 and C6 usually have excellent wrist and hand function although with reduced sensibility to the thumb and index finger. However, they are unable to position their hand in space because they cannot flex the elbow. Restoration of elbow flexion in such cases leads to a dramatic improvement in upper limb function. Loss of elbow flexion in the majority of patients results from brachial plexus injury, although poliomyelitis is an occasional cause.

Many procedures have been described to restore elbow flexion. In 1918 Steindler described proximal advancement of the flexor origin at the elbow and this technique was modified by Bunnell (1951): he recommended an interpositional graft of fascia lata between the flexors and the humerus which allows lateralisation of the insertion and reduces the pronation effect seen with the original Steindler method.

Mayer and Green (1954) transposed part of the medial epicondyle to improve fixation, securing it more laterally on the humerus. The pronation effect may also be reduced by transfer of flexor carpi ulnaris to the dorsum of the radius (Kettlekamp and Larson 1963). Alternatively, the patient may be encouraged to supinate the wrist postoperatively; this develops the supinatory component of flexor carpi ulnaris and extensor pollicis longus, (Mayer and Green 1954).

Transfer of the inferolateral portion of pectoralis major was described by Clark (1946) and modified by Brooks and Seddon (1959) who advocated incorporation of the long head of biceps to lengthen the insertion. A further modification was recommended by Carroll and Kleinman (1979), who transferred the entire pectoralis major across the acromion and anterior capsule in order to stabilise the shoulder and reinforce the transfer. Tsai et al. (1983) proposed simultaneous transfer of pectoralis major and minor, which is technically easier as both muscles can be rotated on their neurovascular pedicle.

Another complete muscle transfer is that of the latissimus dorsi first described by Schottstaedt, Larsen and Bost (1955), but partial transfer is usually adequate

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Fig. 1

Triceps to biceps transfer.
where muscle bulk is normal (Zancolli and Mitre 1973). Stern et al. (1982) point out that a musculocutaneous flap can be used if indicated.

METHOD AND PATIENTS

Triceps transfer was described by Bunnell (1951) and by Carroll (1952) and Carroll and Hill (1970). A posterior incision is used and the medial head of the triceps is reflected while protecting the ulnar nerve and passed through a subcutaneous tunnel. A separate flexor crease incision is made to attach the transposed triceps to the biceps tendon (Fig. 1). The arm is immobilised in an above-elbow plaster slab for four to six weeks postoperatively.

Seven patients have had this triceps to biceps transfer at the Derbyshire Royal Infirmary during the past four years and all have been reviewed. The patients were all young adults with a mean age of 20 years (range 17 to 29 years) who had been involved in motor-cycle accidents and sustained a brachial plexus injury.

Results

Details of each patient and the result of transfer are given in Table I. The mean delay from injury to transfer was 36 months (range seven to 72 months) and mean follow-up was 24 months (range seven to 39 months). All have a good range of active elbow flexion (Fig. 2) with a mean of 123° (range 90 to 140°); five of the seven were able to bring the hand to the mouth. Some loss of passive extension was seen in most cases; the mean loss was 13° (range 0 to 23°). Power was satisfactory, with ability to lift an average of 3.3 kg with the hand when the elbow was at 90° of flexion (range 1 to 5 kg). The only female patient in the series, who also has the shortest follow-up, is the only one, as yet, unable to support 2 kg or more.

Patients were asked about the function of their arm after operation, scoring out of 10, in comparison to the pre-operative state. All reported considerable functional improvement: most scored 8 out of 10. Adequate function is confirmed by the work record, which shows that five are employed, although two have had to change their jobs to lighter work. Two have remained unemployed but one of these has undergone retraining and feels that he will be able to take on a job when one is available.

DISCUSSION

A comparison with the results of alternative operations is restricted by the limited information and the varying criteria used in other reports. Many of the series are small, and include several pathologies, without detailed assessment of the ultimate power of the transfer (Table II). The clinical information most relevant to the assessment of a satisfactory result should include the overall range of motion, the extensor loss, the ability to bring the hand to the mouth, and the sustained power of the transfer expressed as the load (hand held) which can be supported with the elbow at 90° of flexion.

The choice of transfer to regain elbow flexion should be based on the following considerations:

1. Work capability of the muscle groups available
2. Mechanical advantage of the transferred muscle
3. Shoulder stability
4. Loss of function as a result of transfer
5. Prospect of significant functional gain
6. Musculotendinous excursion
7. Appearance

We believe that power is the major factor in the choice of operation. This will depend upon the work capability and mechanical advantage of the muscle transferred. The ideal transfer will follow the route of the biceps muscle, and have a similar excursion.
The work capacity of the different muscles has been studied by Von Lanz and Wachsmuth (1959), who demonstrated a significant potential benefit with pectoralis major and triceps transfers. Holtman et al. (1975) have demonstrated the mechanical superiority of pectoralis major and triceps transfers over the Steindler transfers. In the latter, the ability to lift more than 1 kg is rarely attained, and the best results of 2 to 3 kg are often associated with some loss of extension. The ability to flex the elbow to 90° against gravity is regarded by some as a pre-requisite for Steindler’s flexorplasty.

The principal disadvantage of a pectoralis major transfer is the destabilising effect on a flail shoulder, unless the entire pectoralis major is transferred (Carroll and Kleinman 1979), and the appearance is also unsatisfactory. Patients with a C5/6 palsy will often have

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (yrs)</th>
<th>Injury to tendon transfer (years)</th>
<th>Other operations</th>
<th>Lesion of brachial plexus</th>
<th>Follow-up (years)</th>
<th>Elbow flexion (degrees)</th>
<th>Power at 90° (kg)</th>
<th>Hand to mouth</th>
<th>Patients score at review</th>
<th>Employment Before injury</th>
<th>At review</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>19</td>
<td>3.5</td>
<td>Rotation osteotomy</td>
<td>Myelocoeles C4, 5, 6</td>
<td>2</td>
<td>20 to 140</td>
<td>2.5</td>
<td>Yes</td>
<td>8/10</td>
<td>Fitters mate</td>
<td>Nil</td>
</tr>
<tr>
<td>2</td>
<td>29</td>
<td>4</td>
<td>Exploration and graft (no better)</td>
<td>Myelocoeles C5, 6, 7</td>
<td>3.7</td>
<td>20 to 100</td>
<td>3.5</td>
<td>No</td>
<td>5/10</td>
<td>Machinist / Lift operator</td>
<td>Same</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>6</td>
<td>Exploration Shoulder arthrodesis Rotation osteotomy</td>
<td>Myelocoeles C5, 6</td>
<td>0.6</td>
<td>0 to 135</td>
<td>1</td>
<td>Yes</td>
<td>8/10</td>
<td>Teacher</td>
<td>Same</td>
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<tr>
<td>4</td>
<td>21</td>
<td>0-5</td>
<td>Exploration</td>
<td>C5, 6 avulsion at exploration</td>
<td>3</td>
<td>0 to 135</td>
<td>6</td>
<td>Yes</td>
<td>8-9/10</td>
<td>Heating technician</td>
<td>Same</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
<td>2</td>
<td>Nil</td>
<td>Myelocoeles C6, 7</td>
<td>2.3</td>
<td>20 to 140</td>
<td>5</td>
<td>Yes</td>
<td>9/10</td>
<td>Miner</td>
<td>Same</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>2</td>
<td>Nil</td>
<td>Myelocoeles C6, 7</td>
<td>2</td>
<td>15 to 90</td>
<td>2</td>
<td>No</td>
<td>7/10</td>
<td>Unemployed / Unemployed but trained</td>
<td>Same</td>
</tr>
<tr>
<td>7</td>
<td>20</td>
<td>3</td>
<td>Shoulder</td>
<td>Myelocoeles C5, 6</td>
<td>1</td>
<td>15 to 120</td>
<td>3</td>
<td>Yes</td>
<td>8/10</td>
<td>Engineer (heavy)</td>
<td>Driver</td>
</tr>
</tbody>
</table>

Table II. Previous reports on tendon transfers to restore elbow flexion

<table>
<thead>
<tr>
<th>Author</th>
<th>Method</th>
<th>Number</th>
<th>Pathology</th>
<th>Results and weight lifted (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kettlekamp and Larson 1963</td>
<td>Steindler</td>
<td>15</td>
<td>Poliomyelitis</td>
<td>0 to 2.7 average 0.7</td>
</tr>
<tr>
<td>Nyholm 1963</td>
<td>Steindler</td>
<td>19</td>
<td>Poliomyelitis</td>
<td>Range 0.1 to 1.8 Average 0.5</td>
</tr>
<tr>
<td>Lindholm and Einola 1973</td>
<td>Steindler</td>
<td>59</td>
<td>Poliomyelitis</td>
<td>Best 2, only 10 could lift 1</td>
</tr>
<tr>
<td>Dutton and Dawson 1981</td>
<td>Steindler</td>
<td>24</td>
<td>Poliomyelitis and brachial plexus palsy</td>
<td>18 patients, 1 to 2.3</td>
</tr>
<tr>
<td>Clark 1946</td>
<td>Pectoralis major transfer</td>
<td>1</td>
<td>Brachial plexus (gunshot)</td>
<td>40°, normal power</td>
</tr>
<tr>
<td>Schottstaedt et al. 1955</td>
<td>Pectoralis major transfer</td>
<td>1</td>
<td>Erb’s palsy</td>
<td>1.4 (0.23 pre-op)</td>
</tr>
<tr>
<td></td>
<td>Pectoralis major transfer</td>
<td>1</td>
<td>Poliomyelitis</td>
<td>3.6</td>
</tr>
<tr>
<td>Brooks and Seddon 1959</td>
<td>Pectoralis major transfer</td>
<td>10</td>
<td>Brachial plexus lesion</td>
<td>Best to 2.1</td>
</tr>
<tr>
<td>Holtman et al. 1975</td>
<td>Pectoralis major transfer</td>
<td>7</td>
<td>Brachial plexus lesion</td>
<td>One patient – 3.2 to 145°</td>
</tr>
<tr>
<td>Schottstaedt et al. 1955</td>
<td>Latissimus dorsi transfer</td>
<td>1</td>
<td>Poliomyelitis</td>
<td>1.8 at 90° (0.23 pre-op)</td>
</tr>
<tr>
<td>Zancolli and Mitre 1973</td>
<td>Latissimus dorsi transfer</td>
<td>1</td>
<td>Brachial plexus (iatrogenic)</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>Latissimus dorsi transfer</td>
<td>1</td>
<td>Brachial plexus (traumatic)</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Latissimus dorsi transfer</td>
<td>6</td>
<td>Poliomyelitis</td>
<td>Average 1.0</td>
</tr>
<tr>
<td>Stern et al. 1983</td>
<td>Latissimus dorsi transfer</td>
<td>2</td>
<td>Brachial plexus</td>
<td>3.6 to 100° in one case</td>
</tr>
<tr>
<td>Bunnell 1951</td>
<td>Triceps transfer</td>
<td>1</td>
<td>Amputation below forearm</td>
<td>9.1 to 90°</td>
</tr>
<tr>
<td>Carroll and Hill 1970</td>
<td>Triceps transfer</td>
<td>7</td>
<td>Most had brachial plexus lesions</td>
<td>Some able to lift 3 to 4</td>
</tr>
</tbody>
</table>
partial denervation of pectoralis major (that part supplied by the lateral pectoral nerve). However, if pectoralis major power is normal, an effective transfer may be anticipated.

Latissimus dorsi transfer provides adequate power but, like the pectoralis transfer, is technically difficult, does have a destabilising effect on the shoulder and is less cosmetically acceptable. However, it has the particular advantage of providing skin cover when necessary (Stern et al. 1982). The normal excursion of the transferred tendon compared with that of the biceps is also of significance. Narakas (personal communication) has suggested that latissimus dorsi has a normal excursion of approximately 11 cm (±2) compared with a biceps tendon range of 5 to 6 cm (±2).

The principal advantage of the triceps transfer is that power is always adequate, more than 3 kg at 90°, in both our series and others. The procedure is technically straightforward and cosmetically acceptable. The major disadvantage is loss of active extension; this is felt by some authors (Segal, Seddon and Brooks 1959) to be an absolute contra-indication, unless no other transfer is available. Triceps function is necessary for upper limb weight bearing (for example when rising from a chair, and using a crutch or wheel chair); for upper limb activities which require the ability to press down firmly (for example, cutting a slice of bread); and for the use of the arm above shoulder height.

On balance, we feel that the provision of powerful elbow flexion outweighs the loss of active extension in most cases. Patients with irreparable C5/6 brachial plexus lesions have a potentially useful hand despite altered sensation of the thumb and index finger, but are unable to lift the arm above shoulder height or flex the elbow. An excellent case can be made for triceps transfer in such circumstances because the patient will never be able to abduct the arm above shoulder height. Careful pre-operative counselling on the benefits and disadvantages of the transfer are essential; patients must appreciate that elbow flexion will be regained but there will be reduced ability to press firmly down on hand-held objects. Associated lower limb injuries which require the use of sticks or crutches, of course, contra-indicate its use.

An infrequent indication for triceps transfer is the simultaneous contraction of triceps and biceps which is occasionally seen either after spontaneous recovery or plexus repair. If the unco-ordinated contraction of both muscles significantly reduces power or mobility, triceps transfer should be considered.

In conclusion, we feel that there are definite indications for triceps transfer to restore elbow flexion in cases of upper root plexus palsy. Although pectoralis major and latissimus dorsi transfers may be more powerful, triceps transfer is simpler and cosmetically more satisfactory. Tendon excursion and muscle power are adequate and the range of flexion is generally satisfactory. However, the individual clinical problem should determine the procedure of choice.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES


Steindler A. A muscle plasty for the relief of flail elbow in infantile paralysis. Interstate M J (St Louis) 1918;25:235-41.


