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Anterior Submuscular Transposition of the Ulnar Nerve

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Summary: Though the literature is unclear, ulnar nerve anterior submuscular transposition has a role in the surgical treatment of cubital tunnel syndrome in the primary and revision setting. Along with the submuscular transposition technique, this article reviews some of the history of cubital tunnel syndrome treatment, the strengths and criticisms of each of the procedures, and the literature as of 2006 in terms of treatment guidelines. **Key Words:** Ulnar nerve anterior submuscular transposition—Cubital tunnel syndrome.

Even though cubital tunnel syndrome is not the most common peripheral nerve entrapment syndrome, its varied and confusing treatment options when compared with carpal tunnel syndrome more than makes up for its lack in prevalence. Although the multitude of treatment options for cubital tunnel syndrome may be because of its classic multiple sites of potential compression/friction/traction (Fig. 1), it more likely has to do with its unique location posterior to the axis of rotation of the elbow which is most functional in a state of flexion, if not extreme flexion. Kleinman in 1999 illustrates how flexion of the elbow places traction and local compression forces on the ulnar nerve and strongly advocates for anterior transposition.[14] To which location to anteriorly transpose is the fundamental surgical dilemma, subcutaneous, intramuscular, or submuscular. These transpositions along with in situ decompression comprise the gamut of surgical options for cubital tunnel syndrome.

HISTORY

According to Bartels' *History of the Surgical Treatment of Ulnar Nerve Compression at the Elbow*, Henry Earle in 1816 was the first to report the surgical treatment of ulnar nerve compression at the elbow.[2] This early procedure entailed transection of the nerve in a 14 year old female who had severe pains from ulnar nerve compression. This operation fortunately, did not become commonplace. Benjamin Farquhar Curtis in 1898 described what is today deemed anterior subcutaneous transposition.[5] And finally in 1942, James Rognvald Learmonth described the anterior submuscular transposition of the ulnar nerve placing it deep to the flexor-pronator group of muscles alongside the median nerve.[15]

PROS AND CONS

Many authors have tried to illuminate the appropriate management of cubital tunnel syndrome with minor success. In his 1989 review, Dellon concluded with one of the most often cited quotes in the cubital tunnel literature "little more than personal bias is available for guidance in selecting treatment."[8] However, his study along with others, have provided some guidelines in treatment. We will briefly review the pros and cons of each of the treatment modalities, as well as these guidelines.

In Situ Decompression ± Medial Epicondylectomy

Proponents of in situ decompression claim that decompression of the compression sites of the ulnar nerve is all that is needed to relieve cubital tunnel syndrome. It is technically simple and has a low risk of vascular insult to the nerve which may be of concern in anterior transpositions.[12] Heithoff cites studies that support the segmental nature of the ulnar nerve blood supply that is injured if the nerve is dissected a given distance.[17] Also, he quotes research that shows the sole source of blood

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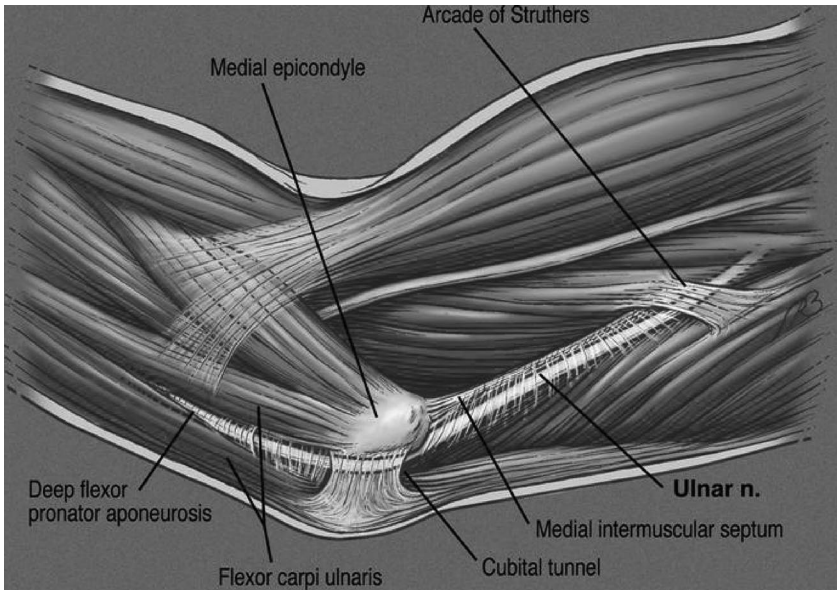

FIG. 1. Five common sites of ulnar nerve compression in the region of the elbow. (Copyright Kevin D. Plancher, MD.)

supply to the ulnar nerve at the medial epicondyle is the inferior ulnar collateral artery which is typically sacrificed with transposition.[21] Medial epicondylectomy can also be combined with decompression. Proponents claim that it allows anterior transposition without extensive dissection thus again, minimizing devascularization. However, critics claim it leaves a raw bony surface for the nerve to lie in, may promote impinging bone spur formation, and may lead to elbow instability. This leads to the general counsel that epicondylectomy should not be performed in the throwing athlete, though this is not proven in the literature.

Subcutaneous and Intramuscular Transposition

Critics of in situ decompression claim that without transposition, the pathologic traction and compression forces from the ulnar nerve's location at the posterior elbow axis of rotation will not be relieved. Kleinman illustrated his argument eloquently with Foley catheters and engineering formulas.[14] In subcutaneous transposition, the nerve is placed below the subcutaneous fat of the arm and forearm. Eaton described a fascia flap sutured to the overlying skin to maintain the transposed position (Fig. 2).[10] The advantages of this technique include placing the nerve in a transposed position where

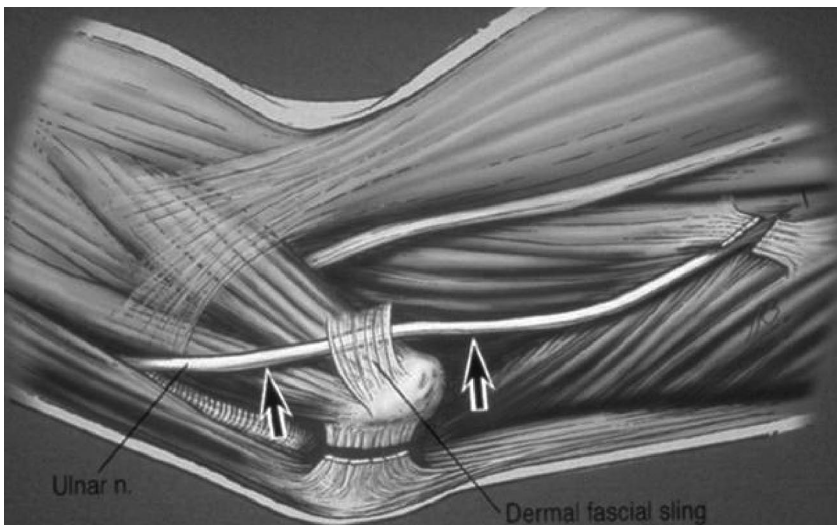

FIG. 2. Subcutaneous transposition of the ulnar nerve. (Copyright Kevin D. Plancher, MD.)

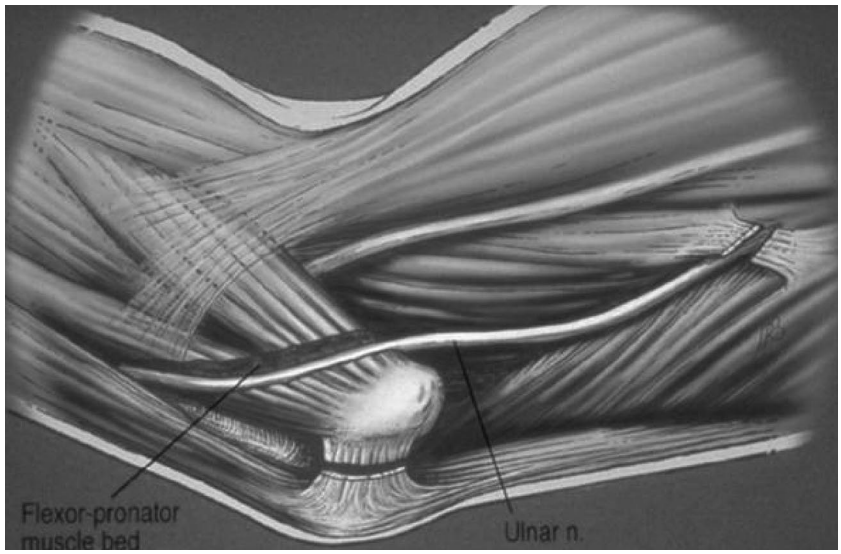

FIG. 3. Intramuscular transposition of the ulnar nerve. (Copyright Kevin D. Plancher, MD.)

scar formation and subsequent compression is unlikely. Disadvantages include the new location's relative avascularity and as Broudy points out, vulnerability to trauma, particularly in patients with scant subcutaneous tissue.[3] On the other hand, intramuscular transposition allows a well vascularized location for the ulnar nerve (Fig. 3). However opponents criticize the nerve's vulnerability to tensile stresses[3] and cicatricial scarring within the intramuscular bed.[13]

Submuscular Transposition

Learmonth described his submuscular transposition in a succinct paper and concluded that this location, "places the nerve in an intermuscular interval, where nerves normally run."[15] Proponents argue that it places the nerve in a good vascular bed that is relatively free from scarring. Also, it may provide the most direct course from the arm to forearm for the ulnar nerve. Besides the issues of vascularity as with the other anterior transpositions, there are concerns of possibly injuring the flexor-pronator muscles. Other complications include elbow flexion contracture because of the extensive surgery and rupture of the flexor-pronator origin repair. A variation of the submuscular transposition includes a Z-lengthening first described by Dellon in 1988.[7] In his 2004 publication on the results of this technique, Dellon advises that a relative contraindication to the procedure is anticoagulation treatment or a coagulopathy because of possible increased bleeding. Also of concern is the patient who is a musician because it is unclear the effect a 1.5 cm musculofascial lengthening will have on coordination and fine motor activity.[9]

TREATMENT GUIDELINES

Which operation to perform is the ultimate question and various authors have attempted to answer this question. In Dellon's 1989 review of 50 published papers between 1898 and 1988, he inferred:

- For minimal compression, excellent results can be obtained in 50% of patients with conservative management and in almost 100% by any surgical method
- For moderate compression, anterior submuscular transposition provides the most excellent result
- For severe compression, the anterior submuscular with neurolysis gave the best results, while intramuscular transposition gave the poorest results with the highest recurrence rate.[8]

In 1998, Bartels reviewed 60 papers between 1970 and 1997 and concluded:

- Irrespective of preoperative status, simple decompression had the best outcome, while anterior subcutaneous and submuscular transposition had the worst
- With McGowan grade 1 patients, no conclusions could be made because of the small number of patients
- With McGowan grade 2 patients, no statistically significant difference could be found between the treatment options
- With McGowan grade 3 patients, anterior intramuscular transposition gave the best outcomes followed by simple decompression and anterior submuscular transposition.[2]

Lastly, Mowlavi in 2000 analyzed 30 papers between 1945 and 1995 and reported:

- With minimal compression, medial epicondylectomy gave the best results while anterior subcutaneous transposition gave the worst
- With moderate compression, submuscular transposition was most efficacious
- With severe compression, no one treatment option was consistently effective, though medial epicondylectomy produced the poorest results.[18]

Revision Surgery

Submuscular transposition has been adopted as the ultimate revision surgery for failed primary cubital tunnel surgery. It is unclear if this is because of support in the literature or because this is the most technically demanding operation leaving no other procedure that is more complex or intricate to choose. Broudy, Gabel, Rogers, and Vogel support submuscular transposition as the revision surgery of choice.[3,11,19,20] However, Caputo supports subcutaneous transposition in this setting.[4] Lastly, Dagregorio reported on simple neurolysis for failed anterior submuscular transposition. They reported 4 good results, 4 fair results, and 1 poor result.[6] Though the literature is confusing, one can surmise that there is a role for submuscular transposition in the primary and revision cubital tunnel syndrome setting.

ANTERIOR SUBMUSCULAR TRANSPOSITION: THE TECHNIQUE

The patient is supine with the middle of the arm table centered at the level of the patient's shoulder. The patient's body should be moved closer to the arm table so that lateral chest wall is at the bed and arm table's junction, which allows access to the elbow. Most use a nonsterile tourniquet but for those patients with shorter arms or in revision cases where more proximal exposure is needed, a nonsterile tourniquet and the ensuing drapes may "block out" the needed surgical field. In these cases, prepping the whole upper extremity including the lateral neck, lateral chest wall, axilla and posterior shoulder, and then using a sterile tourniquet may be more appropriate. The extremity should be placed in 90 degrees of shoulder abduction and external rotation. To avoid a brachial plexus traction injury, at no point in the case should the arm be abducted further or be placed in extreme external rotation. Folded towels under the arm will allow the posterior flap to fall away from the field without manual retraction. The assistant should be on the lateral side of the arm on the other side of the arm table opposite the primary surgeon. The assistant should maintain the elbow in about 30 degrees of flexion with or without the help of a dry goods bolster at the level of the mid-forearm.

With the extremity in the operative position, the surgeon should location the medial epicondyle and olecranon. The midpoint of these 2 bony landmarks indicates the location of the cubital tunnel and the center of the incision. A 15 to 20 cm gently curved incision with the concave side anterior, is generally adequate (Fig. 4). Remember, a patient will be less displeased with a longer incision (that will heal) than with results of an inadequate release or a nerve injury because of a smaller incision. The extremity is then exsanguinated and the tourniquet inflated.

A knife is used to incise the superficial skin and dermis. Tenotomies are then used to spread through the subcutaneous fat. Branches of the medial antebrachial and brachial cutaneous nerves that inevitably cross the field, are preserved (Fig. 5). Most of the initial dissection

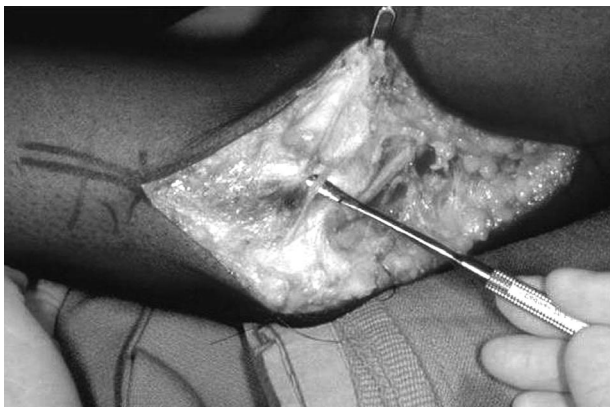

FIG. 4. The incision crosses branches of the medial antebrachial and brachial cutaneous nerves which must be preserved. (Copyright Kevin D. Plancher, MD.)

FIG. 5. Initial exposure cubital tunnel surgery with identification of the ulnar nerve posterior to the medial epicondyle. (Copyright Kevin D. Plancher, MD.)

should be done bluntly and cutting should be avoided, to minimize the risk of injury to the cutaneous nerves to avoid neuroma formation which is one of the most common complications after cubital tunnel surgery. Small vessels are bovied with a bipolar. When enough of the subcutaneous fat is opened, blunt self-retainers are placed to provide exposure.

When the level of the fascia is reached, the ulnar nerve can be identified most predictably posterior to the cubital tunnel. Dissection of the nerve is done with preservation of the perineural vessels as best as possible. Dissection of the nerve is carried proximally to the arcade of Struthers which lies approximately 8 cm proximal to the medial epicondyle (Fig. 6). The arcade of Struthers is released. Next, the arcuate ligament of Osborne is divided and articular branches of the nerve are dissected. Articular branches may be divided but motor branches should not. Thus, the surgeon should prove that a branch in question is entering the joint and not a muscle belly. Leffert advocated the use of a nerve stimulator to verify this.[16] The ulnar nerve is then traced out of the cubital tunnel to its location between the two head of the flexor carpi ulnaris. This interval is divided (Fig. 7). Next the ligament of Spinner, which is the aponeurosis between the flexor digitorum superificialis of the ring finger and the humeral head of the flexor carpi ulnaris is sought.[13] If found, this also needs to be divided. At this stage, branches to the flexor carpi ulnaris and flexor digitorum profundus will be encountered. If during anterior transposition these branches are under tension, intraneural dissection is needed. Remember that failure of cubital tunnel surgery is due not only to inadequate release of known compression sites (the arcade of Struthers, the medial intermuscular septum, the retrocondylar groove, the arcuate ligament of Osborne, and the deep aponeurosis of the flexor-pronator mass) but also iatrogenic creation of new compressive sites created in part by the anterior transposition. Thus, 5 to 8 cm of the distal extent

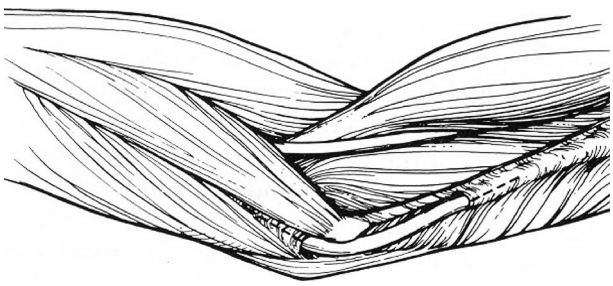

FIG. 6. While preserving its blood supply, the ulnar nerve is dissected proximally to the level of the arcade of Struthers which is located approximately 8 cm proximal to the medial epicondyle.

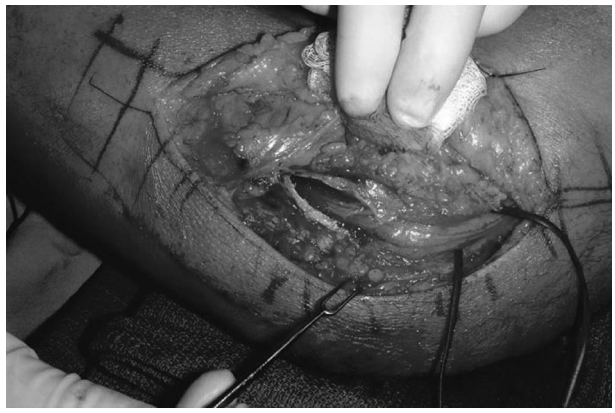

FIG. 7. The arcuate ligament is released and the ulnar nerve is traced to in between the two heads of the flexor carpi ulnaris. (Copyright Kevin D. Plancher, MD.)

of the medial intermuscular is resected to prevent compression of the transposed nerve.

The flexor-pronator origin is exposed. The interval beneath the flexor-pronator group and the flexor digitorum superficialis is bluntly opened by finger dissection. The flexor-pronator origin is divided approximately 1 cm distal to the medial epicondyle to allow a strong tendon to tendon closure later (Fig. 8). The origin is reflected distally and the median nerve is identified in the lateral portion of the incision. The ulnar nerve is then anteriorly transposed next to the median nerve (Fig. 9). At this stage, articular branches if not divided before now, need to be resected at this point to allow the transposition. Also, motor branches if under tension need intraneural dissection. Any preserved ulnar nerve vasculature that prevents transposition is sacrificed. A final check of the ulnar nerve by finger palpation proximally and distally looking for

FIG. 8. Ulnar nerve released from all of its compression sites ready for transposition. (Copyright Kevin D. Plancher, MD.)

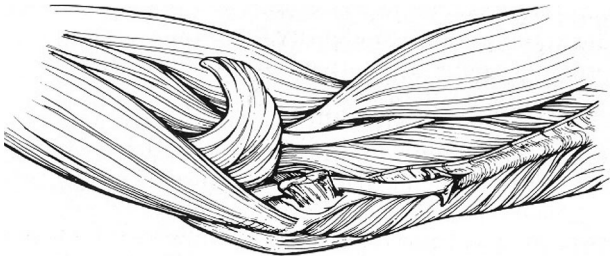

FIG. 9. The ulnar nerve is transposed to a location adjacent to the median nerve with the flexor-pronator mass divided. The arcade of Struthers is not released in this figure.

any unresolved compressive sites is performed. These sites are remedied if encountered. The surgeon should also visually inspect the nerve in the transposed state to see if there are any sites of kinking and that the nerve is in a tension free state.

The elbow is flexed 60 degrees and the forearm is pronated. It is advised to place all the nonabsorbable, braided 0 sutures for the flexor-pronator origin repair before tying, being careful not to inadvertently include the nerve in the repair. The sutures are then tied (Fig. 10). The area under the flexor-pronator origin repair is finger inspected for adequate space for the newly transposed ulnar nerve. Some believe the direct repair of the flexor-pronator origin may compress the ulnar nerve. Dellon described a Z-lengthening procedure that allows a greater space for the nerve (Figs. 9 and 10).[7] It is a difficult situation if after direct repair of the flexor-pronator origin, the space for the ulnar nerve is deemed constricting. To prevent this situation, this author suggests making the division of the flexor-pronator origin in Z-fashion. When it is time for the repair, by using provisional sutures the surgeon can judge the amount of space for the ulnar nerve under the repair. If enough space is present then the flexor-pronator mass can be repaired directly without lengthening. If there is not enough space then the surgeon can proceed with the Z-lengthening.

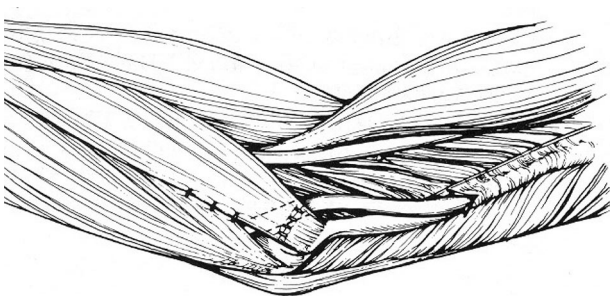

FIG. 10. The ulnar nerve has been transposed and the flexor-pronator origin repaired. Assessment of the space for the ulnar nerve is now performed.

The tourniquet is deflated to obtain hemostasis and is reinflated for wound closure. The wound is irrigated and then closed per the surgeon's preference. A dressing is applied, along with a long arm splint to include the wrist in neutral, the elbow in 90 degrees of flexion and the forearm in 45 degrees of pronation. Finger range of motion is encouraged immediately after surgery. After 2 weeks the splint and dressings are removed and gentle range of motion to protect the flexor-pronator repair, is begun by the patient without the aid of a therapist. At the next visit in 4 weeks if there remains any decreased elbow range of motion, intensive physical therapy is started since the repair has now had 6 weeks to heal. The patient is to refrain from 6 to 8 weeks of heavy lifting and resistive activities.

REFERENCES

1. Bartels RH. History of the surgical treatment of ulnar nerve compression at the elbow. *Neurosurgery* 2001;49:391–400.
2. Bartels RH, Menovsky T, Van Overbeeke JJ, et al. Surgical management of ulnar nerve compression at the elbow: an analysis of the literature. *J Neurosurg* 1998;89:722–727.
3. Broudy AS, Leffert RD, Smith RJ. Technical problems with ulnar nerve transposition at the elbow: findings and results of reoperation. *J Hand Surg* 1978;3:85–89.
4. Caputo AE, Watson K. Subcutaneous anterior transposition of the ulnar nerve for failed decompression of cubital tunnel syndrome. *J Hand Surg* [*Am*] 2000;25:544–551.
5. Curtis BF. Traumatic ulnar neuritis: transplantation of the nerve. *J Nerv Ment Dis* 1898;25:480–484.
6. Dagregorio G, Saint-Cast Y. Simple neurolysis for failed anterior submuscular transposition of the ulnar nerve at the elbow. *International Orthopaedics* 2004;28:342–346.
7. Dellon AL. Operative technique for submuscular transposition of the ulnar nerve. *Contemp Orthop* 1988;16:17.
8. Dellon AL. Review of treatment results for ulnar nerve entrapment at the elbow. *J Hand Surg* 1989;14A:688–700.
9. Dellon AL. Results of the musculofascia lengthening technique for submuscular transposition of the ulnar nerve at the elbow. *J Bone Joint Surg* [*Am*] 2004;86A:169–179.
10. Eaton R. Anterior subcutaneous transposition. In: Gelberman RH, ed. *Operative Nerve Repair and Reconstruction*. Philadelphia: JB. Lippincott; 1991:1077–1085.
11. Gabel GT, Amadio PC. Reoperation for failed decompression of the ulnar nerve in the region of the elbow. *J Bone Joint Surg* [*Am*] 1990;72A:213–219.
12. Heithoff SJ. Cubital tunnel syndrome does not require transposition of the ulnar nerve. *J Hand Surg* 1999;24A:898–905.
13. Inserra S, Spinner M. An anatomic factor significant in transposition of the ulnar nerve. *J Hand Surg* 1986;11A:80–82.
14. Kleinman WB. Cubital tunnel syndrome: anterior transposition as a logical approach to complete nerve decompression. *J Hand Surg* 1999;24A:886–897.
15. Learmonth JR. A technique for transplanting the ulnar nerve. *Surg Gynecol Obstet* 1942;75:792–793.
16. Leffert RD. Anterior submuscular transposition of the ulnar nerves by the Learmonth technique. *J Hand Surg* 1982;7:147–155.
17. Lim BH, Tol CL, Wong HP, et al. Cadaveric study on the vascular

anatomy of the ulnar nerve at the elbow: a basis for anterior transposition? *Ann Acad Med* 1992;21:689–693.
18. Mowlavi A, Andrews K, Lille S, et al. The management of cubital tunnel syndrome: a meta-analysis of clinical studies. *Plast Reconstr Surg* 2000;106:327–334.
19. Rogers MR, Bergfield TG, Aulicino PL. The failed ulnar nerve transposition. Etiology and treatment. *Clin Orthop* 1991;269:193–200.
20. Vogel RB, Nossaman BC, Rayan GM. Revision anterior submuscular transposition of the ulnar nerve for failed subcutaneous transposition. *J Plastic Surg* [*Br*] 2004;57:311–316.
21. Yamaguchi K, Sweet FA, Bindra RR, et al. *The Vascularization of the Human Elbow and the Ulnar Nerve Within the Cubital Tunnel*. Presented at 52nd Annual Meeting, ASSH, Denver, CO, September 13, 1997.