# Compressive Ulnar Neuropathies at the Elbow: II. Treatment

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## Abstract

*Initial treatment of most compressive neuropathies at the elbow is nonoperative, consisting of rest, avoidance of elbow flexion, and, when necessary, temporary immobilization of the elbow and wrist. If symptoms persist, particularly when accompanied by muscle weakness, surgery is usually indicated. Operative procedures include decompression without transposition of the nerve (in situ or by means of medial epicondylectomy) and decompression with transposition of the nerve carried out in a subcutaneous, intramuscular, or submuscular fashion. The indications, advantages, disadvantages, and surgical technique of each operative procedure are discussed.*

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Ulnar nerve compression at the elbow is often transient, in that its symptoms are rapidly reversed by simply changing one's position. Treatment is rarely necessary, and most individuals never seek medical attention because they rapidly learn to avoid those positions that cause discomfort. More serious ulnar neuropathies result in significant disabilities and generally require treatment.

## Nonoperative Treatment

Ulnar compressive neuropathies are commonly classified as acute, subacute, and chronic. Acute compression results from a single episode, such as a blow or other blunt trauma to the medial aspect of the elbow or an acute fracture. It is also seen in the substance abuser who lies for a prolonged period of time in a position that puts pressure on the nerve. Subacute compression takes longer to develop. This type of compression is seen in individuals who continually rest on their elbows at work and in patients confined to bed because of debilitating illness or recent surgery.

Acute and subacute compression have been referred to as "external compression syndrome of the ulnar nerve."[1] Most cases improve if the nerve irritation is reversed, which can frequently be achieved simply by educating patients to avoid prolonged pressure or elbow flexion. For patients who tend to sleep with their elbows flexed, a variety of remedies are available. The simplest is to wrap a towel around the elbow at night to restrict flexion. Reversing an elbow pad so that it covers the antecubital fossa rather than the olecranon can also be used.[2] For daytime activities, modifications in the patient's work environment can be effective. For example, the consoles and seats for computer keyboard operators can be repositioned to ensure that their elbows are not in acute flexion.

Altering the workplace or work activities may not feasible for individuals whose jobs involve manipulative skills that require them to work with their hands close to their bodies (e.g., watch repair). Even when work activities do not require elbow flexion, patients may still flex their elbows frequently enough during the day to aggravate the neuropathy. Temporary splinting is often necessary. A custom-fabricated splint made of lightweight thermoplastic material is preferable to a commercial one. Such a splint, consisting of a posterior shell held in place by several Velcro™ fasteners, maintains the elbow in 35 to 40 degrees of flexion and the wrist in neutral position. The wrist is immobilized to reduce the effects of contraction of the flexor carpi ulnaris muscle. To avoid pressure on the nerve, the edge of the splint and the straps should not be in con-

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tact with the medial aspect of the elbow. If necessary, the splint can be fabricated for the volar surface of the elbow and wrist. The patient is instructed to wear the splint day and night for 3 to 4 weeks, removing it only for bathing. When the splint is removed, active range-of-motion exercises for the elbow and wrist are carried out to avoid joint stiffness. Patients may continue to work provided they wear the splint. Nonsteroidal anti-inflammatory medication can also be prescribed, although immobilization is usually the more effective treatment. Local corticosteroid injections around the nerve should be avoided.

If, in spite of conservative care, local tenderness, numbness, and/or paresthesias continue, surgery is usually necessary. In the absence of muscle weakness, however, there is no urgency. In that situation, the timing of surgery is dependent on the severity of the symptoms and the resultant disability. If work and/or leisure-time activities are significantly compromised, surgery is recommended.

Patients with no muscle weakness who opt for nonoperative care should be periodically reexamined to assess muscle strength. Development of new weakness is an indication for surgery, whether or not there is any change in symptoms. Although repeat electrodiagnostic tests are frequently obtained, the need for surgery should be determined on the basis of deterioration in muscle function rather than the results of the tests, which may remain unchanged. Mild weakness that persists for more than 3 to 4 months is also an indication for surgery.

For the chronic neuropathy associated with muscle weakness, nonoperative treatment is generally not effective, and surgery is warranted. Postoperative improvement depends on a number of factors, including the age of the patient, the duration of nerve compression, and the severity of numbness and muscle weakness. The prognosis is worst when sensibility affects innervation density and two-point discrimination is impaired. It is also worst when weakness is severe and is accompanied by muscle atrophy. Any improvement in sensibility or strength in such cases will be limited. It is even possible that there will be no improvement, particularly in the patient with complete intrinsic muscle wasting. Surgery may still be indicated if elbow pain and dysesthesias are the predominant symptoms. Some limited symptomatic improvement can be expected, but the patient must understand that the objectives of surgery are more palliative than curative.

## Operative Treatment

The history of surgery for ulnar neuropathies at the elbow dates back to 1816, when Earle excised a segment of the damaged nerve.[3] Andrae and Sherren, in 1889 and 1908, respectively, used the same radical treatment, except they repaired the nerve. In 1878, Panas attempted to improve the bed for the ulnar nerve by deepening the epicondylar groove. The first effective operation was carried out in 1898 by Curtis, who transposed the nerve. Since then, a variety of surgical procedures have been proposed, and all continue to be used to some extent. They can be divided into two groups: decompression without transposition and decompression with transposition.

### Decompression Without Transposition

*Decompression in Situ*

Decompression without transposition, also referred to as decompression in situ or "simple decompression," was first suggested by Farqhuar Buzzard in 1922. This term generally refers to a localized decompression of the nerve at the site where it passes between the two heads of the flexor carpi ulnaris muscle (cubital tunnel). This technique is the least complicated of all the operative procedures for ulnar nerve compression in that it simply involves sectioning Osborne's ligament. Resuturing the ligament beneath the nerve has been suggested to reduce scarring, but this can result in recurrent compression and should be avoided. Releasing the nerve more proximally in the epicondylar groove should also be avoided because of the risk that the nerve will subluxate, resulting in compression at a new site. This risk can be greatly reduced by limiting the nerve decompression distal to a line drawn from the medial epicondyle to the tip of the olecranon.[4]

Decompression in situ is an uncomplicated procedure that can be carried out with the use of local anesthesia. The procedure only minimally disturbs the nerve and does not require postoperative immobilization. Limited dissection of the nerve reduces the risk of damage to its motor branches. It also protects the vascular mesoneurium and minimizes the decrease in regional blood flow that has been shown to follow ulnar nerve transposition. Although these ischemic changes are temporary, they are still significant. Decompression in situ may, therefore, be of benefit for the patient who, by reason of advanced age or disease, has poor circulation in the limb.

The ideal candidate for decompression in situ is the patient who experiences recurrent symptoms of ulnar nerve compression localized to the cubital tunnel secondary to swelling of the flexor carpi ulnaris muscle with repetitive activities.

Violinists and violists, who are constantly contracting their wrist and digital flexors for prolonged periods of time while maintaining their elbows in acute flexion, are predisposed to this problem (Fig. 1).

Decompression in situ proximal to the epicondylar groove is indicated in two rare conditions. The first is nerve compression secondary to hypertrophy of the medial head of the triceps, which is sometimes encountered in bodybuilders. The second is snapping of the medial head of the triceps muscle with elbow flexion. The muscle snapping, which is usually confused with habitual dislocation of the nerve, is corrected by decompressing the nerve at the site of irritation and then transferring the abnormal muscle to the central tendon of the triceps.

Decompression in situ is contraindicated for severe cases of compressive neuropathy, particularly posttraumatic cases resulting in perineural scarring. In these situations, the nerve should be moved to an unscarred area. Decompression in situ is also contraindicated when there is a space-occupying lesion in the epicondylar groove and when there is habitual subluxation or dislocation of the nerve.

*Medial Epicondylectomy*

In 1950, King and Morgan[5] modified decompression in situ by excising the medial epicondyle. They recommended the procedure as an alternative to subcutaneous and submuscular transpositions because of problems associated with both operations. They noted that with subcutaneous transposition, the nerve was still subject to irritation if it was displaced posteriorly with elbow extension. The nerve did not have to shift completely back into the epicondylar groove for this to occur. It could be irritated simply by repeatedly slipping onto the apex of the medial epicondyle. They were also concerned that after subcutaneous transposition, the nerve remains in close proximity to the epicondyle, where it is susceptible to repeated trauma. Severe scarring may develop after submuscular transpositions, which can cause nerve "strangulation."

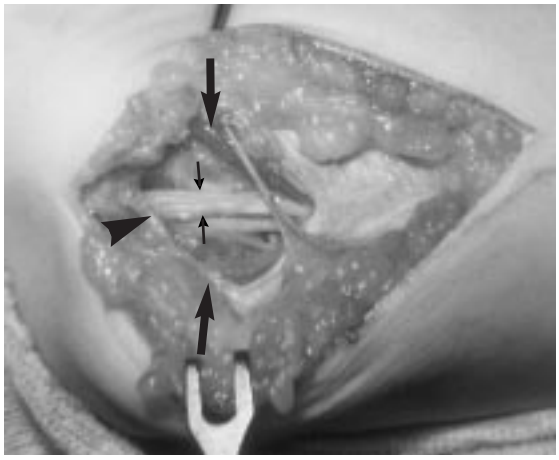

**Fig. 1** Decompression in situ in a professional violinist. A limited incision was made, and Osborne's ligament was divided over the cubital tunnel (large arrows). Compression of the nerve was obvious (small arrows). The fibroaponeurotic covering of the epicondylar groove (arrowhead) was not incised, in order to prevent postoperative dislocation of the nerve. The posterior branch of the medial antebrachial cutaneous nerve was protected where it crossed the operative field.

The advantages of medial epicondylectomy are similar to those of decompression in situ. With removal of the epicondyle, the prominence against which the nerve is compressed is eliminated, and the nerve is free to "seek its own course of least resistance."[6] The disadvantages of the procedure are that it fails to release the most distal potential site of compression, where the ulnar nerve leaves the flexor carpi ulnaris muscle, and it does not relieve traction forces on the nerve as effectively as transposition. Excision of the proper amount of bone is critical, as excising too much bone can damage the medial collateral ligament and result in postoperative valgus instability of the elbow,[7] whereas excising too little bone can compromise the outcome.[8]

## Decompression With Transposition

Ulnar nerve decompression with transposition is far more commonly performed than decompression without transposition. Transposing the nerve has two main advantages. The first is that the nerve is removed from an unsuitable bed and repositioned to one that is less scarred. This is necessary for any of a wide variety of lesions, previously discussed, that are proximal to or within the epicondylar groove (e.g., fracture fragment, arthritic spur, tumor). The second advantage is that by transposing the nerve into a new pathway volar to the axis of elbow motion, it is effectively lengthened several centimeters, which decreases tension on it with elbow flexion. This is important for the neuropathy that develops as a consequence of traction forces, with or without a concomitant valgus deformity of the elbow.

In early articles describing ulnar nerve transpositions, the nerve was transposed either superficial or deep to the flexor muscles. The techniques used for the superficial method positioned the nerve in the subcutaneous tissues or directly within the flexor-pronator muscle. The deep method placed the nerve completely under the muscle. Later articles separated transpositions into subcutaneous, intramuscular, and submuscular categories.

*Subcutaneous Transposition*

Subcutaneous transposition is the most commonly used method of ulnar nerve transposition because it is not technically difficult and has a high success rate. It is the procedure of choice for repositioning the nerve during operative reduction of acute fractures and dislocations, as well as in elbow arthroplasty. It is also useful for secondary neurorrhaphy when length is needed to overcome a large gap after excision of a neuroma. Surgeons who prefer intramuscular or submuscular techniques for transposition will frequently use the subcutaneous method in the elderly, in patients with arthritic elbows, and in obese patients whose arms have a thick layer of protective adipose tissue. The disadvantages of subcutaneous transposition are that it fails to decompress the nerve at the most distal site for compression and that the nerve remains vulnerable to repeated trauma, particularly in thin, active individuals.

*Intramuscular Transposition*

Intramuscular transposition was first proposed by Adson in 1918. The procedure was popularized by Platt in 1928. Platt believed that leaving the transposed nerve in a subcutaneous position was unsound and instead recommended that it be buried in a groove or "intramuscular gutter" within the flexor-pronator muscle. McGowan[9] used a similar technique, but instead of burying the nerve in the muscle, she simply placed it in a shallow groove cut on the surface of the muscle. Scientific support for intramuscular transposition was later provided by animal studies that showed that placing the ulnar nerve intramuscularly did not result in any more scarring at the muscle-nerve interface than placing the nerve submuscularly.[10]

In 1989, Kleinman and Bishop[11] described the operative technique in detail and reported excellent results in a large series of cases. They stated that the procedure was preferable to submuscular transposition because it required less muscle dissection. In spite of their favorable report, intramuscular transposition is the most controversial of the three methods of ulnar nerve transposition. Although proponents of the procedure claim that it does not cause undue scarring, others note that scarring is a common complication because the nerve is placed within the muscle at right angles to its fibers, where it is subjected to traction forces.[12-14]

*Submuscular Transposition*

Submuscular transposition was first described by Learmonth in 1942. The advantages of the procedure are that it ensures that all five potential sites for nerve compression have been explored and released, and it permits the nerve to lie in an unscarred anatomic plane where it is not subject to traction forces. By being positioned deep to the entire flexor-pronator muscle, the nerve is also well protected from external compressive forces, which is important in active individuals, particularly serious amateur and professional athletes. However, submuscular transposition is usually contraindicated when there is scarring of the joint capsule or distortion of the joint due to arthritis or a malunited fracture.

Submuscular transposition is technically more demanding and requires more dissection than decompression in situ, epicondylectomy, and the other two methods of transposition. Submuscular transposition can potentially cause more scarring than the other surgical procedures, although this has not been the experience of those who advocate the procedure. The postoperative immobilization of the elbow that is required to permit healing of the flexor-pronator muscle can also result in a flexion contracture of the joint. This risk is minimized by immobilizing the elbow in no more than 45 degrees of flexion for 3 to 4 weeks.

## Surgical Technique

### General Principles

Several general principles apply to surgical technique, regardless of the method of decompression. Surgery is carried out under tourniquet control, with the use of regional or general anesthesia, although local anesthesia can be used for decompression in situ. The skin incision is relatively short for decompression in situ, being limited to dividing Osborne's ligament over the cubital tunnel. The incision begins midway between the medial epicondyle and the olecranon and extends 6 to 8 cm distally over the flexor carpi ulnaris muscle.

Medial epicondylectomy and the three types of transposition require a longer incision. For these procedures, the incision begins 8 to 10 cm proximal to the medial epicondyle and directly over the medial intermuscular septum, which can usually be easily palpated. The incision continues along the epicondylar groove, midway between the medial epicondyle and the olecranon tip, and ends 5 to 7 cm distal to the epicondyle over the ulnar nerve, which can usually be palpated in its course through the flexor carpi ulnaris muscle. Once dissection has gone through the subcutaneous tissue, care must be taken to protect the posterior branch (or branches) of the medial antebrachial cutaneous nerve. The branch crosses the elbow anywhere from 6 cm proximal to the epicondyle to 6 cm distal to the

epicondyle. It innervates the skin over the area of the medial epicondyle and olecranon, and injury to it must be avoided because it can result in scar tenderness and numbness.[15]

Skin flaps are mobilized sufficiently to expose the medial intermuscular septum and the fascia over the flexor-pronator muscle origin. The fascia immediately posterior to the medial intermuscular septum is incised along the course of the nerve. This is followed by incision, in a sequential fashion, of the fibroaponeurotic covering of the epicondylar groove, Osborne's ligament (arcuate ligament, triangular ligament) at the cubital tunnel, and the fascia over the flexor carpi ulnaris.

With ulnar nerve transposition, regardless of the technique used, the fibrous edge of the medial intermuscular septum is excised, particularly distally, where it is wider and thicker than it is proximally. With excision of the intermuscular septum, the nerve is not compressed at a new site where it courses to the volar aspect of the elbow (Fig. 2). During dissection at the distal end of the intermuscular septum, the surgeon should be aware of several large vessels that are part of the extensive collateral circulation around the elbow. When mobilizing the nerve from its bed, manipulation and traction should be kept to a minimum. This can be best achieved by retracting the nerve with one's finger. The gloved finger is more sensitive to the amount of traction on the nerve than a metal retractor, Penrose drain, or vessel loop. Cauterizing small vessels in the mesoneurium is often necessary; this should be carried out as far away from the nerve as possible. The ulnar nerve can be safely mobilized from the arcade of Struthers to the deep flexor pronator aponeurosis, a distance of approximately 15 cm, without compromising its extrinsic blood supply.

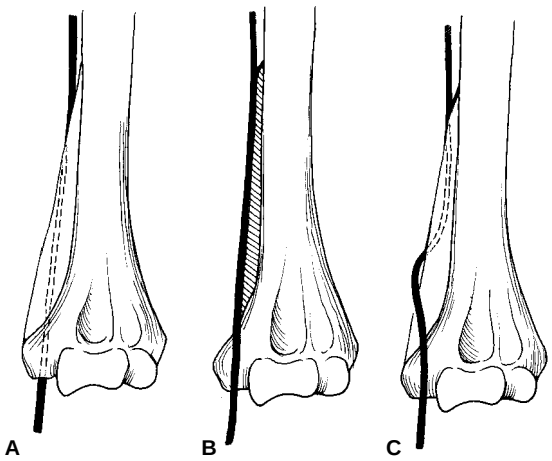


**Fig. 2** **A,** Normally, the ulnar nerve is posterior to the medial intermuscular septum. **B,** The septum should always be excised when the nerve is surgically transposed. **C,** Failure to excise the septum can result in compression where the nerve crosses the edge of the septum. (Adapted with permission from Sunderland S: *Nerves and Nerve Injuries,* 2nd ed. New York: Churchill Livingstone, 1978, p 835.)

Several small nerve branches are sometimes seen to be arising from the posterior surface of the ulnar nerve, tethering the nerve to the epicondylar groove. These branches should not be sacrificed on the assumption that they are unimportant articular branches; microdissection studies have shown that they are almost always motor branches to the flexor carpi ulnaris.[16] The branches should be mobilized using interfascicular dissection.

After release of fascial structures, the ulnar nerve may be enlarged, and its epineurium may be thickened at the site of compression. It loses its glistening white appearance, as well as the transverse striations and the longitudinal fascicular pattern characteristic of a normal nerve. It is important to release the epineurium in this area sufficiently to visualize the fascicles. Epineurolysis, when properly performed with the use of loupe magnification, will not result in additional nerve damage.

## Medial Epicondylectomy

The surgical technique for medial epicondylectomy (Fig. 3) involves exposing the superficial

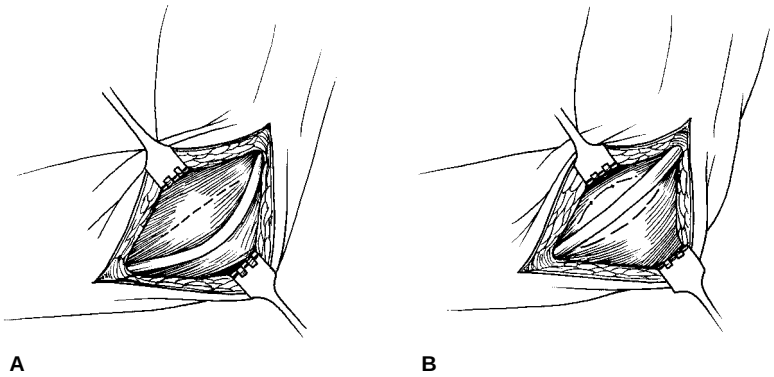


**Fig. 3** Technique for medial epicondylectomy. After the epicondyle has been removed and the soft tissues have been closed **(A)**, the ulnar nerve rolls forward to a new bed **(B)**.

surface of the ulnar nerve proximal to the medial epicondyle, in the epicondylar groove, and at the cubital tunnel. The nerve is not mobilized from its bed, although an epineurolysis can be performed if necessary. The medial epicondyle is then exposed subperiosteally by dissecting the origin of the flexor-pronator muscle mass from its anterior surface and dissecting the periosteum from its posterior surface. The tissues are sharply elevated from the bone, maintaining good margins for later closure.

The epicondyle is removed with a thin osteotome. Scoring the bone reduces the risk of propagating the osteotomy into the elbow joint or into the area of attachment for the collateral ligament. The osteotomy site is smoothed with a small rongeur or rasp, and the previously reflected soft tissues are sutured over the bone to provide a smooth bed for the nerve. The ulnar nerve should slide slightly forward with elbow flexion. If any tension remains, the aponeurosis of the flexor carpi ulnaris is divided further distally. Postoperative immobilization is not required, and active range-of-motion exercises can begin within a day or two.

### Subcutaneous Transposition

When the nerve is transposed subcutaneously, it should be stabilized in its new position to prevent it from slipping back into the epicondylar groove. Various techniques have been recommended, including suturing the epineurium of the nerve to the underlying muscle fascia,[17] suturing the deep subcutaneous tissues to the muscle fascia,[18] and constructing a fasciodermal sling from the fascia over the flexor-pronator muscle.[19] Constructing a fasciodermal sling is the preferred procedure (Fig. 4). In the original description of the procedure, a flap measuring 1.5 cm in width and length was based near the medial epicondyle and reflected medially.[19] The undersurface of the flap was then passed posterior to the nerve and sutured to the subcutaneous tissues. Alternately (and preferably), basing the flap laterally and reflecting it laterally allows positioning of its smooth outer surface against the nerve. Although postoperative immobilization of the elbow in 90 degrees of flexion for 2 weeks has been recommended, immobilizing the joint in no more than 45 degrees of flexion minimizes the risk of later joint stiffness.

### Intramuscular Transposition

For intramuscular transposition, the ulnar nerve is first positioned on top of the flexor-pronator muscle, and its path is noted. The nerve is then temporarily replaced in its original position, and a trough, 0.5 to 1.0 cm in depth, is fashioned in the muscle along the path. Fibrous septa within the muscle are divided to provide a soft, well-vascularized bed for the nerve. The fascia over the nerve is then repaired. Proponents of the procedure recommend 3 weeks of postoperative immobilization with the forearm in full pronation and the elbow flexed 90 degrees.

### Submuscular Transposition

For submuscular transposition, the entire origin of the flexor-pronator muscle mass must be detached. This can be carried out with the use of any of a variety of techniques, including leaving a 1-cm cuff of tissue on the bone to facilitate reattachment,[14] dividing the muscle origin using a step cut or a Z-plasty to lengthen it,[20,21]

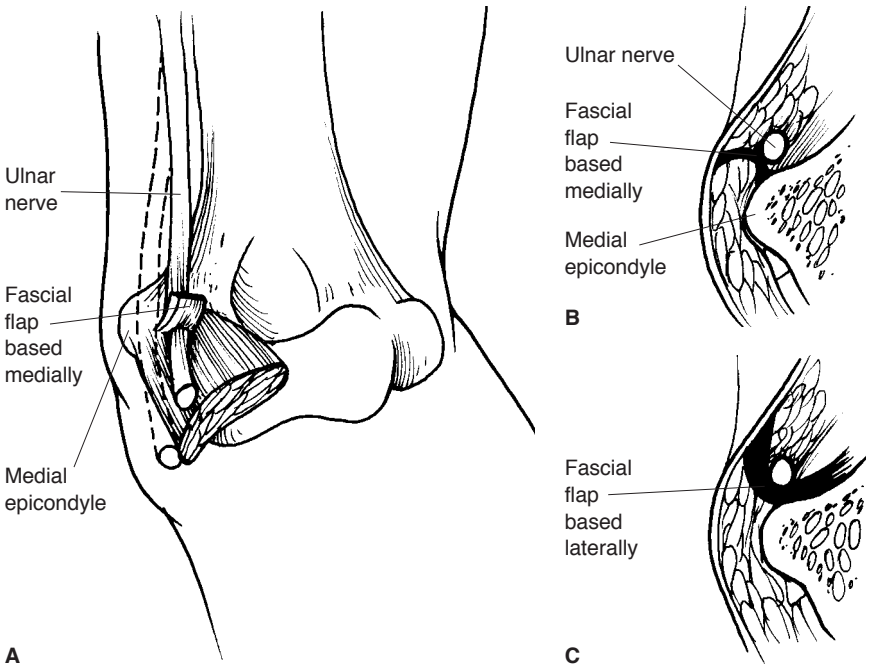


**Fig. 4** **A,** After subcutaneous transposition, a fasciodermal sling is constructed to prevent the nerve from slipping back into the epicondylar groove. **B,** In the original description of the procedure, the flap was based medially. **C,** Basing the flap laterally permits its smooth outer surface to be positioned against the nerve. (Adapted with permission from Osterman AL, Davis CA: Subcutaneous transposition of the ulnar nerve for treatment of cubital tunnel syndrome. *Hand Clin* 1996;12:421-423.)

removing the muscle sharply from the bone,[22] or detaching it together with the medial epicondyle by means of an osteotomy.[23] The latter technique adds the risk that the epicondyle cannot be securely reattached, which can result in nonunion, pain, and weakness. In one study,[24] the reported advantage of the step-cut lengthening technique was that it reduces postoperative intraneural pressures more consistently than other techniques. However, that study was done in cadavers, and its application to clinical situations is questionable.

A preferable technique is to use a scalpel to detach the muscle directly from the epicondyle and any more proximal attachments to the humerus. Care must be taken when detaching the muscle from the epicondyle to avoid damaging the medial collateral ligament. This technique provides a strong fibrous cuff of tissue at the origin of the flexor-pronator muscle for reattachment to the bone after transposition of the nerve (Fig. 5). The flexor carpi ulnaris muscle is also released for a short distance from the ulna distal to the insertion of the collateral ligament to ensure that the new path for the ulnar nerve will be as straight as possible. When the nerve is transferred onto the bed of the brachialis muscle, the median nerve is almost always visible in the lateral aspect of the operative field.

To reattach the muscle, four holes are drilled into the epicondyle in a sequential fashion, start-

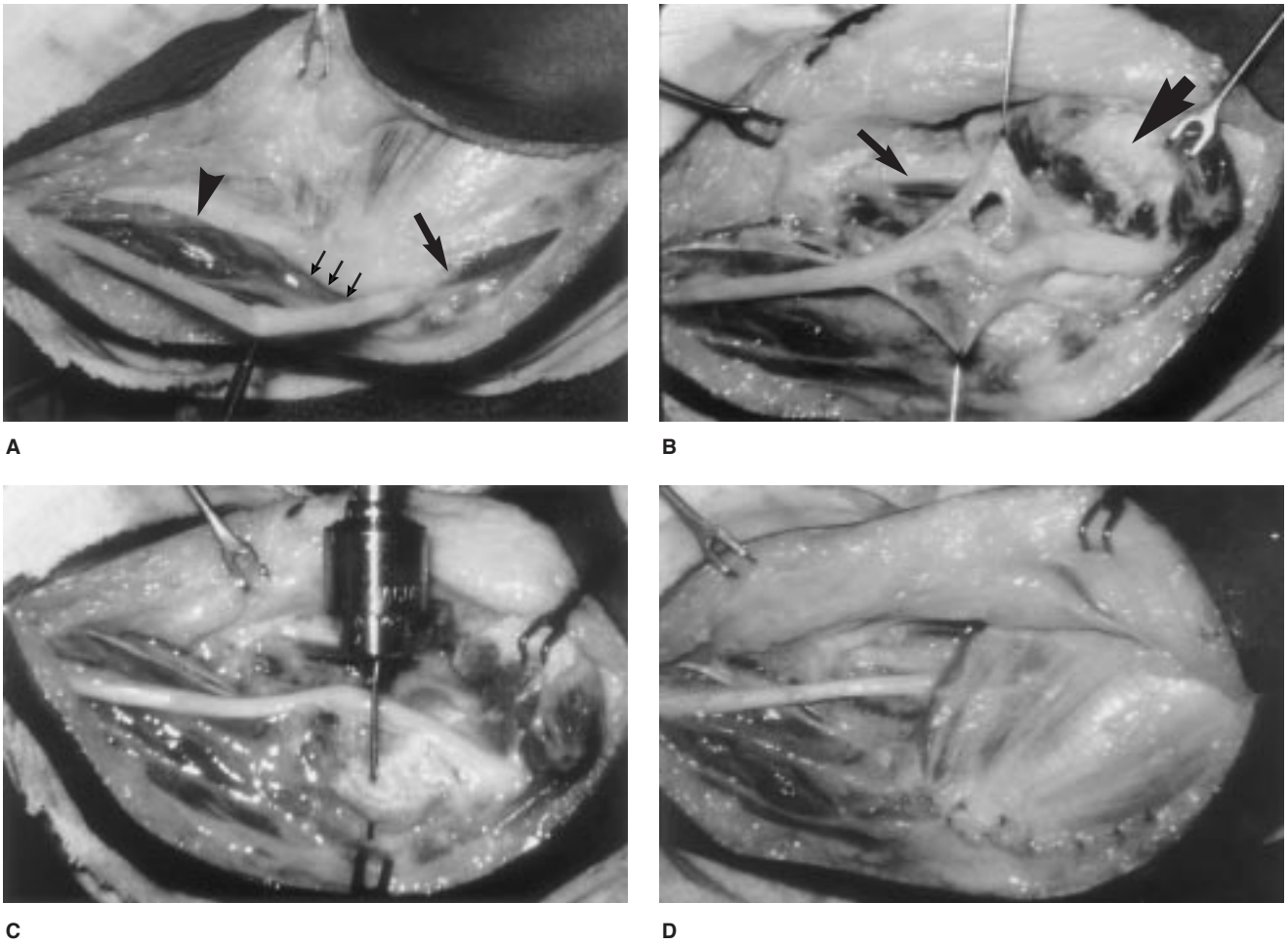


**Fig. 5** **A,** The ulnar nerve has been decompressed throughout the operative field. The roof of the epicondylar groove (small arrows) and Osborne's ligament (large arrow) have been divided. The medial intermuscular septum (arrowhead) has not yet been excised. **B,** The entire origin of the flexor-pronator muscle mass has been sharply elevated from the epicondyle with a rim of fibrous tissue (large arrow) to facilitate later reattachment. Epineurolysis has been carried out in the area of constriction. The median nerve can also be seen (small arrow) in the operative field. **C,** The first of four drill holes made in the medial epicondyle to accommodate two mattress sutures to reattach the flexor-pronator muscle mass. **D,** The muscle has been reattached, and the fascia between the two heads of the flexor carpi ulnaris and over the epicondylar groove is closed.

ing at the proximal edge of the bony prominence and ending distally near the origin of the collateral ligament. Two mattress sutures of 0 synthetic braided suture material are passed though the holes and through the fibrous cuff of tissue at the origin of the flexor-pronator muscle. This technique provides secure fixation, even in the professional athlete. The previously incised fascia between the two heads of the flexor carpi ulnaris and the fibroaponeurosis over the epicondylar groove are closed with 3-0 nylon mattress sutures. The tourniquet is released, bleeding points are controlled, and the subcutaneous tissues are closed.

Postoperatively, a posterior plaster splint is applied, immobilizing the elbow in approximately 45 degrees of flexion, the forearm in neutral rotation or slight pronation, and the wrist in neutral position. Immobilization is continued for 3 to 4 weeks, followed by active range-of-motion exercises. Resistive exercises are encouraged as soon as the patient regains complete active mobility of the elbow, which usually takes several weeks. In most cases, patients resume full activities within 3 to 4 months after surgery. For some activities, particularly sports that require throwing, 6 to 9 months is necessary for complete recovery.

## Prior Unsuccessful Surgery

When symptoms persist after surgery, it is important to accurately determine the source. The original diagnosis may have been incorrect, or the nerve may have been compressed at more than one site. Before recommending additional surgery, the physician must assess the degree of intrinsic nerve damage, which may have been so severe before the previous decompression that, regardless of operative techniques, there was little chance for improvement. This is often the situation with a chronic neuropathy associated with profound intrinsic muscle wasting. Therefore, persistent postoperative numbness or muscle weakness is not necessarily an indication that prior surgery was not effectively performed. However, if pain and tenderness over the nerve and distal dysesthesias have not improved, even to a slight degree, the nerve may not have been completely decompressed, or the nerve may be compressed at a new site.[12,13]

When additional surgery is being considered, electrodiagnostic studies are necessary. These studies are most useful when they show deterioration of nerve function as compared with preoperative studies. Additional surgery is almost always indicated in these cases. The prognosis for revision surgery is uncertain, however, and patients must be informed that their symptoms may not improve. Rarely is additional surgery warranted for the patient who has undergone two or more failed operations.

Another common cause of an unsuccessful result is injury to the posterior branch of the medial antebrachial cutaneous nerve.[15,25] Injury to this sensory branch results in hypesthesia or hyperalgesia. Although hypesthesia over the olecranon area may be bothersome, it is rarely disabling and generally requires no treatment. Hyperalgesia, however, can be disabling because it is often accompanied by local tenderness and pain that is aggravated by elbow motions. When the neuroma lies directly over the ulnar nerve, tapping over it can produce paresthesias into the hand, which can be misinterpreted as being caused by continued compression of the ulnar nerve. Temporarily blocking the medial antebrachial cutaneous nerve with a local anesthetic is a useful diagnostic test. Treatment is initially nonoperative, consisting of local massage and desensitization techniques. If symptoms persist for several months, the neuroma can be resected proximal to the operative site, and the proximal end of the nerve branch can be implanted into the triceps muscle.[15]

With revision surgery, care must be taken to ensure that the ulnar nerve is released at all five sites of potential compression. Frequently, epineurolysis is necessary at the site of nerve damage.[12-14] Internal neurolysis is rarely indicated. Silicone sheathing of the nerve as a means of restricting postoperative scar formation has not proved to be of any benefit. The ulnar nerve should be placed in a well-vascularized area; this is best accomplished by submuscular transposition.

## Summary

The initial treatment of acute and subacute neuropathy is nonoperative. Rest and avoidance of pressure on the nerve may suffice, but if symptoms persist, splint immobilization of the elbow and wrist is warranted. For chronic neuropathy associated with muscle weakness or neuropathy that does not respond to conservative measures, surgery is usually necessary.

A variety of operative procedures have been described in the literature. Deciding on the most effective procedure can be difficult, given the excellent results claimed by proponents of each. Unfortunately, there is a paucity of information based on prospective randomized clinical studies comparing the different surgical methods. Dellon[26] attempted to provide some guidelines by reviewing the data in 50 articles dealing with nonoperative and operative treatment of ulnar neuropathies at the elbow. To provide uniformity, he

reinterpreted the data in these articles using his own system for staging nerve compression. He reported that treatment was most successful for mild neuropathies, a conclusion few would challenge. Excellent results were achieved in 50% of patients with mild neuropathies who were treated nonoperatively and in more than 90% treated by surgery, regardless of the procedure. For moderate neuropathies, nonoperative treatment was generally unsuccessful, as were decompressions in situ. Epicondylectomies, sometimes referred to as "mini-anterior transpositions,"[8] provided excellent results in 50% of cases, but they had the highest recurrence rate.

Regarding ulnar nerve transposition, each of the three methods has its proponents, usually based on the training and experience of the surgeon. Subcutaneous transposition is the least complicated. It is an effective procedure, particularly in the elderly and in patients who have a thick layer of adipose tissue in their arms. It is the procedure of choice for repositioning the nerve during operative reduction of an acute fracture, elbow arthroplasty, and secondary neurorrhaphy. Intramuscular and submuscular transpositions are more complicated procedures. Although proponents of intramuscular transposition report favorable results, the procedure can result in severe postoperative perineural scarring. Submuscular transposition has a high degree of success and is generally accepted to be the preferred procedure when prior surgery has been unsuccessful. It is also the preferred primary procedure for most chronic neuropathies that necessitate surgery.

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