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Outcomes of ulnar nerve anterior transmuscular transposition and significance of ulnar nerve instability in cubital tunnel syndrome

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Background: We investigated the experience of a single surgeon with ulnar nerve anterior transmuscular transposition with the patient in the lateral decubitus position for cubital tunnel syndrome.
Methods: The medical records of all patients who underwent primary or revision ulnar nerve anterior transmuscular transposition were screened to define a cohort of 156 patients (162 limbs) for further study of demographic and disease-specific data and retrospective assessment of short-term outcomes. Ulnar neuropathy severity was stratified by McGowan grade. A prospective cohort composed of 49 patients (51 limbs) with a minimum 2-year follow-up volunteered to complete patient outcome surveys, and some presented for an ulnar nerve–focused examination to assess long-term outcomes.
Results: The overall patient satisfaction rate was 92%, with statistically significant improvements in ulnar sensation and intrinsic strength at short- and long-term follow-up. Outcomes were better for lower McGowan grades than for higher grades and better in primary cases than in revision cases. Ulnar nerve instability was observed in 69 of 162 cases (43%) in this series. A major complication occurred in 7 cases (4.3%), but all were mitigated by contributory patient-related factors. Reoperation for recurrent ulnar paresthesia was required in 4 cases (2.5%). No operations or outcomes were compromised by the lateral decubitus position.
Discussion and conclusion: Ulnar nerve anterior transmuscular transposition in the lateral decubitus position is a good surgical option for primary or recurrent cubital tunnel syndrome and remains our preferred procedure. The high prevalence of ulnar nerve instability observed in this study is a factor worthy of consideration by surgeons and patients weighing the surgical options for ulnar neuropathy at the elbow.
Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Elbow; cubital tunnel syndrome; lateral decubitus position; surgical outcome; ulnar nerve; anterior transmuscular transposition

Ulnar nerve entrapment or subluxation at the elbow is often encountered during upper-extremity evaluations. The diagnosis is primarily based on clinical findings,[7,10,29,50,52] and electrodiagnostic testing may or may not be confirmatory.[29,61]

This research study was approved by the University of Kansas School of Medicine (Wichita) Institutional Review Board (STUDY00002249).

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Although conservative treatment including night splinting and activity modification may be effective for mild disease,[55,59] progressive symptoms often warrant operative treatment. The well-described surgical options[6] consist of simple or in situ ulnar nerve decompression without or with partial medial epicondylectomy or ulnar nerve anterior transposition, broadly subclassified as subcutaneous or submuscular. Recently, endoscopic and other minimally invasive techniques have been popularized,[13,34,45] permitting simple decompression to be accomplished through a smaller incision.

In its native posterior position in the retrocondylar groove, the ulnar nerve is subject not only to compression forces at multiple sites but also to traction forces that increase intraneural pressure[22] and potentially compromise nerve microcirculation as the elbow is flexed.[39] The original anterior submuscular transposition technique described by Learmonth[36] was intended to reposition the nerve in an intermuscular plane, thereby relieving both compression and traction forces. In 1988, Dellon[15] modified the technique by incorporating musculofascial lengthening of the flexor-pronator origin so that the nerve would not be subject to new points of compression in its submuscular position.[14] Later cadaveric experiments performed to compare the mechanical effects of different surgical techniques for cubital tunnel syndrome showed that ulnar nerve anterior submuscular transposition with musculofascial lengthening was the only technique that consistently reduced intraneural pressure.[16] More recently, Mackinnon has popularized this anterior transposition as the "transmuscular" approach,[38] terminology that has now been widely accepted[41] and that will be used in this report.

The purpose of this study was to assess the outcomes of patients treated with ulnar nerve anterior transmuscular transposition for ulnar nerve entrapment or subluxation at the elbow by the senior author. The study goals were to quantify improvement in ulnar paresthesia, sensation, and intrinsic strength; to measure overall patient satisfaction with the operative result; and to enumerate postoperative complications including recurrent ulnar paresthesia and the need for reoperation. Particular attention was directed to assessment of ulnar nerve subluxation before and after surgery to clarify the role of ulnar nerve instability in cubital tunnel syndrome.

Materials and methods

This was a single-surgeon outcome study of ulnar nerve transposition for cubital tunnel syndrome. Consecutive patients with ulnar nerve entrapment or subluxation at the elbow (designated by *International Classification of Diseases, Ninth Revision* code 354.2 or *International Classification of Diseases, Tenth Revision* code G56.2x) treated surgically with anterior transmuscular transposition (specified as Current Procedural Terminology code 64718) from February 2000 through January 2017 were identified. The study start date coincided with the senior author adopting ulnar nerve anterior transmuscular transposition with the patient in the lateral decubitus position as his treatment of choice for primary or recurrent cubital tunnel syndrome. Procedures were performed with patients under general anesthesia. The lateral decubitus position (Fig. 1) was chosen because, in our experience, this position permitted a better view of the neuroanatomy including the intraneural and extraneural blood supply than with patients in the supine position. Details of the surgical indications, preoperative positioning, and operative technique are presented elsewhere.[25]

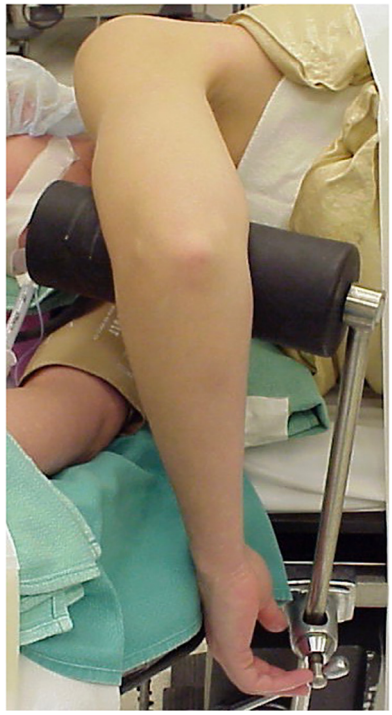

Figure 1 Lateral decubitus position with arm supported.

The medical records of patients identified in the screening process were perused to ascertain medical and surgical histories and to confirm the ulnar nerve procedure and concomitant procedures. Eligibility criteria were applied to enhance the likelihood of unambiguous surgical outcomes and to establish the short-term study group. Patients excluded from further study underwent prior surgical procedures (other than ulnar nerve procedures) on the affected elbow or had pre-existing elbow arthropathy, elbow contractures, or any other secondary diagnosis, such as carpal tunnel syndrome, for which they were treated in the same operative setting.

The written or electronic records of all included patients were systematically reviewed, with a focus on preoperative ulnar sensory loss, motor weakness, and intrinsic atrophy. Ulnar neuropathy severity was determined using the McGowan classification.[44] Ulnar nerve subluxation with elbow flexion was defined as the nerve perching on the medial epicondyle or grossly dislocating over the medial epicondyle.[9] Operative reports provided the anatomic findings at surgery including the location of nerve entrapment. Postoperative encounters were scrutinized to complete the retrospective assessment of short-term surgical outcomes. Ulnar paresthesia was judged to have completely or partially resolved based on review of these clinical data. Symptomatic recurrence was defined as worsening of the ulnar paresthesia after an initial period of postoperative improvement.

Longer-term outcomes were assessed prospectively by enrolling patient volunteers in a research protocol approved by the University of Kansas School of Medicine (Wichita) Institutional Review Board. Informed consent was obtained from all subjects,

and they were not incentivized for their participation. The long-term study group was limited to patients who underwent surgery from January 2004 through December 2015. This period of interest was defined to ensure a reasonable likelihood of contacting patients for the study and a minimum 2-year postsurgical follow-up.

Questionnaires including the Levine-Katz survey[37] were administered to subjects by phone or in the office to assess long-term relief of ulnar symptoms and satisfaction with the procedure. Objective data were derived from an ulnar nerve–focused examination of subjects who returned for long-term follow-up. Ulnar motor strength was assessed manually by resisted finger abduction using the British Medical Research Council grading scale (M0-M5).[30] Static 2-point discrimination at the tip of the small finger was measured with the DeMayo Two Point Discrimination Device (PM-855, Padgett Instruments, Kansas City, MO, USA) to assess ulnar sensation.[18] Grip strength and pinch strength were measured with a Jamar dynamometer and pinch gauge (Model 0030J4, Therapeutic Equipment Corporation, Clifton, NJ, USA).

The χ^2 test was used to analyze categorical variables. The nonparametric Wilcoxon paired-replicate signed rank test for a 2-tailed event was used to determine the significance of postoperative clinical trends. The 95% confidence level ($P < .05$) was chosen as the level of statistical significance.

Results

During the study period, 208 consecutive ulnar nerve procedures were performed by the senior author. Application of the eligibility criteria resulted in 46 cases being excluded, 10 because of prior surgical procedures on the affected side, 9 because of underlying elbow arthropathy and/or elbow contracture release, and 27 because of concomitant open carpal tunnel release. Hence, 162 cases were studied to determine short-term outcomes (Fig. 2). Primary transpositions accounted for 83% of cases in this series.

The demographic characteristics of the cohorts (Table I) showed that 3 patients in each group underwent the procedure on both sides at separate times. Overall, 57 of 162 cases (35%) were workers' compensation cases, and 80 of 156 patients (51%) were present or former tobacco users. Patients

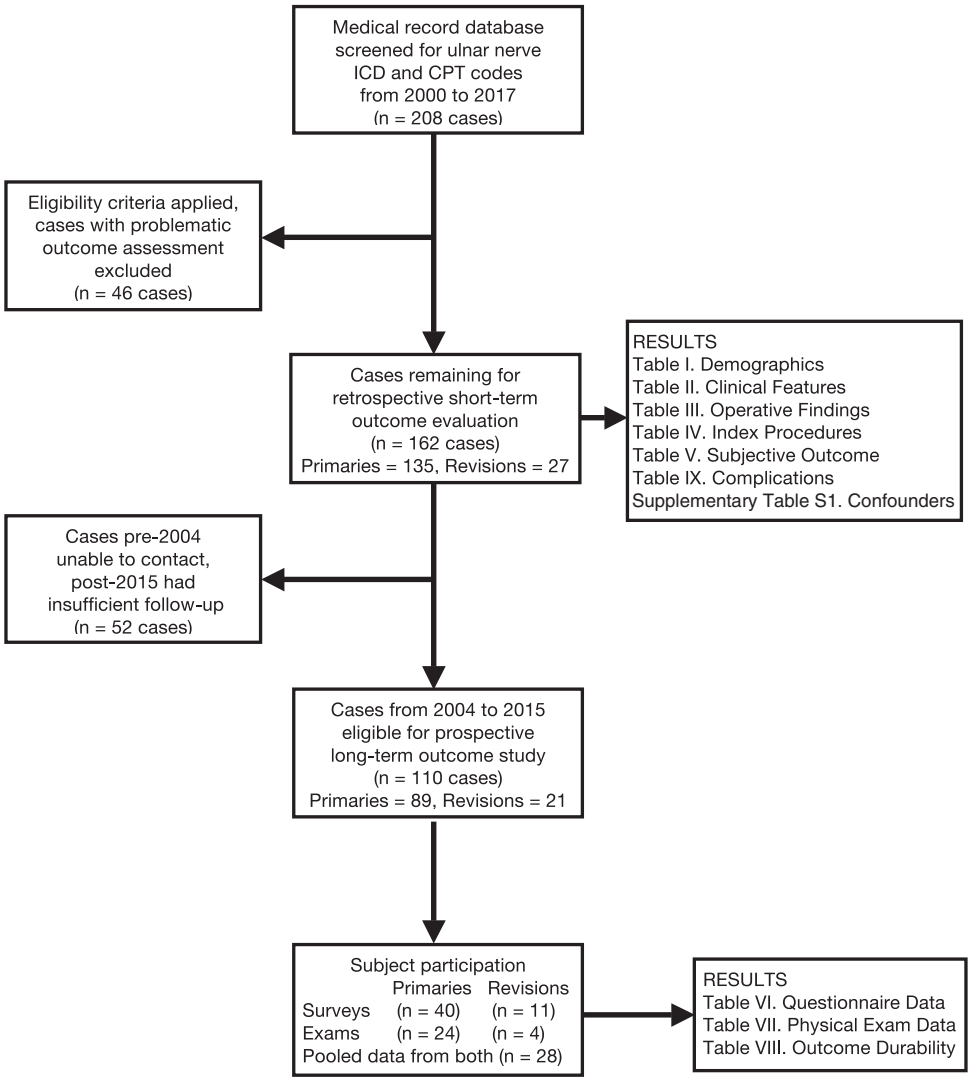

Figure 2 Schematic flowchart defining study cohorts. *ICD*, *International Classification of Diseases*; *CPT*, Current Procedural Terminology.

Table I Patient demographic characteristics

	Primary (n = 135)	Revision (n = 27)	All cases (n = 162)
No. of patients	132	24	156
Female sex*	51 (39%)	15 (63%)	66 (42%)
Age, yr	47.6 (15-84)	42.2 (20-63)	46.8 (15-84)
Right side operated†	68 (50%)	14 (52%)	82 (51%)
Workers' compensation claim†	45 (33%)	12 (44%)	57 (35%)
Comorbidities*			
Tobacco use	50 (38%)	13 (54%)	63 (40%)
Former tobacco use	16 (12%)	1 (4%)	17 (11%)
Diabetes mellitus	5 (4%)	3 (13%)	8 (5%)
Rheumatoid or immunosuppressed patient	4 (3%)	0	4 (3%)

Parameter values are presented as count (percentage of total) or mean (range).
* Percentages based on number of patients.
† Percentages based on number of cases.

Table II Clinical features

	Primary (n = 135)	Revision (n = 27)	All cases (n = 162)
Preoperative symptoms			
Ulnar paresthesia	130 (96%)	25 (93%)	155 (96%)
Duration of ulnar paresthesia, mo	13.4 (1-180)	16.7 (1-120)	14.0 (1-180)
Constant ulnar numbness	72 (53%)	5 (19%)	77 (48%)
Duration of constant numbness, mo	5.9 (1-36)	11.8 (3-22)	6.9 (1-36)
Medial epicondylosis	22 (16%)	2 (7%)	24 (15%)
Physical examination findings			
Ulnar nerve percussion test	51 (38%)	15 (56%)	66 (41%)
Ulnar subluxation or instability	55 (41%)	14 (52%)	69 (43%)
Preoperative McGowan grade			
I (mild)	45 (33%)	16 (59%)	61 (38%)
II (moderate)	58 (43%)	9 (33%)	67 (41%)
III (severe)	32 (24%)	2 (8%)	34 (21%)
Electrodiagnostic tests*			
Decreased ulnar motor conduction	90 of 116 (78%)	7 of 15 (47%)	97 of 131 (74%)
Ulnar denervation potentials	21 of 66 (32%)	3 of 4 (75%)	24 of 70 (34%)

Parameter values are presented as count (percentage of total) or mean (range).
* Electromyography and/or nerve conduction studies were not available for all patients.

in the primary group were, on average, older than those in the revision group.

Nearly all patients in both groups had preoperative ulnar paresthesia for a mean duration of 14 months (Table II). The ulnar nerve percussion test was positive at the retrocondylar groove in the primary group and at the medial epicondyle (where the previously operated nerve was located) in most revision cases. Notably, ulnar nerve subluxation or instability with elbow flexion was found in 69 of 162 cases (43%) in this series. All patients underwent or were offered nonoperative treatment, but those with advanced disease underwent expeditious surgical treatment.

Operative findings

In the primary cohort, the most common site of ulnar nerve entrapment was at the cubital tunnel retinaculum or Osborne's ligament, which occurred in 62% of cases (Table III). In 7%, the nerve was compressed by an anconeus epitrochlearis. Some patients had more than 1 site of nerve compression. In the revision cohort, the average time between index and revision procedures was 4.2 years. In 15 of 27 cases, the interval between procedures was about 2 years or less, but in the remaining 12 cases, the interval ranged from 3 to 14.2 years and spontaneous recurrence of paresthesia was common. Operative findings in the revision cohort typically included perineural scar at the medial epicondyle.

Eighty-five percent of index procedures associated with these revisions were either ulnar nerve in situ decompressions or subcutaneous transpositions (Table IV). In 1996, the senior author performed one of the index procedures, but all others were referred from outside our practice. Preoperative ulnar nerve instability was appreciated in 14 of 27 revisions (8 simple decompressions, 5 subcutaneous transpositions, and 1 medial epicondylectomy). No primary or revision procedure was compromised by having the patient in the lateral decubitus position.

Table III Operative findings

	Primary (n = 135)	Revision (n = 27)
Time between index and revision, yr	—	4.2 (0.8-14.2)
Ulnar nerve entrapment location*		
Cubital tunnel retinaculum	84 (62%)	—
Anconeus epitrochlearis	9 (7%)	—
Leading-edge FCU fascia	16 (12%)	—
Osborne fascia	23 (17%)	—
Medial epicondyle	12 (9%)	8 (30%)
No compression point identified	18 (13%)	6 (22%)
Medial intermuscular septum	1 (1%)	1 (4%)
Perineural scar	—	14 (52%)
Nerve kinked at FCU entry	—	2 (7%)
Tourniquet time, min	63.0 (33-100)	71.7 (39-129)

FCU, flexor carpi ulnaris.
Parameter values are presented as count (percentage of total) or mean (range).
* Some patients had more than 1 point of nerve entrapment.

Table IV Index procedures associated with revision cases

	No. of cases (n = 27) (%)	Nerves unstable at epicondyle (%)	Tourniquet time, min*
Open in situ decompression	12 (44)	8 (30)	54.8 (39-99)
All other index procedures	15 (56)	6 (22)	85.2 (45-129)
Medial epicondylectomy	2 (7)	1 (4)	—
Subcutaneous transposition	11 (41)	5 (19)	—
Submuscular transposition	1 (4)	0	—
Transmuscular transposition	1 (4)	0	—

Parameter values are presented as count (percentage of total) or mean (range).
* The tourniquet time difference was statistically significant by the χ^2 test ($P = .003$).

Clinical outcomes

At short-term follow-up, preoperative ulnar paresthesia improved in 88% of patients in the primary cohort and 78% in the revision cohort (Table V). As expected, those with mild neuropathy, that is, McGowan grade I neuropathy, were more likely to improve subjectively than those with ulnar motor weakness (grade II) or intrinsic atrophy (grade III). This was true for both the primary and revision subgroups. However, only 30% of patients in the primary group and 26% of those in the revision group had complete relief of the preoperative ulnar paresthesia at short-term follow-up.

Between January 2004 and December 2015, 105 patients were operated on and were thus eligible for long-term follow-up (Fig. 2). Of 87 patients in the primary group, 40 completed the study questionnaire, for a participation rate of 46%. They provided data on 40 procedures at a mean follow-up of 4.6 years (Table VI). Although 88% indicated long-term improvement in ulnar paresthesia, only 38% claimed complete resolution of symptoms. Subject responses on the Levine-Katz survey, although indicating favorable symptom severity and functional status scores, confirmed that about half had residual ulnar paresthesia and weakness with fine motor activities. Nevertheless, overall satisfaction was high, with 90% stating they would undergo the same operation again. In the revision group, 9 of 18 patients completed study surveys, for a participation rate of 50%. They provided data on 11 procedures at a mean long-term follow-up of 8.2 years. All subjects had long-term improvement in ulnar paresthesia, and all would consent to the same operation for similar symptoms despite residual ulnar motor or sensory symptoms in most. No patient in either cohort was worse postoperatively or required reoperation.

Twenty-four subjects in the primary group returned for follow-up examination (Table VII). The ulnar nerve was found to be in a stable position anterior to the medial epicondyle in all subjects. However, some had nerve sensitivity, and 3 had new evidence of first dorsal interosseous atrophy not appreciated preoperatively. In the revision group, only 3 subjects were available for follow-up examination, providing data on 4 procedures. The subject who underwent revisions on both sides reported mild bilateral ulnar paresthesia insufficient to warrant further surgery.

Pooled data from both the primary and revision groups were analyzed to determine whether short-term outcomes were durable in the long term (Table VIII). Short- and long-term parameters were compared with preoperative values by the Wilcoxon test to establish statistical significance of data trends. Ulnar sensation was assessed by an ulnar paresthesia severity score on a numerical rating scale (0-10) and by small-finger static 2-point discrimination. Measures were moderately improved at short-term follow-up and markedly improved at long-term follow-up. These results are consistent with our clinical experience and understanding that axonal regeneration in high-grade entrapments may lead to long-term ulnar sensory improvement not present at short-term follow-up. Resisted finger abduction on the British Medical Research Council (M0-M5) grading scale, used as a proxy for ulnar motor strength, was improved at short-term follow-up, and this improvement was maintained long term. On the Bishop rating scale,[33] outcomes were stratified as follows: excellent, 21; good, 6; and fair, 1.

Table V Short-term subjective outcome for ulnar paresthesia*

	Primary (n = 135)	Revision (n = 27)	All cases (n = 162)
Short-term follow-up duration, weeks	13.6 (1-64)	18.3 (3-63)	14.4 (1-64)
Preoperative ulnar paresthesia			
Paresthesia improved	119 (88%)	21 (78%)	140 (86%)
Paresthesia resolved	40 (30%)	7 (26%)	47 (29%)
Improvement by McGowan grade			
I (mild)	44 of 45 (98%)	15 of 16 (94%)	59 of 61 (97%)
II (moderate)	50 of 58 (86%)	5 of 9 (56%)	55 of 67 (82%)
III (severe)	25 of 32 (78%)	1 of 2 (50%)	26 of 34 (76%)

Parameter values are presented as count (percentage of total) or mean (range).
* Data based on inquiry at final short-term in-office evaluation.

Table VI Long-term outcomes based on questionnaire data

	Primary (n = 40)	Revision (n = 11)	All cases (n = 51)
Long-term follow-up duration, yr	4.6 (2-10.5)	8.2 (5.7-11.2)	5.4 (2-11.2)
Demographic characteristics			
No. of subjects	40	9	49
Female sex*	15 (38%)	8 (89%)	23 (47%)
Age, yr	49.2 (15-79)	41.7 (27-56)	47.6 (15-79)
Patient satisfaction*			
Would undergo same operation again	36 (90%)	9 (100%)	45 (92%)
Would recommend operation	36 (90%)	9 (100%)	45 (92%)
Preoperative ulnar paresthesia†			
Paresthesia improved	35 (88%)	11 (100%)	46 (90%)
Paresthesia resolved	15 (38%)	3 (27%)	18 (35%)
Levine-Katz questionnaire†			
Symptom severity scale	1.53 ± 0.66	2.05 ± 0.96	1.65 ± 0.76
Functional status scale	1.39 ± 0.75	1.99 ± 1.08	1.52 ± 0.85
No ulnar paresthesia‡	18 (45%)	3 (27%)	21 (41%)
No ulnar motor weakness§	22 (55%)	6 (55%)	28 (55%)
Reoperation for paresthesia	0	0	0

Parameter values are presented as count (percentage of total), mean (range), or mean ± standard deviation.
* Percentages based on number of patients.
† Percentages based on number of cases.
‡ No daytime numbness, tingling, or nocturnal paresthesia.
§ No difficulty buttoning clothes, turning keys, or picking up a dime.

Complications

Minor complications in this series occurred in 24 cases (Table IX). Most were seromas or ecchymoses despite meticulous intraoperative hemostasis and closed drainage of the wound for a minimum of 3 days. The seromas resolved using compression with or without needle aspiration. Six patients had recurrent ulnar paresthesia, but recurrence in 3 was attributed to trauma or repetitive overuse during early recovery. None of those with minor complications required further operative treatment.

Major complications requiring a second operation occurred in 7 cases (4.3%), but all were mitigated by contributing factors such as significant comorbidity, elbow trauma soon after surgery, workers' compensation status, or noncompliance with postoperative instructions (Supplementary Table S1). Three patients (4 limbs) experienced moderately severe recurrent ulnar paresthesia requiring reoperation and external ulnar neurolysis. All 6 patients with major complications (7 limbs) symptomatically improved after the secondary intervention. In this series, reoperation for symptom recurrence was needed in 4 cases (2.5%).

Discussion

At mean 5.4-year follow-up, patients with ulnar nerve entrapment or subluxation at the elbow treated by ulnar nerve anterior transmuscular transposition in the lateral decubitus position showed statistically significant improvement in key outcome measures of ulnar paresthesia, ulnar sensation, and intrinsic strength. This was true for both primary and revision ulnar nerve transpositions. By our measures, outcomes after primary procedures were better than those after revision cases. Overall, 92% of patients studied were satisfied with the surgical outcome and would recommend the operation. These results compare favorably with outcomes when the

Table VII Long-term outcomes based on physical examination data

	Primary (n = 24)	Revision (n = 4)	All cases (n = 28)
Long-term follow-up duration, yr	4.4 (2-7.4)	8.1 (5.8-10.6)	5.0 (2-10.6)
Demographic characteristics			
No. of subjects	24	3	27
Female sex*	8 (33%)	3 (100%)	11 (41%)
Age, yr	50.1 (18-79)	31.1 (27-37)	47.4 (18-79)
Physical examination findings†			
Scar hyperesthesia	3 (13%)	2 (50%)	5 (18%)
Ulnar nerve percussion test	6 (25%)	2 (50%)	8 (29%)
Ulnar nerve subluxation	0	0	0
Intrinsic atrophy	6 (25%)‡	1 (25%)	7 (25%)
Elbow flexion contracture	0	0	0

Parameter values are presented as count (percentage of total) or mean (range).
* Percentages based on number of patients.
† Percentages based on number of cases.
‡ Three patients had atrophy preoperatively.

Table VIII Subjective and objective outcome durability

	Ulnar paresthesia severity*: NRS score (n = 51)	Ulnar sensation†: static 2PD, mm (n = 28)	Ulnar motor strength‡: BMRC grade (n = 28)
Preoperative	8.16 ± 1.96	7.39 ± 3.52	4.65 ± 0.41
Short-term postoperative	4.94 ± 2.95	6.36 ± 2.43	4.93 ± 0.15
% change vs preoperative	39.5% ($P < .001$)	13.9% ($P = .126$)	6.0% ($P = .002$)
Long-term postoperative	2.55 ± 3.01	5.71 ± 1.65	4.88 ± 0.22
% change vs preoperative	68.8% ($P < .001$)	22.7% ($P = .043$)	4.9% ($P = .005$)

NRS, numerical rating scale; *2PD*, 2-point discrimination; *BMRC*, British Medical Research Council.
Parameter values are presented as mean (± standard deviation) derived from data combining both primary and revision cases. For improvement in parameter means, $P < .05$ was deemed statistically significant by the 2-tailed Wilcoxon test.
* Ulnar paresthesia severity on NRS, in which 0 indicates no symptoms and 10 indicates constant paresthesia.
† Static 2PD of the small finger is an indicator of ulnar sensation.
‡ Resisted finger abduction is an indicator of ulnar motor strength on the BMRC (M0-M5) grading scale.

Table IX Surgical complications

	Primary (n = 135) (%)	Revision (n = 27) (%)	All cases (n = 162) (%)
Minor complications*	21 (15.5)	3 (11.1)	24 (14.8)
Seroma	9	1	10
Ecchymosis	4	—	4
Scar hypertrophy	2	—	2
Superficial wound infection	2	—	2
Mild recurrent ulnar paresthesia	4	2	6
Major complications†	6 (4.5)	1 (3.7)	7 (4.3)
Wound dehiscence	1	—	1
Deep wound infection	2	—	2
Recurrent ulnar paresthesia	3	1	4
All complications	27 (20.0)	4 (14.8)	31 (19.1)

Parameter values are presented as count (percentage of total).
* Minor complications were treated nonoperatively.
† Major complications required operative treatment.

transmuscular transposition was performed with patients in the standard supine position.[17,49,51,53]

Despite the high satisfaction rate with our procedure and clinical evidence of improvement, many subjects in our study reported residual ulnar paresthesia and diminished though improved ulnar intrinsic strength. Similar outcomes of ulnar nerve anterior transmuscular transposition and of other operative techniques for cubital tunnel syndrome have been reported. In 1 study, 119 patient-reported outcomes of ulnar nerve anterior transmuscular transposition indicated subjective improvement in 77% of patients but normal sensation in only 43% and normal strength in just 38%.[51] Bartels et al[3] found that 46 of 77 study participants (60%) who underwent anterior subcutaneous transposition and only 36 of 75 (48%) who underwent simple decompression were completely free of ulnar symptoms at 1-year follow-up. Gaspar et al[21] noted that after in situ ulnar nerve decompression, 50% of patients were still symptomatic, although a majority, 62%, had improved by at least 1 McGowan grade. Other studies confirmed that residual postoperative ulnar symptoms and signs are common regardless of surgical technique.[40,47,56]

In this study, 51% of patients were present or former tobacco users. A high prevalence of smoking among

patients with cubital tunnel syndrome has been previously observed.[35,51] One recent study found that the difference in mean pack-years smoked between a cubital tunnel syndrome cohort and matched controls was statistically significant.[58] Collective evidence suggests that tobacco use is a risk factor for ulnar neuropathy at the elbow.

Our study found a 43% incidence of preoperative ulnar nerve subluxation, which was symptomatic and considered a strong operative indication. No surgery was indicated for asymptomatic nerve hypermobility. Calfee et al[9] found hypermobile ulnar nerves in 37% of elbows in a random population, and Henn et al[26] documented that 45% of 67 young patients who underwent cubital tunnel surgery had ulnar nerve subluxation. Taken together, these data suggest that the true prevalence of ulnar nerve subluxation based on preoperative examination, particularly in cohorts with ulnar neuropathy, may be higher than the 6%-29% range previously reported.[2,3,5,11,44] Although some surgeons have tried to quantify ulnar nerve instability,[9,11,60] the assessment of subluxation for most surgeons remains subjective,[43] thereby explaining the wide variation in prevalence cited in the literature.

The presence or absence of ulnar nerve subluxation preoperatively and intraoperatively is a significant factor in considering the surgical options for cubital tunnel syndrome. Some surgeons believe that preoperative ulnar nerve subluxation is a relative contraindication to simple decompression,[13,21,54] whereas others do not.[3] Some who prefer in situ decompression now convert the procedure to an anterior transposition if there is intraoperative evidence of nerve instability after simple decompression.[31,32,43] Investigators in 1 study found that 21% of 363 patients with ulnar neuropathy had ulnar nerve instability, and notably, in 12% of the cohort, the instability was determined intraoperatively during a planned in situ decompression.[43]

Surgeons must also consider the possibility of postoperative ulnar nerve instability after simple decompression. Recent cadaveric studies have examined the issue of ulnar nerve instability after nerve release. Whereas 1 study showed no subluxation after limited in situ decompression from the medial intermuscular septum to the flexor carpi ulnaris entrance,[8] another study of 16 cadaveric elbows showed ulnar nerve subluxation in 50% of specimens, particularly with decompression extending more than 4 cm proximal to the medial epicondyle.[28] Hsu et al[27] found significantly greater ulnar nerve subluxation after anterior release of the Osborne ligament from its attachment at the medial epicondyle compared with posterior release from the olecranon attachment.

Iatrogenic ulnar nerve instability requiring revision anterior transposition has been reported in several clinical series.[1,21,35,42,63] In our revision cohort, 8 of 27 patients had recurrent symptoms owing to ulnar nerve instability, at times presenting years after the simple decompression. In some clinical series, successful surgical outcomes were defined solely on the basis of whether revision surgery was needed after primary simple decompression. One report on 216 cases with less than 2-year follow-up cited a 3.2% reoperation rate,[21] and another documented a 7.2% revision rate in 69 cases with minimum 1-year follow-up.[24] In 231 cases, Krogue et al[35] found a remarkably high revision rate of 19%, which would have been 21% if all patients who were offered revision in their series would have consented to reoperation. This surprising finding is problematic because the results of revision surgery are not as favorable as those of primary procedures, as shown in our study and elsewhere.[1]

This high revision rate should prompt re-evaluation of the decade-old evidence-based analysis[12] on which many surgeons have based their preference for simple decompression. In that study of 3 prospective randomized trials, there was no statistically significant difference in the clinical outcomes of patients who underwent simple decompression compared with those who underwent either subcutaneous[48] or submuscular[4,23] transposition. Simple decompression was recommended based on its relative technical simplicity and the potential for fewer complications and a quicker recovery. Although we acknowledge the complication rate after in situ decompression is less than that after transposition in most studies, the overall morbidity of simple decompression includes the potential for revision surgery, which—according to Krogue et al[35]—may be much greater than previously estimated. On the basis of this new evidence, we share the concerns of Dy and Mackinnon[19] regarding the efficacy of simple decompression for cubital tunnel syndrome.

The general consensus is that ulnar nerve anterior transposition is preferred for patients who have had prior elbow trauma, elbow arthropathy with contracture, or previous surgery for ulnar neuropathy. Many surgeons also recommend primary transposition for patients with high-grade McGowan lesions, preoperative ulnar nerve subluxation, or for those who show nerve instability during in situ decompression. Considering the high frequency of ulnar nerve subluxation in our study and other studies,[9,26] anterior transposition may be indicated in 50% or more of those with cubital tunnel syndrome. Furthermore, informed consent for simple decompression requires that patients understand that the procedure does not address regional ulnar nerve strain,[20,46] that the procedure may be associated with a 20% chance of persistent or recurrent symptoms requiring revision surgery,[35] and that the results of revision surgery are inferior to those of primary procedures.[1] Taken together, these factors suggest that ulnar nerve transposition may be a better option for most patients.

The overall complication rate in our series was 19.1%, but nearly half of the complications were ecchymoses or seromas and likely related to our postoperative protocol allowing immediate elbow motion. All major complications were associated with confounding factors not within our control (Supplementary Table S1). The literature shows that complication and reoperation rates vary widely (Supplementary Table S2) but that our experience is consistent with other ulnar nerve transposition series.[3,4,57,62] In some studies, the reoperation rate was unreported,[51,62] and in others, it may have been underreported owing to the relatively short duration of follow-up.[4,23,49,53] Symptom recurrence in 12 of our 27 revision cases

was manifest 3 years or more after the index procedure, suggesting that longer-term outcome studies may capture more surgical failures.

The limitations of our study are similar to those of other retrospective analyses. Some clinical parameters sought were not present in all medical records, resulting in an incomplete though still robust database. Because we were unable to contact all potential study participants, there remains the possibility that some patients were treated elsewhere for symptom recurrence. Subject recall bias may have affected the long-term results of our study. Levine-Katz questionnaire data were useful to assess postoperative outcomes, but no preoperative data were available for comparison. Despite these limitations, we believe that the available data support the conclusions drawn from this study.

Conclusions

The favorable results of this study reaffirm our conviction for ulnar nerve anterior transmuscular transposition as the treatment of choice for cubital tunnel syndrome. The procedure effectively addresses the pathoanatomy including both nerve compression and traction or strain, obviates complex informed-consent discussions and intraoperative decision making associated with simple decompression, and minimizes the likelihood of patient dissatisfaction and regret that transposition was not performed during the index procedure in the event of a suboptimal outcome after in situ decompression. The high prevalence of ulnar nerve subluxation found in our study, the potential difficulty determining ulnar nerve instability preoperatively and intraoperatively, and the long-term uncertainty regarding late nerve instability after simple decompression are factors worthy of consideration by surgeons and patients weighing the surgical options for cubital tunnel syndrome.

Disclaimer

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Supplementary data

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