The pronator quadratus muscle flap

Traumatic injuries to the distal forearm present a challenging problem for soft tissue coverage. There is a need for a local flap to provide a vascularized soft tissue bed. This article demonstrates the anatomic basis that enables the pronator quadratus muscle potentially to fulfill these needs. (J HAND SURG 9A:423-27, 1984.)


Stimulated by Ger's1 use of muscle flaps to provide soft tissue coverage in the lower extremity, a period of intense investigation has culminated in an encyclopedic variety of reliable myocutaneous flaps available for use virtually throughout the body. The distal forearm, however, is an area devoid of superficial expendable muscles and is therefore of limited myocutaneous flap potential. The groin flap has been the most frequently used flap for coverage in the distal forearm.2, 4 The distal flexor aspect of the forearm would benefit from the availability of a local muscle flap to provide a bed for skin grafting over exposed vital structures and to provide a well-vascularized bed for a nerve graft for implantation of sensory nerves after neuroma resection5, 6 or elective amputation. This flap could provide a nutritive interface between an internally lysed nerve and overlying dysesthetic or adherent skin.7 This article describes the anatomic basis for the use of the pronator quadratus muscle flap to satisfy these needs in the distal upper extremity.

Anatomic dissections

Cadaveric dissections were performed on 16 upper extremities in eight cadavers. The muscle was found to average 5 cm in length and 4 cm in width (with the forearm supinated). There was no significant variation between right and left or male and female extremities.

The neurovascular bundle uniformly consisted of the anterior interosseous artery and nerve lying on the flexor surface of the interosseous membrane and entering the muscle on its dorsal surface. The neurovascular bundle lies on the midlongitudinal axis of the limb and enters the muscle between 1 and 2 cm distal to its proximal edge. At this point, the dorsal branch of the artery pierces the interosseous membrane. A series of perforating vessels are found at 2 cm intervals proximal to the leading edge of the muscle. These vessels branch from the anterior interosseous vessels and pierce the interosseous membrane. If the dissection of the neurovascular bundle is carried proximally as far as the first branch of the anterior interosseous nerve to the flexor pollicis longus, then the muscle can be raised on a neurovascular pedicle that is 5 to 6 cm in length. This provides an arc of motion that will allow coverage of the distal forearm and the medial and lateral aspects of the wrist (Fig. 1).

Surgical technique

The pronator quadratus muscle may be approached through any preexisting palmar wrist scar or longitudinal incision. The proximal limit of the incision must be extended, usually to 12 cm proximal to the wrist crease to permit dissection of the neurovascular pedicle.

Before dissection of the pronator muscle, the necessary exploration and dissection are carried out. The majority of the required procedures can be performed, leaving only the more delicate operative procedures (such as nerve grafting) until after the pronator quadratus muscle is elevated.

Elevation of the muscle flap is facilitated first by approaching the muscle radially between the flexor profundus muscle group and the flexor pollicis longus tendon (Figs. 2 and 3). The distal edge of the muscle is divided sharply from the radius and ulna, and the terminal branches of the anterior interosseous artery and
Fig. 1. Left. The pronator quadratus muscle shown schematically supplied by the anterior interosseous neurovascular bundle with vessels perforating the interosseous membrane. Center. The arc of rotation of the pronator quadratus muscle flap allows coverage of the medial and lateral aspects of the forearm and distally to the proximal wrist crease. Right. The flap may be extended superficially by either a radial or ulnar route.

Table I. Clinical data

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>WCB</th>
<th>No. previous hand operations</th>
<th>Operation performed with PQM flap</th>
<th>Follow-up (mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. C.</td>
<td>26</td>
<td>F</td>
<td>No</td>
<td>6</td>
<td>Neurolysis, median nerve</td>
<td>27</td>
</tr>
<tr>
<td>J. M.</td>
<td>42</td>
<td>F</td>
<td>Yes</td>
<td>3</td>
<td>Neurolysis, median nerve</td>
<td>21</td>
</tr>
<tr>
<td>E. W.</td>
<td>25</td>
<td>M</td>
<td>No</td>
<td>2</td>
<td>Neurolysis, ulnar nerve</td>
<td>18</td>
</tr>
<tr>
<td>D. H.</td>
<td>30</td>
<td>M</td>
<td>Yes</td>
<td>2</td>
<td>Neurolysis, median nerve</td>
<td>14</td>
</tr>
<tr>
<td>B. C.</td>
<td>38</td>
<td>M</td>
<td>No</td>
<td>2</td>
<td>Neurolysis, median nerve; excision, neuroma, PCM, tenolysis</td>
<td>13</td>
</tr>
<tr>
<td>R. N.</td>
<td>37</td>
<td>M</td>
<td>Yes</td>
<td>1</td>
<td>Neurolysis, median nerve; excision, neuroma, PCM</td>
<td>10</td>
</tr>
<tr>
<td>J. B.</td>
<td>38</td>
<td>M</td>
<td>No</td>
<td>10</td>
<td>Neurolysis, median nerve; excision, neuroma, PCM</td>
<td>10</td>
</tr>
<tr>
<td>R. C.</td>
<td>38</td>
<td>M</td>
<td>Yes</td>
<td>4</td>
<td>Median nerve graft, tenolysis</td>
<td>16</td>
</tr>
<tr>
<td>D. C.</td>
<td>25</td>
<td>M</td>
<td>No</td>
<td>2</td>
<td>Median and ulnar nerve graft</td>
<td>16</td>
</tr>
</tbody>
</table>

WCB, Workmen's Compensation Board; PCM, palmar cutaneous branch of median nerve.

nervea are divided (Fig. 2, B). The insertion of the pronator onto the radius is next divided by an incision at the most radial border with a scalpel and then by elevation more medially to the interosseous membrane with an elevator. There are deep muscle fibers on the ulnar border of the interosseous membrane. Although the origin of the pronator from the ulna may be reached through this approach, the next step is facilitated by development of a plane between the profundus muscle and the flexor carpi ulnaris. Here the ulnar border of the
muscle is incised and the medial dissection is performed with the elevator. The muscle may now be dissected from distal to proximal aspects by gentle traction, elevating it from the interosseous membrane until the dorsal branch of the anterior interosseous artery tethers the elevation (Fig. 2, C). Next, the anterior interosseous neurovascular bundle is identified proximally and dissected to this same tethering point. The membrane is incised on its ulnar border to facilitate ligation of these dorsal branches, thereby freeing the entire muscle flap. More length is gained on the pedicle by proximal dissection. The proximal perforating branches are ligated and the flap is elevated on its neurovascular bundle (Figs. 2, D, and 3). The flap may then be extended superficially to provide soft tissue coverage.

The initial dissection is performed under tourniquet control, and after the pronator quadratus muscle flap is elevated and the appropriate associated surgical procedures are carried out, the tourniquet is deflated, the flap is then allowed to perfuse, and any hemostasis necessary is obtained (Fig. 3).

During closure, the dermis of the previously well-mobilized skin flap is tacked with 4/0 polyglactin (Vicryl) sutures to the superficial surface of the pronator quadratus muscle flap to maintain the flap’s position.

Results

The pronator quadratus muscle flap has been elevated surgically without technical complications in nine patients (Table I). There has been one immediate postoperative complication, a hematoma, which drained spontaneously. Flap viability has been assessed intraoperatively by deflation of the pneumatic tourniquet and observation of bleeding from the muscle edges. Viability of the flap after operation has been suggested by the palpable bulge beneath the skin flap and occasionally a palpable contraction or wrinkling of the skin overlying the muscle with the patient attempting resisted pronation. In three patients evaluated at 10, 13, and 14 months after operation, electromyography with the needle inserted into the pronator quadratus muscle and recording proximal from the median nerve demonstrated silence at rest and normal potential and recruitment as the patient attempted pronation, thus demonstrating a viable muscle.

Clinically six of the seven patients treated for pain have had either good or excellent results at a mean of 22 months after operation: The seventh patient had had a wooden beam fall on the wrist 6 months after the operation, causing the previously palpable muscle mass to flatten, and has had recurrent pain. This patient’s early good result is considered a poor long-term result. No patient’s condition was made worse. The remaining six patients have returned to work or are able to carry out their household activities, although two of the six are working at a reduced capacity. This includes all three patients involved in the Workmen’s Compensation cases.

The two patients in whom the pronator quadratus muscle flap was used to provide a vascularized bed for a nerve graft are demonstrating excellent rates of recovery of sensibility.

Discussion

The distal forearm is devoid of superficial muscles, and vital structures in this area are protected by only skin and subcutaneous tissue. This study demonstrates, by anatomic dissection, that the pronator quadratus muscle can be elevated on a single, well-defined neurovascular pedicle and transposed within a wide arc to provide a well-vascularized pad of muscle for a variety of clinical needs in the distal forearm. While the pronator quadratus muscle supplies only a small area of soft tissue coverage, this is often all that is necessary for reconstructive purposes in this region. For example, recent reports have demonstrated the clinical usefulness of small muscle flaps for skin and nerve and bone...
Fig. 3. Intraoperative views. A, Pronator quadratus muscle exposed. Note proximal neurovascular bundle (left). B, Pronator quadratus muscle elevated to show neurovascular bundle entering its deep side (vessel loop to the right). C, Pronator quadratus muscle elevated. Note neurolysed median nerve and palmar cutaneous neuroma (overlying background). D, Tourniquet let down. Note bleeding from edges of flap. E, Muscle flap being interposed between skin and neurolysed median nerve. F, Flap in place. Palmar cutaneous neuroma has been resected and nerve end implanted into the muscle.
problems in this area. The pronator quadratus muscle flap may thus serve as an alternative to larger distant and more extensive reconstructive flap procedures.

The degree of technical difficulty in the use of this flap suggests that its clinical use should be more as a "salvage" type procedure than as a primary procedure and in conjunction with neuro- and tendolysis. It is emphasized further that the pronator quadratus muscle flap can provide coverage no farther distally than the proximal wrist flexion crease, and skin must be mobilized to cover the muscle without tension. Muscle coverage more distal than this can be provided by the abductor digiti minimi muscle flap.

One more way to prove that this pronator muscle flap is viable would be to use it as a bed for a skin graft. Although we have not yet had the clinical opportunity, skin grafting this muscle is possible and should prove to be as successful in the upper extremity as similar procedures have proved to be in the lower extremity.

Loss of function of the pronator quadratus muscle has not been a problem to any of the nine patients. All can still pronate with some resistance, even with the elbow flexed. This action may be provided by the deep head of the pronator teres.

REFERENCES
11. Lister GD: Personal communication, 1983