Surgical Options for Ulnar Nerve Entrapment: An Example of Individualized Decision Analysis

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Abstract The decision-making process in the diagnosis and treatment of an ulnar nerve entrapment (UNE) at the elbow is presented from the viewpoint of the patient and from that of a physician who in this case, were the same individual. The problems of diagnosis and the selection of the appropriate therapy—conservative or surgical and the choice of a particular surgical approach are discussed in the light of recent evidence-based medicine (EMB) literature.

Keywords Ulnar nerve · Syndrome · Entrapment · Transposition · Decompression

Introduction

Physicians confronted with their own illnesses must undergo the same journey of seeking the therapy that is the most appropriate for their personal and professional needs that is undergone by their patients. When faced with the diagnosis of ulnar nerve neuropathy in his nondominant arm, the author underwent a personal journey in search for the best surgical procedure, based on scientific research, advice from colleagues (professional bias) and his own conclusions (personal bias) in an attempt to optimize his management as a patient. The author will present the thoughts and conclusions learned through this unique perspective.

The surgical treatment of ulnar nerve neuropathy resulting from elbow entrapment is shared by at least three

surgical specialties, namely, plastic surgery, orthopedics, and neurosurgery. Multiple surgical procedures have been used to treat this condition. They include simple decompression (open or endoscopic), simple decompression with medial epicondylectomy, medial epicondylectomy alone, transpositions (subcutaneous, submuscular, and intramuscular transposition) and combination of these. Novak and Mackinnon in a survey that included the response of 154 surgeon-members of the American Association of Hand Surgery (AAHS) indicated that most surgeons utilize more than one procedure for the treatment of ulnar neuropathy [23].

In an attempt to choose the appropriate therapy—conservative or surgical—and if surgical which procedure, the author sought evidence-based clinical decision-making algorithms that might direct his therapy

Material and Methods

A Pubmed review of the literature in the English language was performed covering the time period from the database inception to September 2008, in search for meta-analysis, prospective randomized trials, and decision-analysis algorithms. The studies were organized and limitations to the studies identified.

Case Report

A 32-year-old, right-handed man, neurosurgery resident, presented with an acute onset of numbness in the left hand with ulnar nerve distribution and inability to adduct the fifth digit (Wartenberg's sign). The day prior to the onset of symptoms, the patient underwent weight-training involving an abdominal crunch machine that required active handle

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traction with elbow in flexed position. Possible long-term repetitive precipitating causes included a 3-month period of increased exertional activity focused on triceps, forearm, and grip development both performing spinal instrumentation cases and during parallel conditioning with weight training. A course of methylprednisolone dose-pack was initiated within 24 h without resolution of symptoms. One week thereafter, worsening of hand intrinsic motor function and coordination were noted, and the patient ceased operative occupational activities.

On neurological examination, pertinent findings were flexor pollicis brevis (3/5), flexor digitorum profundus (3+/5), abductor digiti minimi (3/5), and third and fourth lumbricals and first dorsal interosseous (2/5). Decreased sensation was present from elbow to hand following ulnar nerve distribution. Hand grip was 60 lb in the left hand and 100 lb in the right hand measured in elbow flexion with a hydraulic hand dynamometer adjusted at level-3 resistance. Isometric key pinch was 9 lb in the left hand and 12 lb in the right hand measured with hydraulic pinch gauge. Moving and static two-point discrimination was between 3 and 4 mm, but subjectively, the sensation in the ulnar nerve distribution in the left hand compared to the right was only five to six out of ten compared to ten out of ten in the median nerve distribution in the left hand and the median and ulnar nerve distributions in the right. There was mild ulnar intrinsic atrophy in the left hand, with positive Tinel's sign at the elbow. The more recently described scratch-collapse test at the FCU tendinous leading edge was also positive. In this test, the patient resists bilateral shoulder external rotation with the elbows flexed and the area of suspected nerve compression is gently "scratched," followed by immediate repetition of shoulder external rotation. A positive test is seen when transient loss of shoulder external rotation resistance on the affected side occurs, while the nonstimulated side is still able to resist. The reported sensitivity of this test is 69% and the accuracy 89% for the diagnosis of cubital tunnel syndrome [6]. There was evidence of medial epicondylitis, but no subluxation of the nerve was noted and no evidence of compression at Guyon's canal or more proximally.

Motor nerve conduction studies (NCS) of the arms and left leg were normal except for mildly reduced compound muscle action potential (CMAP) amplitudes of the left ulnar nerve when recorded off abductor digiti quinti (ADQ) and first dorsal interosseous (FDI) muscles with mildly slowed conduction velocity across the elbow. There was no evidence of conduction block. Although the CMAP amplitude was mildly reduced, a 50% difference in CMAP amplitudes of the ulnar nerve was observed, when the ulnar nerve was evaluated off the abductor digiti quinti (ADQ). F-wave latencies were normal. Sensory NCS of the arms and left leg were normal. A 40% difference between the

amplitude of the left and right ulnar sensory nerve action potential (SNAP) was also observed. Electromyography of the left arm and cervical paraspinal muscles was performed. Signs of mild active denervation with increased insertional activity, fibrillation potentials, positive sharp waves and reduced recruitment patterns were detected in the flexor carpi ulnaris (FCU) and first dorsal interosseous muscles. Additionally, mild chronic denervation with polyphasic, large amplitude motor unit action potentials (MUAPs), and reduced recruitment patterns were seen in the FDI muscle. The cervical paraspinal muscles had a normal response.

Magnetic resonance imaging (MRI) in the setting of ulnar neuropathy at the elbow can be particularly useful to detect constriction bands or space-occupying lesions [13, 20]. In this case, it supported the diagnosis of nerve entrapment at the elbow, revealing thickening and abnormally increased T2 signal along the ulnar nerve adjacent to the medial humeral epicondyle (Fig. 1).

Progressive fine-motor coordination loss and neuropathic pain triggered with arm abduction and elbow flexion were noted over a 5-day course, suggestive of dynamic entrapment and increased nerve tension. Due to the rapid progression of symptoms and signs, the patient and surgeon elected the route of surgical intervention. In this case, a left anterior submuscular transposition with Z-plasty lengthening of the flexor pronator muscle was performed [19]. An incision was made behind the medial epicondyle. Dissection was carried out through the soft tissue preserving the medial antebrachial cutaneous branches. A large triceps insertion was displacing the ulnar nerve anteriorly, but no subluxation of the nerve or muscle was observed. There was dramatic compression of the nerve by exceedingly tight tendinous bands which were decompressed at the cubital tunnel. The medial intermuscular septum was then removed, and a Z-plasty lengthening of the flexor-pronator mass performed. Fascial flaps were created, and tendinous bands within the flexor pronator muscle origin were removed where they compressed the nerve once transposed. Dissection was carried down proximally to the level of the brachialis muscle. No sites of compression were identified along the nerve proximally or distally. Fascial flaps were closed very loosely over the ulnar nerve. A Jackson-Pratt drain was left in place for 24 h. Active range of motion without weight bearing was initiated on the second postoperative day.

Resolution of Wartenberg's sign was present 7 days after surgery. Physical and occupational therapy were started at that point. The patient resumed full occupational activities including surgical training and weight bearing 2 weeks postoperatively. Postoperatively, strength testing revealed a marked improvement of grip and lateral pinch values at 12-week follow-up (Fig. 2). In addition, Semmes-Weinstein monofilament sensory testing

Figure 1 MRI of the elbow. **a** T2W1 Sagittal view: There is thickening and abnormally increased T2 signal along the ulnar nerve adjacent to the medial humeral epicondyle extending proximally and distally for a total length of approximately 3.2 cm consistent with ulnar neuritis (*arrowheads*). **b** T2W1 Coronal view: There is adjacent

edema surrounding the nerve. The tunnel retinaculum does not appear thickened (*white arrow*). No accessory muscles around the ulnar nerve, such as anconeus epitrochlearis were identified. The common flexor and extensor tendon origins were intact.

improved from 4.31 to 2.83 in the left fifth digit and from 3.61 to 2.83 in the ring finger.

Results

A review of the existing class I and clinical guidelines studies are presented in Table 1. Four randomized controlled trials (RCT) [2, 3, 10, 22], three meta-analysis [16, 21, 30], and one study regarding clinical decision analysis were found [5].

The conclusions of the four randomized controlled trials coincided in finding no statistical differences in clinical outcomes regarding the different procedures described [2, 3, 10, 22]. Interestingly, most randomized trials ultimately recommend simple decompression as the procedure of choice based either on technical simplicity [22] or lower complication rates and procedural cost [1]. The meta-analysis developed by Zlowodzki et al. studied simple decompression versus all forms of transposition and found no statistical difference in outcome. However, the authors recommended simple decompression as a “reasonable alternative” to anterior transposition [30]. Macadam et al. (meta-analysis comparing simple decompression versus subcutaneous and submuscular transposition) suggested that transposition had a higher trend toward improvement when compared to simple decompression [16]. Mowlavi et al. (meta-analysis of 30 studies) concluded that for minimal-staged patients, medial epicondylectomy was the best treatment option, whereas anterior submuscular transposition in moderate-staged patients produced a statistically significant difference in total relief of symptoms and a very

high patient satisfaction rate (95%). For severe stages, this study found no surgical alternative as superior to the rest [21]. The conclusions, methodology, and limitations of all the studies described above are found in Table 1.

The only clinical decision-analysis study with a reliable design recommends simple decompression as the preferred surgical treatment for moderate-to-severe cubital tunnel syndrome, with submuscular transposition as a salvage procedure if sensory symptoms are not resolved [5]. Some assumptions are necessary for the creation of such study, based on probability of occurrences of both the utilities (favorable advantages) and the disutilities (complications or inconveniences) of the different procedures. Brauer et al.

Figure 2 Pre- and postoperative grip and lateral pinch values. Results indicate an improvement beyond baseline preoperative values registered the day before surgery.

Table 1 List of randomized controlled trials and clinical decision analysis studies.

Author/year	Study methodology	N	Class evidence	Results and recommendations	Limitations
Macadam et al. 2008	Meta-analysis SD vs. SMT/SCT	906	I	No statistical clinical differences in outcome Trend toward an improved clinical outcome with transposition of the ulnar nerve	Inconsistency in preoperative status and postoperative outcomes in the different studies selected in this analysis
Zlowodzki et al. 2007	Meta-analysis AT vs. SD	332	I	No statistical clinical differences in outcome SD proposed as a reasonable alternative to AT	Applicable only for patients without previous traumatic injury or surgical procedure at the affected elbow. AT procedures (SMT and SCT) are considered as whole based on the studies below
Mowlavi et al. 2000	Meta-analysis NO/SD/ME/ SCT	903	I	Minimum-staged: ME provided higher rates of total relief. SCT provided the least amount of relief. NO lowest rate of normal strength Moderate-staged: SMT provided a statistically significant highest rate of total relief, normal strength and patient satisfaction with lowest recurrence rates Severe-staged: No statistical clinical differences in total relief. All modalities yielding poor results. ME and NO associate highest recurrence rate ($p=0.003$). ME resulted in highest rate of persistent atrophy/weakness ($p=0.001$) and pain ($p=0.002$) No statistical clinical difference in outcome regardless of the neuropathy grade	Insufficient data to provide statistical analysis of outcome in minimum-staged patients High variability and inconsistency in the literature reviewed regarding preoperative dysfunction Variability of follow-up duration and outcome assessment
Biggs and Curtis 2006	RCT SD vs. SMT	44	I	SMT was associated with a higher incidence of complications SD suggested as procedure of choice	Low-grade lesions greater in the neurolysis (SD) group ($n=6$) compared to the SMT group ($n=2$) (McGowen grade 0–1/LSUMC 5) Higher rate of wound infections in SMT group was identified; however <i>routine</i> antibiotics were not used SD suggested as procedure of choice based on simplicity of procedure and less infection rate, not functional/neurologic outcome Outcome assessor not blinded. Unclear if randomization was concealed and patients blinded All patients severe (Dellon grade III)
Gervasio et al. 2005		70	I	No statistical clinical difference found, even in severe cases	Only SMT with Z-plasty extension of the flexor origin was considered Randomization not concealed Unclear if randomization was concealed and patients blinded Outcome assessor only blinded in 30/152 patients
Bartels et al. 2005	RCT SD vs. SCT	152	I	No statistical clinical difference found SD suggested as procedure of choice due to lower complication rates and procedural cost	Unclear if randomization was concealed and patients blinded Outcome assessor only blinded in 30/152 patients
Nabhan et al. 2005		66	I	No statistical clinical difference found SD suggested as procedure of choice due to simplicity	Unclear if patients and outcome assessor were blinded Complication rates not compared Small sample size

Brauer and Graham 2007	Decision-analysis utility model	III	SD is the preferred surgical treatment for moderate-to-severe cubital tunnel syndrome SMT as a salvage procedure if sensory symptoms are not addressed	Relief of sensory symptoms considered “good outcome”. Motor function not considered SMT was the both the default salvage procedure and endpoint of the model after bad outcome in 1st procedure Recent trends in “early mobilization” with both SCT and SMT were not recognized, increasing the disutility of these procedures vs. SD
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Evidence-based medicine: Class I = Prospective, randomized controlled trial (PRCT) or multi-center study, indicative of standards (high degree of clinical certainty); Class II = retrospective comparative clinical studies, indicative of practice guidelines (moderate degree of clinical certainty); Class III = case series, case reports, or expert opinion, indicative of consensus opinion (unclear degree of clinical certainty).

ME medial epicondylectomy, N number of subjects studied in the protocol indicated, NO nonoperative management, SD simple decompression, SMT submuscular transposition, SCT subcutaneous transposition, AT anterior transposition (SMT + SCT)

considered relief of sensory symptoms as the most important factor for “success” due to the fact that sensory complaints are more common than motor symptoms. In this study, submuscular transposition was considered the procedure of choice when other procedures failed, based on a series of studies [8, 11, 24, 27], and failure to improve following submuscular transposition was considered an endpoint of the model.

Discussion

Ulnar nerve entrapment at the elbow is accepted as the second most common nerve entrapment disorder after carpal tunnel syndrome. Previous studies involving work exposure to biomechanical factors demonstrated that holding tools in static positions repetitively constitutes an important biomechanical risk factor [9]. The use of hand-operated vibrating tools and prolonged periods of elbow flexion are an additional risk [12]. The above-described risk factors are markedly present in neurosurgical procedures, e.g., bone drilling, microscopic dissection, or sustained retraction with elbow flexion in operations of long duration. Repetitive motions of typing and data entry, intrinsic part of the life of a resident, have also been defined as a risk factor for peripheral nerve injury [17]. An increase in work production or change in work organization is also associated with occupational ulnar nerve neuropathy [25]. Both were present in this case where a fourfold increase in operative totals performed during professional activities was observed due to the transition from a research year to a very active scheduled operative clinical rotation.

Conservative therapy (avoiding pressure on the nerve, activity modification, physical therapy with nerve gliding exercises and if warranted, splinting at the elbow) seems to have best results when patients present with minimal symptoms [7]. When atrophy is present or paresthesias are persistent, nonoperative management seems to provide the lowest rate of relief and the highest rate of recurrence [21].

In the case presented, both patient and surgeon agreed in not prolonging conservative management due to the severity of the symptoms, moderate to severe in most classification systems [7, 21].

The choice of the operation selected in this case may seem counterintuitive. Although the literature seems to favor simple decompression, the author chose to undergo a submuscular transposition. The reasons are as follows:

1. The recommendation to favor simple decompression (SD) despite lack of statistical evidence is debatable. All randomized clinical trials show no clinical difference when comparing simple decompression versus transposition [2, 3, 10, 22].

2. If the entrapment is extensive or if the entrapment is dynamic (movement increasing tension on the nerve), both present in this case, simple decompression may not suffice [23].
3. The impact of a re-operation in occupation is not taken into consideration in any of the randomized controlled studies up to date. In this case, the patient considered a re-operation an unacceptable risk due to the associated exponential increase in complications [18].
4. The disadvantage of submuscular transposition as a more “demanding technique,” is surmounted by choosing a skilled surgeon whose procedure of choice is submuscular transposition, in this case with Z-plasty lengthening [19]. In addition, this procedure places the nerve in a better perfused and anatomically protected area, which is important in repeated exposure to pressure points during occupational activities [5].
5. The disadvantage of long immobilization following transposition techniques is not necessarily factual. Studies performed in the late 1990s indicated that prompt postoperative mobilization with active range of motion exercises does not impair outcome when compared to delayed mobilization in patients following anterior transpositions [28] or decompression with epicondylectomy [26]. The idea that early postoperative mobilization may allow earlier return to occupational duties has been confirmed by other studies [4].
6. Finally, the author opted to undergo surgery in an institution with high volume of both complex peripheral nerve surgery and vast experience in ulnar nerve submuscular transposition. There are class I evidence studies that indicate a well-established relationship between operator volume and successful outcome in multiple specialties [14, 15, 29].

Conclusion

Anterior submuscular transposition with Z-plasty lengthening was chosen for ulnar nerve decompression in a patient whose occupation requires fine motor skills. Individualized decision analysis should be made in each clinical scenario, including degree of entrapment, occupational interference, and surgeon's expertise, in order to select the procedure optimal for the individual patient.

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