Ulnar Neuropathy at the Elbow
An Evidence-based Algorithm

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KEYWORDS

• Ulnar neuropathy • Cubital tunnel syndrome • Ulnar nerve • Nerve transposition • Endoscopic • Nerve compression

KEY POINTS

- Current evidence suggests that the different surgical methods to treat UNE do not differ in their clinical outcomes.
- Lack of standardized grading systems and outcome measures makes preoperatively determining of which type of procedure to perform impossible at this time.
- Outcomes for revision surgery are poorer than primary procedures.
- Anterior transposition is commonly used for revision cases but no literature is available to support this practice.

INTRODUCTION

From its origin at the brachial plexus to entering Guyon canal at the wrist, the ulnar nerve may be compressed at multiple levels; however, the cubital tunnel represents the most common site of compression and the target of numerous surgical techniques that are aimed at decompressing and/or relieving tension on the nerve at this level.[1–3] The aim of this review is to discuss current literature on clinical and functional outcomes after surgical treatment of ulnar neuropathy at the elbow (UNE), focusing on the best available evidence. As the methodological quality of orthopedic research continues to improve from retrospective case series to prospective randomized clinical trials (RCT), the goal of developing an evidence-based algorithm to guide clinical decision making hopefully may be reached.

PATHOPHYSIOLOGY

With progressive elbow flexion, the ulnar nerve experiences friction, traction, and compression forces.[2,4] In a cadaver study, Gelberman and colleagues[5] advocated that traction is responsible for the increase in intraneural pressure found with progressive elbow flexion to 130°. Wright and colleagues[6] demonstrated unrestricted upper extremity motion could produce up to a 29% increase in ulnar nerve length, placing substantial strain on the nerve. Several sites of compression are possible, including the medial intramuscular septum, the internal brachial ligament, the cubital tunnel, and the flexor-pronator aponeurosis. Although compression most commonly occurs at the level of the cubital tunnel,[3] it is important to realize that both the fibrous canal located 7 cm to 8 cm proximal to the epicondyle as well as fibrous bands within the flexor carpi ulnaris[7] are additional potential sites of compression, and decompression at these sites should be strongly considered to prevent incomplete release of the ulnar nerve. Less common sources of compression include osteophytes from degenerative arthritis, tumors, vascular malformations, anomalous bands of fibrous tissue, and the anconeus epitrochlearis muscle.[1] Anterior transposition should eliminate both pathologic traction and compression forces on the nerve[8]; however, extensive mobilization

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necessary for transposition has the potential for segmental transient devascularization, which may exacerbate the problem.[9] Proponents of transposition have argued that in situ decompression fails to address hypermobility and may, therefore, be unsuccessful. It remains unclear, however, whether or not preoperative or intraoperative nerve subluxation is correlated with clinical outcomes.

STAGING SYSTEMS AND OUTCOME MEASURES

Several classification systems of UNE severity have been proposed. In 1950, McGowan[10,11] described a subjective system that is still routinely used (**Table 1**). In 1989, Dellon[12] introduced his classification that scores patients on a 10-point numeric scale based on objective physical findings, including 2-point discrimination and vibratory perception, muscle weakness, and atrophy. Subjective outcomes are important in determining the effectiveness of treatment. Unfortunately, subjective outcomes for treatment of UNE lag behind those for carpal tunnel syndrome.[13] The most widely used outcome measure was reported by Wilson and Krout in 1973[14] and qualitatively divided patient outcomes from excellent to poor. Macadam and colleagues[15] performed a systematic review looking at outcome measures for UNE that identified 13 reports of unique author-generated scales and found that most studies report outcomes as excellent/good/fair/poor. Only 1 study to date has reported a validated, patient-based measure to assess symptoms.[16] In 2006, Mondelli and colleagues described a 9-item questionnaire, the UNE questionnaire, which focuses primarily on numbness and tingling in the small and ring fingers, elbow pain, and change in symptoms with elbow positioning.

Table 1
McGowan classification of ulnar neuropathy at the elbow, as modified by Goldberg

Grade	Sensory Symptoms	Motor Examination
1	Mild parasthesias or sensory loss	No weakness
2A	Moderate sensory loss	No intrinsic atrophy, mild weakness
2B	Moderate sensory loss	3/5 Intrinsic strength, moderate weakness
3	Severe sensory loss or parasthesias	Severe intrinsic atrophy and weakness

Data from Goldberg BJ, Light TR, Blair SJ. Ulnar neuropathy at the elbow: results of medial epicondylectomy. J Hand Surg Am 1989;14(2 Pt 1):182–8.

In addition to generic quality-of-life measures, such as the 36-Item Short Form Health Survey and visual analogue scale (VAS), upper extremity specific measures, such as the Disability of the Arm, Shoulder and Hand Questionnaire, have been used to describe outcomes, but impairment resulting from UNE is often not severe enough to create a meaningful change in these more general measures of overall or upper extremity health.

EXAMINING THE LITERATURE

In 1998, Bartels and colleagues[17] performed a systematic review of the literature from 1970 through 1997, including all levels of evidence available. Statistical combination of the studies was performed by grading the preoperative and postoperative McGowan classification grades, which resulted in more than 2000 patients; however, only 2 of the included studies were prospective and none was a RCT. When analyzed in relation to their preoperative McGowan classification grade, those patients with grade 1 or 2 had the best outcomes from in situ decompression whereas the more severely affected grade 3 patients had better results with anterior intramuscular transposition. The investigators suggested that in situ release be performed initially in all patients along with an intraoperative assessment of nerve stability and subsequent transposition only for those nerves that sublux with elbow flexion. Using this study as a starting point, this article reviews the subsequent literature on clinical and functional outcomes.

In Situ Release

Karthik and colleagues[18] published on a prospective cohort of 30 patients with severe ulnar neuropathy undergoing simple decompression using a minimally invasive approach (<4 cm incision) (level III); 80% good to excellent results were noted at 1 year without any complications. Pavelka and colleagues[19] retrospectively examined 55 patients at 13 months; 70% were Dellon grade 3 preoperatively and 80% were very satisfied with their outcome (level IV). Long-term outcomes suggest that approximately 62% of patients show substantial subjective improvement between 1-year and 12-year follow-up[20] (level IV). Taniguchi and coworkers[21] used a minimally invasive approach (2-cm longitudinal incision) for simple decompression in their study of 18 patients retrospectively examined at 14 months (level IV). These investigators report 77% good to excellent results and only

1 case of postoperative hematoma not requiring reoperation. Together these studies suggest 60% to 90% good to excellent outcomes with a trend toward better outcomes for less-severe preoperative grades.

Medial Epicondylectomy

Medial epicondylectomy seeks to relieve strain on the nerve by allowing it to glide anteriorly and may be performed as a partial (>40%) or minimal (<20%) resection of the epicondyle with or without decompression. Concerns regarding postoperative nerve subluxation, valgus elbow instability, and bony tenderness have been reported.[9] The authors were not able to identify any studies with higher levels of evidence (level I/II) for medial epicondylectomy. Existing literature includes retrospective outcomes or comparative cohort studies.[22–26] Using the Wilson/Krout criteria, reported outcomes among the retrospective case series are similar, with 75% to 79% good to excellent results[23,25] even among patients with the most severe disease.[24] Amako and colleagues[22] retrospectively compared partial (40%–80% resection) and minimal medial epicondylectomy (<20%) and found no difference in clinical or neurophysiologic outcomes between the groups but reported a 74% rate of valgus instability in the partial cohort compared with 0% in the minimal cohort group (level III). Pain over the osteotomy site is reported, with rates between 13% and 45% at 6 months to 3 years. Complications or adverse events reported with this procedure include medial elbow dysesthesias due to injury to branches of the medial antebrachial cutaneous (MABC) nerve (7%), revision to submuscular transposition (7%), and painful subluxation (13%).[25] Seradge defined recurrence as return of symptoms after 3 months of clinical improvement and reported a rate of 13% at 3 years[26] (level III).

Anterior Transposition

After anterior transposition, the ulnar nerve may be placed in a subcutaneous, intramuscular, or submuscular location, with the latter requiring the most extensive dissection.[3] Transposition procedures are commonly used for revision surgery or more severe stages of neuropathy based on the concept that transposition relieves tension more than in situ decompression or medial epicondylectomy. Some investigators argue that the amount of soft tissue dissection necessary may increase the risk of postoperative infection or recurrence from scar tissue formation.[9,27] After subcutaneous anterior transposition, good to excellent results have been reported in 84% to 94% of cases in level IV retrospective case series.[28–30]

In a prospective cohort study of 29 patients undergoing subcutaneous transposition, Hamidreza and colleagues[31] noted 62% good to excellent results at 1 month, increasing to 82% at 12 months, as well as a correlation between preoperative grade and postoperative outcome with an odds ratio of 3 for fair or poor outcome in the most severe cases (level III). Iba and colleagues[32] noted that patients undergoing subcutaneous transposition who have osteoarthritis at the elbow with osteophytes in the cubital tunnel might require a more extensive release to achieve good outcomes (level III). Several reports suggest that injury to branches of the MABC during dissection is a potential complication of transposition.[33–35] Fitzgerald and colleagues[34] reported 19 of 20 patients had excellent results 2 years after submuscular transposition, with 2 transient and 1 permanent MABC neurapraxias (level IV).

At least 2 studies comparing different transposition techniques have failed to show subtantial differences in clinical outcomes.[36,37] Charles and colleagues[36] reported similar motor and sensory recovery in patients with moderate and severe disease treated with either submuscular or subcutaneous anterior transposition in a retrospective case comparison (level III). In a similarly designed study, Kose and colleagues[37] retrospectively reviewed patients who underwent anterior transposition to subcutaneous, submuscular, or intramuscular position and reported an overall rate of 77% good to excellent results and a trend toward less improvement among McGowan grade 3 patients (level III).

In an attempt to predict preoperative factors that may affect postoperative outcome for all types of transposition, Shi and colleagues[38] performed a systematic review of the literature (level III). The investigators focused on age, duration of symptoms, preoperative symptom severity, neurophysiologic studies, type of transposition, and workers' compensation status but failed to find predictive factors affecting outcomes. Novak and colleagues[39] suggested that smoking might play a role in outcome after submuscular transposition and found that greater improvement was reported among nonsmokers than smokers at 2 years (level IV).

Traditionally, subluxation has been thought to be an indication for anterior transposition, but the determination of subluxation is largely subjective and there is not a uniform consensus. Calfee and colleagues[40] evaluated patients for ulnar nerve subluxation and found 37% of asymptomatic volunteers demonstrated nerve hypermobility.

Keith and Wollstein[41] performed submuscular transposition after making an intraoperative determination of instability and found that preoperative clinical examination was not a reliable predictor of intraoperative instability (level 4), noting a 14% rate of subluxation, which is lower than reported by Bartels and colleagues[42] (27%) (level I), who demonstrated outcome was not related to the presence of intraoperative subluxation by documenting the stability of the nerve without changing the surgical treatment and noting no difference in outcomes between those with and without with intraoperative subluxation.

Endoscopic Decompression

Thorough reviews of the surgical technique for endoscopic decompression of the ulnar nerve have been published previously.[43,44] Outcomes have reported 70% to 94% good to excellent results at 6 months to 4 years, suggesting results similar to other techniques are reproducible using endoscopic or minimally invasive techniques.[44–47] Reported complications include 30% rate of postoperative hematoma and a 12% rate of transient hypoesthesias in the MABC nerve distribution that resolved at 3 months. Intraoperative subluxation of the nerve requiring conversion to an open medial epicondylectomy was described in 6 of 21 procedures.[48] Comparison of open and endoscopic techniques was reported by Watts and Bain who prospectively collected patient-reported outcomes and reported equivalent results between cohorts at 12 months, with a trend toward improved satisfaction in the endoscopic group[49] (level III). The open cohort had more complications (40% vs 11%), including scar tenderness and mild numbness around the medial elbow.

Revision Surgery

Similar to other procedures involving ulnar nerve surgery, the literature on this topic is limited to retrospective case series and descriptions of techniques. Persistent symptoms may exist and are reported in up to 35% of procedures.[2] Goldfarb and colleagues[50] reported a 7% failure rate after primary in situ decompression at 4-year follow-up (level IV) and similar rates of 8% to 10% have been reported for submuscular anterior transposition and partial medial epicondylectomy.[51,52] Pathology identified at the revision procedure includes nerve compression at a remote site from the index surgery, inadequate decompression, cicatrix or scar formation, neuromas, and nerve subluxation. Submuscular transposition is commonly performed for revision surgery.[1] Vogel and coworkers[53] reported 55% good to excellent outcomes at 3 years after revision to submuscular position for failed subcutaneous anterior transposition (level IV). Dagregorio and Saint-Cast[54] performed simple anterior neurolysis to treat failure after submuscular transposition and noted 90% good to excellent results, with 50% resolution on neurophysiologic testing (level IV). Autologous vein wrapping using the greater saphenous vein has been reported to improve visual analogue pain and function scores[55] (level IV). In cases of extensive scar formation, allograft biomatrix scaffolds (ie, GraftJacket, Wright Medical Technology, Arlington, TN, USA) have been used to wrap the nerve in a fashion similar to autologous vein wrapping but without the donor site morbidity from vein harvest[56] (level IV). Although anterior submuscular transposition is traditionally used as the revision procedure for failed surgery, the literature does not demonstrate one procedure is superior to another in terms of symptom relief or objective improvement.

COMPARATIVE LITERATURE

Nonrandomized Studies

Several nonrandomized, retrospective cohort studies comparing outcomes between in situ decompression, minimal and partial medial epicondylectomy, and anterior transposition to subcutaneous, submuscular, or intramuscular positions have not demonstrated differences in outcomes.[57–61] Keiner and colleagues[62] prospectively followed 33 patients for a minimum of 3 years and compared submuscular transposition with in situ decompression and found no differences in complication rates or outcomes, leading the investigators to recommend in situ decompression based on the thought that it is less invasive (level II). Mandelli and Baiguini[63] performed a prospective cohort study of patients with all McGowan grades; those with grade 1 underwent in situ decompression whereas those with grade 2/3 underwent either anterior transposition to a subcutaneous or submuscular position (level II). Patients undergoing in situ decompression demonstrated 84% excellent results compared with 33% and 8% for subcutaneous and submuscular transpositions, respectively. Interpretation of this result is difficult, however, given existing literature, suggesting poorer outcomes for patients with more severe stages of the Dellon classification.

Using a decision analysis model, Brauer and Graham[64] compared 4 procedures using complete relief of sensory symptoms for at least 2 years as the primary measure of a good outcome (level I). The analysis showed that for moderate-to-severe UNE symptoms, in situ decompression had the highest expected utility or the most desirable outcome while accounting for potential complications, with subcutaneous anterior transposition closely in second place. The investigators found that this result held until the complication rate for in situ decompression in the model was increased to 82% (an unrealistically high percentage). This argues for in situ decompression as the primary treatment for UNE and reserving epicondylectomy or transposition for those patients where revision surgery is required.

Randomized Studies

Prospective RCTs are not common for ulnar neuropathy because there is not even a consensus on diagnosis or treatment indications. Some surgeons rely on objective findings of electrodiagnostic (EDX) studies for diagnosis, whereas other surgeons think it is primarily clinical.[65] Some investigators advocate surgical treatment in patients with clinical symptoms and negative EDX studies,[66] whereas other investigators suggest that up to 50% of these patients show spontaneous clinical improvement with nonoperative management.[67] Variation in surgical techniques between investigators also makes comparative studies difficult to interpret.

Despite these limitations, several RCTs exist.[42,68–71] Bartels and colleagues[42] randomized patients with EDX evidence of UNE to either in situ decompression or subcutaneous anterior transposition (level I). At 1 year, there were no statistically significant differences in terms of the percentage of patients with good to excellent outcomes but a higher complication rate was noted in the transposition cohort, largely due to hypoesthesia in the region of the incision as well as a higher incidence of postoperative infection (9% vs 2%). Similar results were reported by Nabhan and colleagues,[70] who found no differences in outcome for in situ decompression compared with subcutaneous anterior transposition at 9 months and thus recommend in situ decompression (level I). In 2005, Gervasio and coworkers performed an RCT in 70 patients with severe (Dellon grade 3) neuropathy to evaluate in situ decompression and submuscular anterior transposition[69] (level I). No significant differences were noted in EDX or clinical outcome, which correlated with the existing literature for either method with 80% and 82% good to excellent outcomes reported for in situ decompression and submuscular anterior transposition, respectively. These investigators did not have any major complications in either group. Zarezadeh and colleagues[71] reported on 48 patients randomized to subcutaneous or submuscular transposition and found more improvement in postoperative pain levels with submuscular transposition (level I).

Biggs and Curtis[68] randomized 44 patients to in situ decompression or submuscular anterior transposition and reported their 1-year outcomes, McGowan grade, and complication rates (level I). At final follow-up, there were no differences between the groups even when controlling for preoperative grade and examining only the most severe cases. Importantly, however, the submuscular transposition group had more complications, including 3 cases of deep wound infection requiring intravenous antibiotics and 2 cases of re-exploration. The investigators hypothesized that the increased dissection necessary to perform a submuscular transposition may have created increased potential space, which, along with an increased operative time for submuscular transposition, may explain the increased risk of infection among these patients. Therefore, these investigators also suggest in situ decompression be performed for primary UNE.

Meta-Analyses

Since the 1998 report by Bartels and colleagues,[17] 1 meta-analysis of level I studies[72] and 1 Cochrane review[73] have been published and together these studies represent the highest level of evidence to date on the management of UNE. Similar analyses have been performed previously[74,75]; however, these reports combined results from studies with lower levels of evidence and, therefore, represent a lower level of evidence themselves.[76] Both Zlodowski and colleagues[72] and Caliandro and colleagues[73] included the same 4 randomized studies in their analysis (discussed previously).[42,68–70] Although the investigators used different statistical pooling methods, both found similar conclusions. There was no difference in the risk ratio for clinical or neurophysiologic improvement between in situ decompression and anterior transposition and significantly more wound infections were found associated with transposition.[73] Based on this evidence, the investigators were unable to recommend one treatment as the best identifiable procedure for UNE and are further unable to identify when patients should be treated operatively or conservatively.

SUMMARY

On the basis of the authors' review of the literature, preoperative determination of which patients will benefit from which type of procedure is not possible at this time. In the authors' practice, simple decompression is performed, either by open or endoscopic techniques, for primary cases. An effort is made to determine if the nerve subluxes preoperatively, as described by Calfee and colleagues.[40] For perching nerves, the nerve is left in its native position and for nerves that sublux anterior to the epicondyle, a transposition in the subcutaneous plane is performed. Although subluxation is not an absolute indication to perform transposition, the literature demonstrates outcomes for revision surgery are not as good as primary surgery; thus, the nerve is transposed in hopes of decreasing the need for revision surgery. Submuscular transposition is reserved for revision cases or active patients with minimal subcutaneous tissue where the nerve is thought at risk for irritation in the subcutaneous position. The authors are aware of current studies to validate outcomes for treatment of UNE, which is the next step in determining the optimal treatment, but they are yet to be published.

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