

Techniques for Successful Management of Ulnar Nerve Entrapment at the Elbow

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Ulnar nerve entrapment at the elbow is being recognized with increasing frequency and currently represents the second most common indication for nerve entrapment surgery in the upper extremity. Unfortunately, the outcome of surgical treatment has been disappointing¹³; thus, some surgeons have suggested treatment of the patient by long-arm plaster immobilization.²⁴ A half century of surgical dissatisfaction has left the present day peripheral nerve surgeon with a wide spectrum of treatment alternatives: nonoperative management, simple decompression of the ulnar nerve, anterior subcutaneous transposition, anterior intramuscular transposition, submuscular transposition, or medial epicondylectomy. The etiology, diagnosis, pathophysiology, and surgical technique in ulnar nerve entrapment at the elbow have been discussed in-depth in a recent review.³⁶ The purpose of this article is to describe the techniques for success that have made our approach to anterior submuscular transposition¹² predictable and to discuss its application not only in initial but also in recurrent ulnar nerve entrapment.

ETIOLOGY AND DIAGNOSIS

The cause for the apparent epidemic of peripheral nerve compressions is the increase in occupation-related disorders. Repetitive work phenomena have increased, primarily with the increase in office-related activities, such as computer data entry jobs where the employee must work with wrists and elbows flexed or the executive with elbows flexed while writing at a desk. Assembly line work, with and without the use of vibrating tools, also requires repetitive elbow flexion and extension. The presence of congenital anomalies, such as in the epitrochleoanconeus muscle,³¹ and the presence of either a partly (10%) or completely (2%) subluxing ulnar nerve at the elbow⁶ further predispose younger members of the work force to ulnar nerve entrapment at the elbow.

A further cause for the epidemic in nerve compressions is the large number of patients with ulnar nerve compression at the elbow who are finally being given the correct diagnosis for their complaints. For example, it is now recognized that the complaints of weakness, clumsiness, and dropping objects (Table 1) are not those of carpal tunnel syn-

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Table 1. *Staging of Ulnar Nerve Compression At the Elbow**

Mild
Sensory
Paresthesias come and go
Vibratory perception increased
Motor
Subjective weakness, clumsiness, or loss of coordination
Tests
Elbow flexion test or Tinel's sign or both are positive
Moderate
Sensory
Paresthesias come and go
Vibratory perception normal or decreased
Motor
Measurable weakness in the pinch or grip strength
Tests
Elbow flexion test or Tinel's sign or both are positive
Finger crossing may be abnormal
Severe
Sensory
Paresthesias are persistent
Vibratory perception decreased
Abnormal two-point discrimination
Motor
Measurable weakness in pinch and grip plus muscle atrophy
Test
Positive elbow flexion test or positive Tinel's sign or both may be present
Finger crossing usually abnormal

* Adapted from Mackinnon SE, Dellon AL: Ulnar nerve entrapment at the elbow. In: Mackinnon SE, Dellon AL (eds): *Surgery of the Peripheral Nerve*. New York, Thieme, 1988, pp 217-273.

drome. When a patient with carpal tunnel syndrome complains that his or her "whole hand" is affected, the diagnostic search should specifically eliminate the possibility of a coexisting ulnar nerve compression. With our better understanding of the multiple crush syndrome,³⁷ the patient who may appear to have thoracic outlet syndrome (brachial plexus compression), should be examined for coexisting problems in areas such as the cervical discs at C8 and T1 and the region of the cubital tunnel. An appropriately directed initial surgical attempt at the cubital tunnel may eliminate the need for surgery at the more proximal levels of compression.

We must restrain our initial impulse to make the diagnosis on electrophysiologic criteria.¹⁷ Although there is no question that the diagnosis of ulnar nerve compression

can be made with electrodiagnosis,^{25, 30} in my experience the large number of fibers in the ulnar nerve and the small degree of compression required to produce symptomatology results in approximately 50% of the patients in my practice coming to surgery with "normal" findings. To be sure, in more advanced stages in humans a good correlation may be found between the clinical, electrophysiologic, and even morphometric assessment of ulnar nerve compression at the elbow.²² However, it should be our goal to have sufficient confidence in the findings of physical examination to be able to make the clinical diagnosis.

The aids in history taking and physical examination (Table 2) should be reemphasized. During the history taking when a suspicion of ulnar nerve compression is raised, the useful provocative test of elbow flexion²⁸ is performed. The patient is simply asked to flex each elbow, and the history taking is continued. After a very short period of time, the patient should notice an increase in numbness with or without tingling in the little finger or a sensation of discomfort at the elbow and, frequently, a perception of coldness in the extremity. Because the earliest changes in nerve compression are threshold changes for both the sensory and motor systems rather than changes of axonal degeneration, the qualitative change in the patient's perception of vibratory stimuli, as detected with a tuning fork,⁸ or the quantitative change, as detected by a vibrometer,⁹ can be measured. A computer-linked technique to quantitate cutaneous pressure threshold, the Pressure-Specifying Disk-Criminator (NK Biotechnical Engineering Company, Minneapolis, Minn), has recently been described.¹⁵ Two-point dis-

Table 2. *Ulnar Nerve Entrapment at the Elbow: Diagnosis*

History
Fifth and/or ring finger numbness
Weakness/clumsiness
Dropping things
Elbow discomfort
Physical examination
Elbow flexion test
Sensory loss dorsal-ulnar hand
Weakness of flexor profundus V
Positive Tinel's sign at elbow

crimination, as determined with a Disk-Criminator (PO Box 16392, Baltimore, Md), documents the loss of innervation density that accompanies more progressive axonal degeneration in more chronic and severe nerve compression. In the muscle system, weakness (pinch and grip strength determinations) would be analogous to threshold and muscle wasting in axonal degeneration. Localization of ulnar nerve compression at the elbow instead of more distally at the wrist is documented by manual muscle testing of the flexor profundus to the little finger, by determination of sensory loss over the dorsal ulnar aspect of the hand³⁶ and the presence of a positive Tinel's sign somewhere along the postcondylar groove, representing a site of increased mechanosensitivity due to demyelination or the presence of regenerating myelinated or unmyelinated units.¹⁰ The history and physical examination should be further directed to rule out more proximal sites of this symptomatology, such as compression in the brachial plexus or C8 and T1 cervical disc disease.

STAGING

Increasingly in "scientific medicine," treatment is based on a better understanding of the pathophysiology of disease. This should also be the goal in the management of nerve compression. Based upon the findings of the physical examination and the patient's symptomatology, as described previously, a system for staging the degree of compression of ulnar nerve entrapment at the elbow may be defined (Table 1).³⁶ The lack of such a comprehensive staging system, which includes both sensory and motor findings in contrast with the most commonly used staging system of the past³⁸ (which was based primarily on motor findings) has been partially responsible for the failure of the surgical literature to give good guidelines for treatment. Using this sensory-motor staging system, a review of the literature from 1898 through the 1980s was published that recommended treatment strategies based on surgical outcomes¹³ (Table 3). Unfortunately, the conclusion from this literature review is that presently there is no prospective randomized clinical trial to serve as the basis for choosing one surgical approach

over another. Therefore, the techniques that are discussed next come from my experience in treating more than 800 patients with ulnar nerve entrapment over the past 12 years.

NONOPERATIVE APPROACH

To better inform patients about nerve entrapment syndromes, booklets were prepared that described cubital tunnel syndrome and carpal tunnel syndrome.* These booklets explain the nonoperative approach to management of ulnar nerve compression at the elbow (as well as the risks and potential benefits of submuscular transposition). Approximately 50% of patients with a minimal degree of ulnar nerve compression at the elbow may obtain relief without surgery if they make an effort to use these techniques over a 3-month period: keeping elbow flexion to a minimum by not sleeping with the arm curled under the body; switching to the opposite hand or using a headset for telephone use; using a bookstand for reading rather than holding a book by hand; adjusting the height of a chair, the angle of a computer keyboard, or the distance of a chair from a desk to keep elbow flexion less than 30 degrees; and not sitting with the arms folded across the chest nor resting the head upon the hand with the elbow flexed. A preferred position is to have the patient sit with the arms in the lap, the hand in a supinated position, and the elbow flexed no more than 30 degrees. In a car, a preferred position is to place the hand beneath the steering wheel rather than above the steering wheel. Patients should recognize that any degree of abduction of the shoulder with the elbow flexed further accentuates the pressure applied to the ulnar nerve in the postcondylar groove^{3, 41} and, therefore, should attempt to minimize activities with the arm elevated. At night, it is helpful to wrap a towel loosely around the elbow to prevent elbow flexion. Actual splints are generally not acceptable to the patient because there is such a frequent need to adjust the extremity's position.

* Included as Appendix A and B *In* Mackinnon SE, Dellon AL: *Surgery of the Peripheral Nerve*. New York, Thieme Publishing, 1988. Brochures available through P.O. Box 16392, Baltimore, MD 21210.

Table 3. *Summary by Degree of Compression of Treatment for Ulnar Nerve Compression at the Elbow*¹³

TREATMENT	STAGE	NUMBER	PERCENT OUTCOME				
			No Atrophy (96)	Normal Strength (96)	No Paresthesia (96)	Worse (96)	Recurrence (96)
Nonoperative	Minimal	141			58		42
	Moderate	9		0			77
	Severe	3	0				100
	Total	153					
Decompression	Minimal	216			94		1
	Moderate	141		33	33		16
	Severe	210					
	Total	567					
Medial epicondylectomy	Minimal	35			100		
	Moderate	78		41	50		23
	Severe	43	25		30		35
	Total	156					
Anterior subcutaneous transposition	Minimal	35			94		0
	Moderate	113		43	71	2	15
	Severe	113					
	Total	281					
Anterior intramuscular transposition	Severe	79		6	6	67	
Anterior submuscular transposition	Minimal	5			100		
	Moderate	31		81	77		3
	Severe	66	12		14		30
	Total	102					
Recurrent (anterior submuscular transposition)*	Moderate	8		63	63		6
	Severe	31	15		52		
	Total	39					
TOTAL PATIENTS REVIEWED		1,377					

* Plus internal neurolysis.

OPERATIVE TECHNIQUE

My preferred operative technique is a modification of the anterior submuscular transposition for the ulnar nerve originally described by Learmonth in 1942.³³ This report, which contains 11 figures, is only two pages long and contains no indication as to Learmonth's surgical success in treating the problem. Learmonth simply recommended that if the ulnar nerve was to be transposed anteriorly, it should be placed into an intermuscular plane similar to that in which the median nerve lies. Learmonth was the first to describe and depict carefully an excision (not incision) of the medial intermuscular

septum. A few subsequent reports that describe anterior submuscular transposition^{34, 42} emphasized excision of the median intermuscular septum and described a technique by which the flexor pronator muscle mass was completely incised and then reapproximated into its normal anatomic position after the ulnar nerve had been placed into its submuscular location. Later reports have emphasized that the problems of failure or recurrent ulnar nerve entrapment are related to incomplete excision of the intermuscular septum, scarring between the ulnar nerve and transected muscle,^{5, 29} and the presence of additional constricting regions, such as the alleged "Struthers arcade,"^{43, 44}

or unusual fibrous septa distal to the medial humeral epicondyle.^{2, 32}

The surgeon performing peripheral nerve surgery should choose a technique which gives him or her complete control over all the possible anatomic variables that may affect the successful outcome of the procedure. Modifications in technique, which have been described,¹² permit complete visualization and potential alteration or correction of anomalies throughout the course of the ulnar nerve. These modifications are

1. Extensive release of the fascia from the medial head of the triceps to the medial intermuscular septum (which is what Struthers described^{45, 46} rather than a true thickened arcade) permits transposition of the ulnar nerve from posterior to the medial intermuscular septum to anterior to the septum.

2. Elongation or lengthening of the flexor pronator muscle mass through a Z-plasty combined with a muscle slide technique, permits the new roof or covering of the transposed ulnar nerve to place no tension upon the nerve.

3. Identification and release of the periosteal origin of the flexor carpi ulnaris from the ulna eliminates the potential distal point of constriction that is analogous to that created by an incomplete excision proximally of the medial intermuscular septum.

4. Intramuscular dissection distally of the flexor carpi ulnaris branch (rather than a proximal interfascicular dissection) prevents a proximal tethering of the ulnar nerve.

These modifications (Figs. 1 through 3) prevent the zigzag pattern found during exploration for recurrent ulnar nerve compression (see following text and Fig. 4).

The operation is performed with an upper extremity tourniquet which may be nonsterile and is placed as high toward the axilla as possible. Anesthesia may be either general or a brachial plexus block, preferably placed by the anesthesiologist. The arm is prepared with povidone-iodine (Betadine) and the tourniquet draped out of the sterile field. The hand is elevated and exsanguinated with an elastic bandage and a tourniquet inflated to 90 to 100 mm Hg above the systolic pressure. The incision may be made as long

as necessary to gain appropriate exposure but with increasing experience averages 6 cm in length. The incision is located directly over the ulnar nerve in the postcondylar groove (see Fig. 1). The incision is carried down to the roof of the cubital tunnel while attempting to identify the medial antebrachial cutaneous nerve. When the nerve is identified, realizing that in some instances it will cross anterior or posterior and inferior to the incision, it should be encircled with a vessel loop and protected throughout the operative procedure. Injury to this nerve is the most common cause of significant postoperative complications (other than failure of the procedure or recurrence of the entrapment). The ulnar nerve is identified beneath the fascia that extends from the medial head of the triceps to the medial intermuscular septum. A scissors is inserted beneath this fascia, and under direct vision with the skin being elevated by an Army-Navy retractor, the fascia is incised for at least 6 cm proximal to the medial humeral epicondyle. This exposure is possible after having elevated a skin and subcutaneous flap anterior to the level of the flexor pronator fascia, care being taken to cauterize the small vessels that supply the skin through this fascia. The ulnar nerve is then encircled with a vessel loop and slight traction placed inferiorly. At this point, a finger can be placed above the ulnar nerve, and the medial intermuscular septum can be palpated clearly. Its sharp edge is then incised adjacent to the medial humeral epicondyle, and the scissors is used to release the septum from the humerus going proximally again for 6 cm and then excising the septum. Deep large veins lie beneath and occasionally penetrate through the septum. Hemostasis again must be carried out meticulously to prevent postoperative hematoma. The need for further proximal dissection is judged at the end of the procedure when the elbow is flexed with the ulnar nerve in the transposed position to give final direct control over the degree of release necessary; the frequently observed 16-cm long skin incision supposedly necessary for "complete visualization" is avoided.

The ulnar nerve is released in the cubital tunnel (Fig. 1) by incising the fascial connection from the medial humeral epicon-

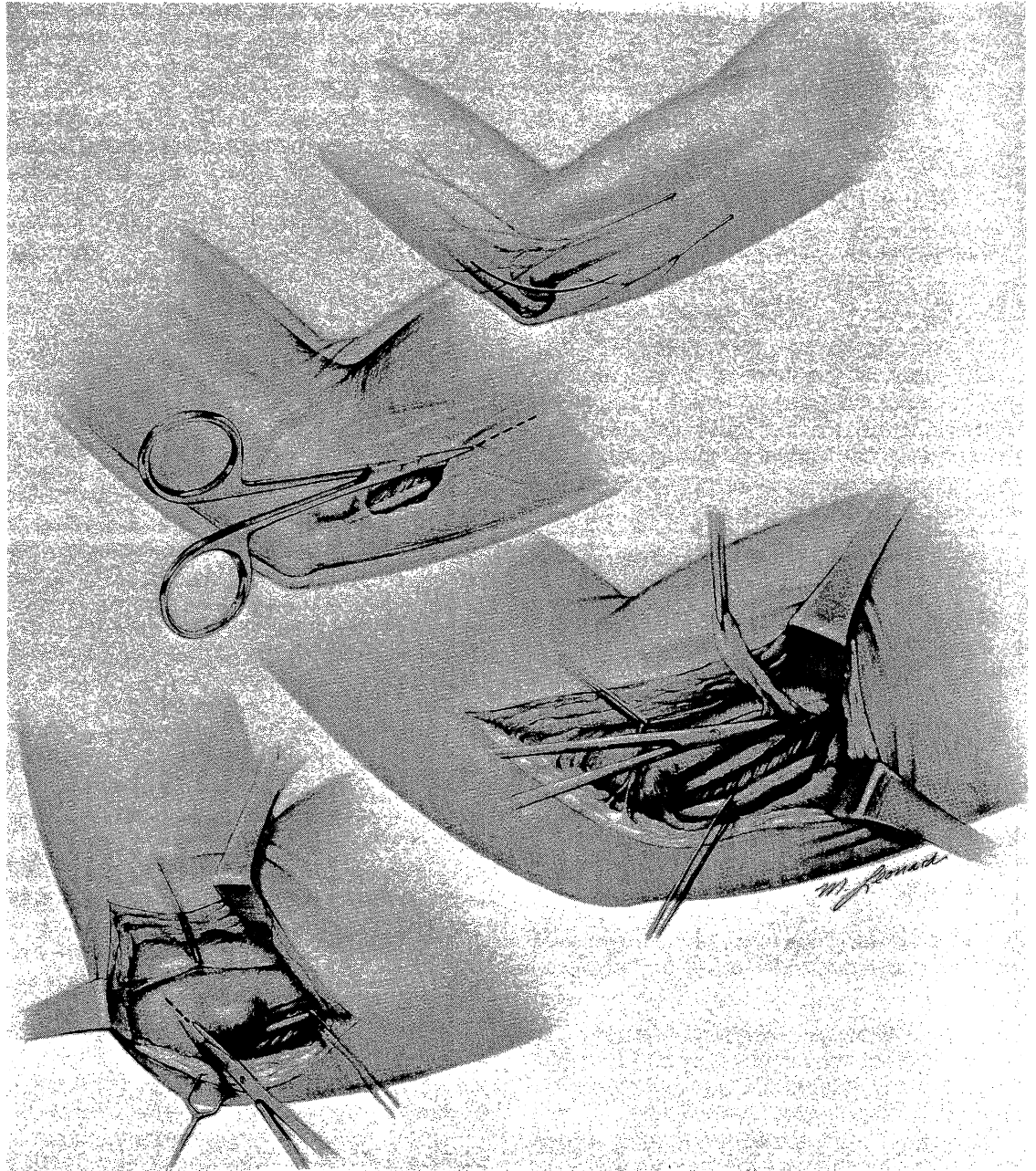


Figure 1. Incision outlined with regard to cutaneous nerves. Release of fascia from medial head of triceps to intermuscular septum. Excision of intermuscular septum. Release of roof of cubital tunnel, including Osborne's band with protection of cutaneous nerve (vessel loop).

dyle to the olecranon. The distal edge of this is the thickened "Osborne's band"⁴⁰ identified in three-quarters of cadaver dissections.¹¹ Feindel and Stratford²⁷ coined the term, "cubital tunnel syndrome," for com-

pression beneath this band. It is during this stage that phylogenetic variations¹¹ are encountered, such as the ulnar nerve embedded in the medial head of the triceps or the medial head of the triceps extending be-

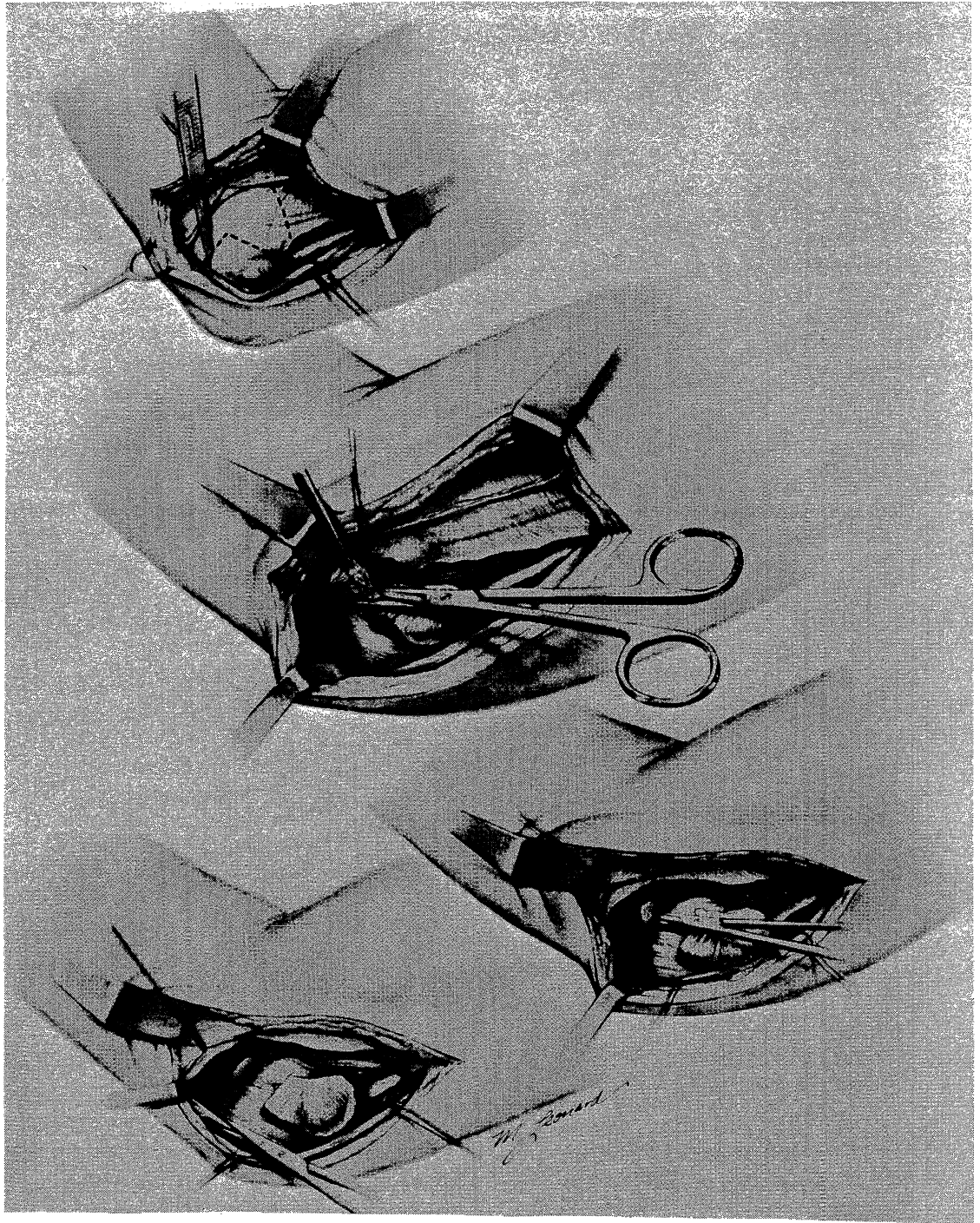


Figure 2. Outline of Z-cut for lengthening of flexor pronator fascia. Release of common flexor tendon origin at epicondyle and then distal release to permit slide (lower right). Release of periosteal origin of flexor carpi ulnaris (lower left).

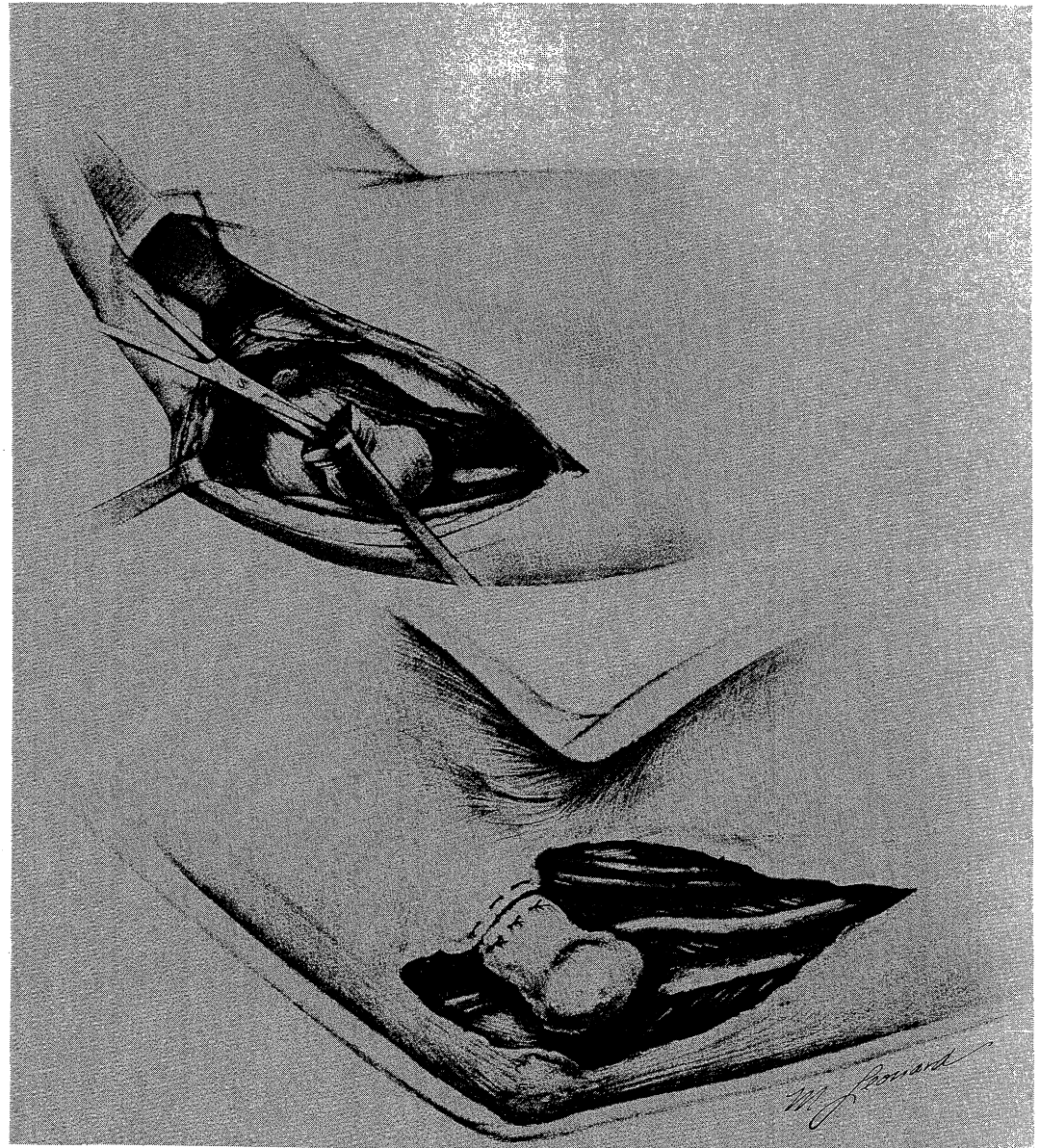


Figure 3. Proximal flap dissection prior to transposition of ulnar nerve to anterior submuscular position. Reconstruction of lengthened fascial flaps over transposed nerve.

neath the ulnar nerve to insert, in part, into the subcondylar groove (causing additional compression of the nerve against the overlying medial humeral epicondyle with or without subluxation of the ulnar nerve) or an anomalous muscle, the epitrochleoanconeus (being present in place of the thin fascial cubital tunnel roof and Osborne's band). If

these structures are found, the ulnar nerve must be neurolysed from the medial head of the triceps and the anomalous muscle taken down. In this portion of the dissection, the branch from the ulnar nerve to the flexor carpi ulnaris will be identified laying in the areolar tissue or still within the epineurium in a posterior or medial location to the ulnar

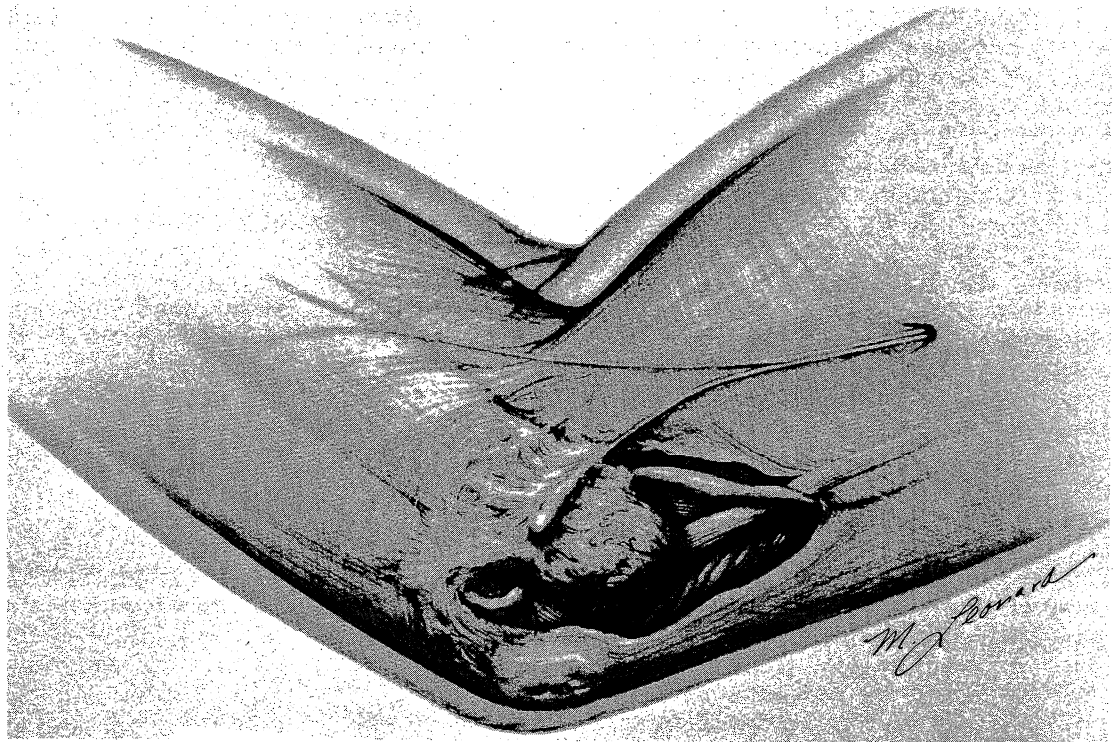


Figure 4. Zigzag pattern in recurrent ulnar nerve compression. Note neuroma of medial antebrachial cutaneous nerve, which is commonly present. Note compression of ulnar nerve proximally at retained medial intermuscular septum. Note that failure to dissect motor branch distally to flexor carpi ulnaris pulls ulnar nerve proximally at distal edge of medial humeral epicondyle, kinking the nerve and restricting its glide.

nerve and coming off it as a very thin proximal branch in the dissection. This is usually a larger distal branch. This proximal branch must be dissected distally as an intermuscular dissection. This is facilitated by holding up on the ulnar nerve with the vessel loop and with fine scissors under loupe magnification, dissecting the motor branch intermuscularly. A small accompanying blood vessel must be cauterized with the bipolar coagulator. It is this distal dissection of the muscle branch that will allow the ulnar nerve to transpose anteriorly in this distal segment of the dissection. It can be seen readily that if this motor branch is pulled proximally, the ulnar nerve remains in a proximal location and does not permit easy distal transposition (to be discussed further in the section on recurrent nerve zigzag pattern). The previously described techniques whereby this branch is dissected proximally as an interfascicular dissection permit the main course of the ulnar nerve to be trans-

posed anteriorly but leave this fascicle to either be caught in the muscular connections or to lay over the medial humeral epicondyle and do not permit the entire ulnar nerve to be transposed as a single structure. During the distal intermuscular dissection, a small proximal branch may be divided inadvertently. It should be remembered that the flexor carpi ulnaris is a two-headed muscle and that there are two wrist flexors in addition to the flexor carpi ulnaris. I have not had a single patient with weak wrist flexion as a postoperative problem.

The submuscular dissection is planned in a fashion to lengthen the flexor pronator fascia. A "Z" is outlined leaving a 1.5- to 2-cm attachment to the medial humeral epicondyle with the "back-cut" of the Z being along the fascia that is the superior border of the superficial head of the pronator teres (Fig. 1). The flexor pronator fascia at this juncture blends in with the lacertus fibrosis and the more proximal deep fascial layer of

the brachium (Fig. 1). Ultimately, this transposition of flexor pronator fascia will form a loose roof beneath which the ulnar nerve and the surgeon's finger will glide easily. During the division of the muscle bulk of the flexor pronator muscle mass, the thick common flexor tendon origin is encountered. This is frequently 1.5 cm in height and 2 to 3 mm in width. It is persistence of this structure which almost certainly causes the failure or recurrence of ulnar nerve compression in the anterior intramuscular transposition of the ulnar nerve. This persistence will limit excursion of the ulnar nerve and cause fibrosis of the ulnar nerve to the muscle. If an ulnar nerve is permitted to glide sufficiently postoperatively, placement either intermuscularly or submuscularly will not cause postoperative adherence of the nerve to muscle.²⁰ Thus, it is not the degree of muscle division, in and of itself, that is a cause of postoperative recurrence but rather the failure to release all structures that might inhibit postoperative gliding of the ulnar nerve. The common flexor tendon must not only be divided down to the capsule of the joint but must be released distally, allowing the common flexor tendon and the muscle that it primarily gives origin to, the flexor sublimis, to slide distally. The completed muscular division now comes to the flexor carpi ulnaris head, which also must be released to allow it to glide distally. This leaves the periosteal origin remaining just to the inside of the ulnar nerve. As the ulnar nerve is placed under slight traction medially and the flexor muscle mass laterally, this fibrous ridge comes into view and may be divided distally for 2 or 3 cm under direct vision. Once this is completed, the ulnar nerve transposes anteriorly.

The elbow now may be flexed and the skin elevated, and proximally the surgeon's finger may trace the course of the ulnar nerve. If it is still found to be tethered somewhat proximally, an additional release of the fascia from the medial head of the triceps may be performed, as well as additional proximal release of the medial intermuscular septum. Not uncommon in this region is a fibrous edge due to thickening in the fascia overlying the brachialis muscle. This must be incised directly. Occasionally, a thick vascular leash goes toward the skin that must be di-

vided as it will create a fulcrum over which the ulnar nerve will pass. Distally the ulnar nerve may be checked again, and any fibrous structures within the flexor pronator mass may be divided additionally. The flexor pronator fascia is now transposed and sutured together in direct vision with three horizontal mattress sutures of abraded nonabsorbable material, taking care, of course, not to include the ulnar nerve in the suture (Fig. 2). At completion, the surgeon's finger may easily slide beneath the muscle and the ulnar nerve.

The wound is closed with 4-0 absorbable intradermal sutures and continuous 5-0 nylon sutures to the skin and dressed with a nonadherent gauze over the incision, covered with gauze and soft roll. A plaster splint may be applied with the elbow left in approximately 60 degrees of flexion, or kling and stockinette may be applied without the Ace bandage. Because the closure of the flexor pronator muscle mass is performed with the elbow extended, extension of the elbow will not, in and of itself, tear out the sutures. However, it may be prudent to immobilize the patient's arm for 1 week for comfort in the postoperative period. An Ace wrap is then applied, and the tourniquet is let down. The Ace wrap should remain in place for approximately 45 minutes. Bupivacaine hydrochloride (Marcaine) is generally instilled (0.5% without epinephrine) into the wound before closure to also aid in the patient's comfort postoperatively. The arm is placed into a sling in the recovery room.

Internal Neurolysis

If the preoperative examination suggests the presence of axonal degeneration within the ulnar nerve, internal neurolysis may be indicated. Axonal degeneration, as described earlier, is indicated by abnormal two-point discrimination or muscle wasting. Persistent sensory symptoms in the ulnar nerve distribution suggest the presence of intraneural fibrosis. During the operative procedure when the ulnar nerve has been released completely, an inspection of the ulnar nerve may suggest that additional intraneural neurolysis is indicated. If a pseudoneuroma is identified or an area of

significant narrowing, for example, beneath an Osborne's band, is noted, these should be released, beginning with an incision in the thickened epineurium. The epineurotomy provides visualization of the extent of intraneural fibrosis. If a good fascicular pattern is seen, the fascicles are soft, and the bands of Fontana are clearly present, no additional intraneural dissection is indicated. At this level in the ulnar nerve, there is usually a significant degree of plexus formation. However, there is a great variability in the number of fascicles present. Most commonly, there will be three to five separate fascicles. In our experience, the presence of a greater number of fascicles is associated with less interfascicular plexus formation and a greater ability of the fascicles to slide among themselves in response to stress. In this situation, it is less likely to form a pseudoneuroma. Pseudoneuroma has usually been present when there are one or two large fascicles with marked plexus formation. In this situation, after the epineurium is incised, extreme care must be taken because additional extensive intraneural dissection may cause direct damage to intraneural plexus formation. Experimental studies related to the safety of intraneural neurolysis have recently been reviewed,³⁵ as well as the experience of surgeons performing internal neurolysis for median nerve compression at the wrist.³⁵ There has been no direct investigation of internal neurolysis with the ulnar nerve at the elbow. Internal neurolysis is believed to be helpful in severe ulnar nerve compression at the elbow based on the observation that the best results in treating recurrent ulnar nerve compression at the elbow were reported when an intraneural neurolysis was added to a submuscular transposition (Table 3).¹³

Postoperative Rehabilitation

The most common postoperative problem is bruising. Any increased swelling or discoloration proximal to the dressing or, of course, bleeding on the dressing must be treated urgently. Certainly, the dressing may be removed and the wound inspected directly. Over the course of 12 years, not one patient has returned to operation for bleed-

ing. However, two patients have had a hematoma requiring drainage carried out by opening sutures during the second or third day. Six patients over the course of the first to second week have had drainage of a resolving hematoma through the incision, with sutures still in place. Diffuse bruising is treated with topical heat and gentle massage. Once drainage has occurred, the patient is started on a regimen of oral antibiotics. Suture removal may be delayed up to the third week in this situation, and any drainage should be cultured and antibiotic coverage adjusted appropriately.

Wound infection, although theoretically possible, has not occurred. Patients suspected of having wound healing problems, such as those with diabetes or collagen vascular disease, or those on steroids are treated with intraoperative antibiotics before inflating the tourniquet and continue to receive oral antibiotics for 48 hours following surgery.

Usually the dressing is removed on the eighth postoperative day, and gentle flexion-extension of the elbow is begun (Table 4). The patient is told that he or she is expected to have the elbow completely extended between the third and fourth postoperative weeks. It should be recognized that 8 to 10 days of immobilization will not create significant fibrosis between the nerve and the surgical bed, because collagen deposition in response to wound healing is still minimal during this time. Increased range of motion beginning on the eighth or tenth postoperative day allows excursion of the nerve to prevent this degree of fibrosis. Maintaining the elbow in flexion beyond 2 weeks is not recommended. The patient is

Table 4. Ulnar Nerve Entrapment at the Elbow: Postoperative Rehabilitation

8-10 days	Immobilization in sling (+/- plaster dressing)
2-3 weeks	Moist heat to elbow twice daily Range of motion to elbow and wrist twice daily
3-6 weeks	Play Doh—gentle strengthening Sensory reeducation (desensitization)
6-9 weeks	Resume activities of daily living Topical steroid cream to scar Unrestricted exercises

encouraged to wear the sling for as long as 2 weeks, especially during sleeping, when inadvertent turning might cause a rapid extension of the elbow and some discomfort. Mobilization of the elbow is facilitated by application of moist heat by means of a wash cloth gently applied twice a day with subsequent massage and gentle attempts at extension: having the patient stand while holding the weight of a pocketbook or a soda bottle in the hand while observing television or some other means of distraction is often a helpful technique.

At approximately the third postoperative week, the patient is instructed to begin gentle exercises, such as squeezing *Play Doh* or exercise putty. This facilitates use of the intrinsic muscles and allows the extrinsic flexors to go through a full range of motion. Squeezing a rubber ball or a handheld grip is discouraged. The exercises are to be continued until the patient feels aching or discomfort in and about the region of the elbow. The patient is instructed not to "push through" the pain. The most common significant postoperative problem is pain in the elbow scar and in small branches in the region of the incision. Usually, the incised area will be adherent to the medial humeral condyle. The patient is given the explanation for this and is instructed to massage in a cortisone-containing cream twice a day for approximately 1 to 2 minutes, using a gentle rubbing pressure after first warming the area with a moist warm cloth. This type of discomfort, with some loss of sensation inferior or posterior to the incision, may be expected, and the patient should be informed of this (see brochures described previously on informed consent). This type of discomfort is to be distinguished from a true neuroma problem with the medial antebrachial cutaneous nerve. Use of the cortisone cream may be continued up to the third month postoperatively to minimize redness and thickening of the scar.

If between 6 and 12 weeks a significant painful area is identified in the scar with a significant area of loss of sensibility, a direct injury to the medial antebrachial cutaneous nerve may be considered. In this instance, an injection of dexamethasone into the dermis and subcutaneous tissue may facilitate mobilization of this skin from an underlying

presumed entrapped cutaneous nerve between the scar and the underlying bony structures. At the same time, a desensitization program can be carried out with the aid of the occupational or hand therapist.

A frequently encountered postoperative complaint is tingling in the forearm and shooting pains into the ring and fifth fingers. These are interpreted for the patient as being "regenerative" phenomena. The forearm may be palpated and tingling produced going out into the fingers. These areas are demonstrated to the patient as the sites of advancing regenerating axons and this sensation followed distally to the fingertip.

The patient is instructed that he or she will begin to recover good strength in the flexor muscles by 3 months and continuing into the intrinsic muscles, for example, pinch, for at least 1 year. Recovery from numbness and tingling can occur anywhere between 1 to 3 months, with improvement in two-point discrimination occurring for at least a year, although this may recover much sooner.

If the patient is a workmen's compensation case, the work limitations include prohibition against using vibrating tools and working with the arm extended above the shoulder level. Repetitive use of the elbow in flexion and extension may still be possible and can only be determined by a return to work trial or by the patient going through a work-hardening program.

ASSOCIATED MEDIAN NERVE ENTRAPMENT AT THE ELBOW LEVEL

Frequently, a patient may clinically and electrodiagnostically have median nerve compression at the wrist and ulnar nerve compression at the elbow. In this situation, it is difficult to identify an associated ulnar nerve compression at the wrist or an associated median nerve compression at the elbow. At the time of surgical treatment of the median nerve compression at the wrist, the ulnar nerve is decompressed in Guyon's canal for the "sake of completeness" and to relieve any potential for double crush entrapment along the course of the ulnar nerve. This same philosophy may be ap-

plied to the median nerve at the elbow, which implies that an attempt should be made to evaluate the median nerve at this level.

The technique for submuscular transposition described previously, in fact, carries out a release of three of the structures that commonly cause median nerve entrapment in the elbow and forearm region. An approach to median nerve compression at the elbow and forearm region would, at the minimum, require release of the lacertus fibrosis, the pronator teres sling, and the sublimis sling, commonly accomplished by dividing the deep head of the pronator teres at its origin and of the sublimis origin from the interosseous membrane if a separate, second arch should be found to exist.²¹ The "back-cut" required for the lengthening of the pronator fascia effectively releases the lacertus fibrosis from any compression on the median nerve. The lengthening by 1.5 to 2 cm of the superficial head of the pronator teres effectively releases one side of the yoke of the pronator arch over the median nerve. At the completion of the procedure for the ulnar nerve transposition, the surgeon's finger may be run down along the surface of the median nerve, and if an additional fibrous arch from the deep head of the pronator teres is found to be present, this may be divided under direct vision from this same surgical approach. The division of the common flexor tendon and its release from the capsule of the elbow joint, and its subsequent distal slide, release one portion of the sublimis yoke or arch. If the surgeon's finger, upon moving distally along the median nerve, encounters further deep arches compressing the median nerve, this distal level may require a second incision in the forearm because it is usually not possible to obtain sufficient visualization through the ulnar nerve incision to release this arch safely. The median nerve may be compressed by a high origin of the superficial head of the pronator teres, present in approximately 20% of cadaver dissections.¹¹ This would have been released during the initial take down of the flexor pronator mass. Clearly, in the mobilization of the ulnar nerve in an anterior direction, the presence of a supracondylar bony process and a ligament of Struthers^{45, 46} would be apparent and could be treated.

This structure has been encountered only once in my experience. In the case of a crush injury, the overlying fascia of the median nerve in this region is well visualized and easily incised. Thus, a neurolysis of the median nerve from the elbow to the proximal forearm can be carried out easily during this anterior submuscular transposition of the ulnar nerve and usually through the same incision.

IS A LESSER SURGICAL PROCEDURE EVER INDICATED?

This question of whether a lesser surgical procedure is indicated should not be asked because the surgeon is concerned about doing a procedure as extensive as a submuscular transposition. I prefer to think of the submuscular transposition, as described in this article as being "complete" rather than "extensive." Once this concept has been discarded, you may then ask if there is ever an indication when the patient's symptoms can be relieved without the necessity for submuscular transposition. It is clear from the review of the results of treatment (Table 3)¹³ that for a degree of minimal compression of the ulnar nerve at the elbow, good results may be obtained by simple surgical decompression of the type described by Osborne.⁴⁰ However, it must be realized that perhaps half of the patients with this degree of compression may be successfully treated without an operative procedure. A simple decompression fails to treat any underlying pathologic condition related to the elbow joint itself, such as arthritis; bone irregularities resulting from elbow trauma, such as dislocation or fracture; and congenital irregularities, such as a cubitus valgus "carrying" position. Simple decompression also fails to treat any underlying soft tissue problems, such as synovitis related to arthritis or gouty tophus deposition.

A specific example in which a simple decompression might be considered is that of a singular event causing compression, such as the patient awaking from anesthesia with an ulnar nerve problem.^{1, 26} Such a postoperative palsy should be followed expectantly with a baseline electrodiagnostic study and then physical examination, this study being

repeated at 6-week intervals with the realization that a simple apraxic condition will resolve spontaneously within that period of time. If the condition does not resolve, a simple decompression may be effective. A similar situation, which I have encountered three times, has been the appearance of an ulnar nerve loss subsequent to blood drawing with a complicating hematoma. With resolution of the hematoma but failure of resolution of the ulnar nerve symptomatology, a simple decompression has been effective when carried out between 6 and 12 weeks following the onset of symptoms. The theoretical advantage of a "lesser" surgical procedure is a shorter period required for postoperative rehabilitation. In each case in which a surgical decompression is offered to the patient, he or she should be made well aware that if symptoms fail to improve, a further procedure with submuscular transposition should be expected.

RECURRENT ULNAR NERVE ENTRAPMENT

Recurrent ulnar nerve entrapment has been reported in as many as one third of the patients who have had ulnar nerve entrapment treated by surgery (Tables 3 and 5).¹³ To best understand what will be encountered at operation, it has been helpful to conceptualize the recurrent ulnar nerve entrapment in what I have termed the "zigzag pattern" (Fig. 3). In the complete zigzag pattern, the ulnar nerve will be found from proximal to distal to travel from inferior to

the intermuscular septum to across the intermuscular septum to above the medial humeral epicondyle. At this point, the nerve will usually undergo a 90-degree turn coming across the distal edge of the medial humeral epicondyle if a submuscular or intermuscular transposition has occurred or across the sling that has been fashioned for a subcutaneous transposition. The ulnar nerve then will come to lay inferior to the medial humeral epicondyle where it will then undergo another angulation to proceed in its distal course. Clinically, a Tinel's sign may be present above, or below the medial humeral epicondyle or both. A Tinel's sign may be present directly across and superficial to the medial humeral epicondyle. The Tinel signs roughly correspond to sites of entrapment. The most common causes for these entrapments at the proximal level are

failure to release the fascia from the medial head of the triceps (termed in the past an "arcade of Struthers")

an impingement of the ulnar nerve against an underlying remnant of the medial intermuscular septum (or one of the other fascial or vascular structures in this region described earlier)

an impingement between a fascial sling and the medial humeral epicondyle if a subcutaneous transposition has occurred

an impingement between the flexor pronator fascia and the underlying common flexor tendon if an intermuscular transposition has occurred

an adherence between the anatomically reconstructed flexor pronator fascia and the ulnar nerve against the underlying connective tissues of the elbow capsule

a tethering proximally by the nerve to the flexor carpi ulnaris causing adherence of the ulnar nerve to the medial humeral epicondyle

or, finally, an impingement of the ulnar nerve against the periosteal origins of the flexor carpi ulnaris.

The approach to the treatment of recurrent ulnar nerve entrapment at the elbow should begin with a detailed clinical examination carefully documenting the extent of the sensory and motor loss. If pain is a significant contribution to the patient's symptoms, it

Table 5. *Recurrent Ulnar Nerve Compression: Anatomic Mechanisms*

Medial intermuscular septum	Incomplete excision
Fascia: triceps to MIS*	Incomplete release
Motor branch to FCU†	Proximal tethering
Periosteal origin of FCU	Incomplete release
Brachialis fascia	Not released
Fabricated sling tightness	Subcutaneous transposition
Common flexor tendon	Intramuscular transposition
Medial humeral epicondyle	Medial epicondylectomy
Elbow joint	Simple decompression
Medial head of triceps	Proximal kinking
High pronator teres origin	Proximal kinking

* MIS = medial intermuscular septum. There is no "arcade of Struthers."

† FCU = flexor carpi ulnaris.

must be ascertained whether this is from chronic ulnar nerve problems or from an associated adherence of a neuroma of the medial antebrachial cutaneous nerve to the underlying ulnar nerve. Palpation of the painful area may not cause transmission of the pain into the little finger but rather into the proximal posterior forearm. In this case, preoperative block of the medial antebrachial cutaneous nerve proximal to the antecubital crease and anterior to the location of the ulnar nerve should give relief of pain without causing loss of sensation in the fifth finger, allowing the surgeon to plan intraoperatively and to prepare the patient preoperatively for a resection of a neuroma of the medial antebrachial cutaneous nerve (see next section). Preoperative electrodiagnostic testing may be useful as a baseline study, although if the test is not performed by the same person who carried out the testing before the first surgical procedure (if one was done), there will be problems in interpreting the new study.²³ However, it is usually advisable to carry out an electrodiagnostic examination before the surgical treatment of a recurrent ulnar nerve problem.

At operation, lengthening the previous incision may not be necessary. Frequently, patients with extremely poor postoperative results will have incredibly long incisions from their first surgical procedure. The length of the incision is frequently an inverse relationship to the degree of success of the first surgical procedure. When the incision is reopened, a search for the medial antebrachial cutaneous nerve should be carried out. If the pain in the incision is proximal, injury may have occurred to the medial brachial cutaneous nerve. The ulnar nerve should be identified in the proximal aspect of the wound in previously nonoperated areas and encircled with a vessel loop. The dissection may then proceed distally, bearing in mind each of the structures described previously that may play a role in the zigzag pattern. At the transposition points where the angulation and zigzag pattern occur, great care must be taken not to injure the ulnar nerve directly (Fig. 4). It may be valuable to identify the ulnar nerve distally and to proceed in both a distal and proximal direction through the significantly scarred regions. A particularly difficult surgical area is

the most distal aspect where the ulnar nerve reenters the flexor carpi ulnaris. The nerve in this region must be identified with extreme care so as not to injure the branches to the flexor digitorum profundus. It may be necessary to divide a proximal branch to the flexor carpi ulnaris to release the ulnar nerve from bone. If a submuscular transposition has not been carried out previously, appropriate flexor pronator fascial flaps should be created to permit the lengthening-type procedure described earlier. If a previous submuscular transposition was carried out, the scarring within the reconstructed flexor pronator muscle mass must still be divided in such a way as to permit a lengthening of the flexor pronator muscle mass. If the flexor pronator muscle mass has been elevated initially with a portion of the medial humeral epicondyle, inspection should be planned so as to anticipate whether the nerve may be stuck down in callous formation. If a previous medial epicondylectomy procedure has been carried out, the ulnar nerve must be expected to be adherent to periosteum or to be involved in some new bone formation or to be adjacent to some irregularity accompanying the initial bone resection.

It is not recommended that the externally neurolysed ulnar nerve be ensheathed in any membrane, such as Silastic, to prevent its readherence.³⁹ Previous recommendations to this effect^{4, 6} have been published. However, Silastic may serve to further ensheath the ulnar nerve and cause further compression.³⁹ Simply placing the ulnar nerve into the new submuscular position, and eliminating any future sites of impingement, and allowing full range of motion in the postoperative period will be sufficient to prevent adherence. If the patient appears to have some predisposition for extensive scar formation, dexamethasone could be placed along the course of the ulnar nerve, although I have not done this.

In two of my cases, I have worsened the patient's condition by operating upon a recurrent ulnar nerve entrapment. In one patient, it was the second and in another, the third reoperation. Each patient was older than 60 years and had undergone prior internal neurolysis. In the postoperative period, the ulnar nerve appeared to have been infarcted, and over a period of 2 years, some sensation slowly recovered. One patient still

has significant pain. Accordingly, internal neurolysis in recurrent ulnar nerve entrapment procedures should be used with caution in patients older than age 60 years. However, in younger patients and at a second operation, if a significant area of fibrosis is encountered and, depending upon the preoperative physical examination of the patient, an internal neurolysis is believed to be indicated intraoperatively, it should be performed carefully as described earlier. Because of the scarring encountered and the large subcutaneous plane developed surgically, postoperative bleeding is more likely. Accordingly, placement of a Penrose drain in the wound is recommended.

NEUROMA OF THE MEDIAL ANTEBRACHIAL CUTANEOUS NERVE

Neuroma of the medial antebrachial cutaneous nerve should be diagnosed preoperatively, as already indicated, by demonstration of a loss of sensation in the distribution of the nerve and of a painful area discretely localized, palpation of which causes pain to radiate into the anesthetic area, where pain can be relieved by preoperative block with local anesthetic.¹⁹ The preferred treatment is to resect the neuroma and to place the end of the medial antebrachial cutaneous nerve into a site in which it cannot regenerate into the denervated skin of the antecubital region. This may be accomplished by cutting the nerve sufficiently back, recognizing that this may be associated with a 50% recurrence rate of the neuroma, or preferably, by implanting the nerve into a muscle. I prefer to use the triceps muscle. The medial antebrachial cutaneous nerve is dissected proximally, and sparing of the anterior branch is usually possible with an interfascicular dissection. The posterior branch of the medial antebrachial cutaneous nerve, which is usually the branch involved with a neuroma, is brought between the ulnar nerve and the triceps muscle and implanted into the triceps muscle with the elbow taken through a full range of flexion and extension to ensure that the nerve is not placed under any tension. The nerve is sutured with a 6-0 nylon suture through the epineurium into the muscle to prevent the muscle from pulling out.

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