General

A Comprehensive Review of Cubital Tunnel Syndrome

Danyon Anderson[1a], Bison Woods[1], Tunde Abubakar[2], Colby Koontz[2], Nathan Li[1], Jamal Hasoon[3], Omar Viswanath[3], Alan D. Kaye[2], Ivan Urits[4]

[1] Medical School, Medical College of Wisconsin, [2] School of Medicine, Louisiana State University Health Science Center Shreveport, [3] Anesthesiology, Beth Israel Deaconess Medical Center-Harvard Medical School, [4] SouthCoast Health

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Cubital Tunnel Syndrome (CuTS) is the compression of the ulnar nerve as it courses through the cubital tunnel near the elbow at the location colloquially referred to as the “funny bone”. CuTS is the most commonly diagnosed mononeuropathy after carpal tunnel syndrome. Cubital tunnel syndrome can manifest as numbness, tingling, or pain in the ring/small fingers and dorsoulnar hand. Repetitive pressure, stretching, flexion, or trauma of the elbow joint are known causes of CuTS. Chronic ulnar nerve compression and CuTS, when left untreated, can lead to atrophy of the first dorsal interosseus muscle and affect one’s quality of life to the point that they are no longer able to participate in daily activities involving fine motor function.

It is estimated that up to 5.9% of the general population have had symptoms of CuTS. CuTS is underdiagnosed due to lack of seeking of treatment for symptoms.

Compression or damage to the ulnar nerve is the main cause of symptoms experienced by an individual with CuTS. Repetitive elbow pressure or a history or elbow joint trauma or injury are additional known causes that can lead to CuTS.

Common presentations of CuTS include paresthesia, clumsiness of the hand, hand atrophy and weakness. The earliest sign of CuTS is most commonly numbness and tingling of the ring and 5th finger. Older patients tend to present with motor symptoms of chronic onset; younger patients tend to have more acute symptoms. Pain and point tenderness at the medial elbow may also be seen.

CuTS lacks universally agreed upon diagnostic and treatment algorithms. CuTS can be diagnosed by physical exam using Tinel’s sign, flexion-compression tests, palpating the ulnar nerve for thickening presence of local tenderness along the nerve. Ultrasound and nerve conduction studies may be used in combination with physical exam for diagnosis.

Conservative treatment for CuTS is almost always pursued before surgical treatment and includes elbow splints, braces, and night-gliding exercises. Surgical treatment may be pursued in severe CuTS refractory to conservative treatment. Surgical options include open and endoscopic in-situ decompression, medial epicondylectomy, and anterior transposition of the ulnar nerve.

CuTS is a prevalent disease that, if left untreated, can significantly alter an individual’s quality of life. Therefore, an accurate diagnosis and appropriate treatment is paramount in reducing further damage and preventing worsening or future symptoms.

a **Corresponding author:**
Danyon Anderson
Medical College of Wisconsin
Medical School
8701 W Watertown Plank Rd
Milwaukee, WI 53226
Phone: (719)-310-2831
djanderson@mcw.edu

INTRODUCTION

Cubital Tunnel Syndrome (CuTS) is the most commonly diagnosed mononeuropathy after carpal tunnel syndrome.[1] Despite its prevalence, CuTS is often difficult for physicians to diagnose and treat diagnostic and treatment frameworks have not been widely agreed upon. Although research analyzing disease susceptibility and premier treatment approaches are mostly inconclusive, they can broaden physician knowledge of disease causation and management when viewed collectively. Cubital tunnel syndrome can manifest as numbness, tingling, or pain in the ring/small fingers and dorsoulnar hand.[2] Symptoms are often worse at night or present with certain joint positions or movements such as elbow flexion. Symptoms decrease quality of life and vary in severity from weakness to loss of fine motor skills.[2] Ulnar pain can originate from compression of a variety of places such as the cervical nerve roots as they exit the spinal cord, the brachial plexus, the thoracic outlet, or further down the upper extremity in the arm, elbow, forearm, or wrist.[3] CuTS is defined as compression of the ulnar nerve at the elbow in the cubital tunnel. Repetitive pressure, stretching, flexion, or trauma of the elbow joint are known causes of CuTS.[1] Overuse of these motions and anatomical susceptibility of the elbow partially explain this syndrome's frequency. Chronic ulnar nerve compression and CuTS, when left untreated, can lead to atrophy of the first dorsal interosseus muscle and affect one's quality of life to the point that they are no longer able to participate in daily activities involving fine motor function.[2] Thus, an accurate and adequate diagnosis and treatment of CuTS is necessary to prevent further progression of the disease and reduce the likelihood of decreased quality of life.

EPIDEMIOLOGY

The prevalence of CuTS is surprisingly high. It is the second most common peripheral mononeuropathy of the upper extremity and the most common neuropathy of the ulnar nerve.[4] Despite its prevalence, high quality epidemiology studies are lacking. This is likely due to the attention that carpal tunnel syndrome gets in relation to CuTS. It is estimated that up to 5.9% of the general population have had symptoms of CuTS, which closely follows carpal tunnel syndrome with 6.8% of individuals experiencing symptoms.[5] Additionally, these numbers are thought to possibly be low due to several factors. First, some individuals may forgo visiting their physician and decide to self-treat with NSAIDs or rest. Second, even when individuals visit their physician, the lack of a precise diagnostic test has made the diagnosis of CuTS very challenging. Traditionally, nerve conduction studies, in conjunction with a physical exam, have been used to make a diagnosis. However, many patients can present with severe disease and have a normal nerve conduction study. Therefore, nerve conduction studies are not a consistent and effective way to diagnose CuTS. The median age for patients with CuTS is 46 years with a standard deviation of 15.7 years.[5] White individuals are more likely to develop CuTS (74%) when compared to black (22%) and Hispanic (3%) individuals.[5] Individuals with a lower level of education have a higher rate of CuTS. This is thought to be due to the higher likelihood that individuals with a lower level of education work more physically labor-intensive jobs, leading to increased risk of injury leading to CuTS.[6]

PATHOPHYSIOLOGY

Compression or damage to the ulnar nerve is the main cause of symptoms experienced by an individual with CuTS. The compression or damage can happen anywhere along the ulnar nerve, from the nerve roots (C8-T1) as they exit the spinal cord all the way down to the wrist. However, the most common area of compression is within the cubital tunnel in the elbow. The cubital tunnel lies beneath the Osborne ligament and is the passageway between the olecranon and medial epicondyle.[7] For most individuals with CuTS, repetitive prolonged elbow flexion can lead to onset or increased severity of symptoms. This is due to the unique anatomic relationship of the ulnar nerve in relation to the anatomy of the elbow.[7] When elbow flexion occurs, the arcuate ligament elongates, leading to a 55% decrease in the volume of the cubital canal.[8] Another occurrence during elbow flexion is an extension of the ulnar nerve that can be between 4.7 and 8mm. This extension is due to the anatomic course behind the medial epicondyle, which acts as a hinge when the elbow is flexed.[8] Repetitive extension of the ulnar nerve can lead to nerve damage which may result in symptoms of CuTS. Another common location for nerve entrapment is the arcade of Struthers. The arcade of Struthers is the area in the arm where the ulnar nerve pierces the intermuscular septum about 8 cm proximal to the medial epicondyle and enters the posterior compartment.[9] This band of connective tissue may compress the ulnar nerve, leading to symptoms of CuTS .[7] Additionally, individuals with a history of ulnar collateral ligament insufficiency or an ulnar collateral ligament tear also have an increased likelihood of developing CuTS. This is a result of the increased laxity of the joint due to the defective ulnar collateral ligament, which leads to more strain on the ulnar nerve, especially during elbow flexion.[10]

As mentioned in the introduction, repetitive elbow pressure or a history or elbow joint trauma or injury are additional known causes that can lead to CuTS.[4] Smoking has also been shown to be a risk factor for developing CuTS. The exact mechanism is unclear of how smoking is a risk factor for CuTS; however, it is hypothesized that smoking is associated with peripheral nerve dysfunction. It has also been shown that nicotine, found in cigarettes, causes ischemia and may prohibit the repair of nerves/tissue. Interestingly, regardless of what arm the individual used to smoke with, the left arm was most often associated with CuTS.[11] Other risk factors, however, are not as universally accepted. Some articles find that being male is a risk factor for developing CuTS, while others state that being male is not a significant risk factor.[6,12,13] Similarly, some claim an elevated BMI puts individuals at an increased risk, while

others say that there is no increased risk with an elevated BMI.[6,12,13]

CLINICAL PRESENTATION

CuTS can present in many ways. Common presentations include paresthesia, clumsiness of the hand, hand atrophy and weakness. Variation in symptoms of CuTS may be associated with compression of the ulnar nerve at different points around the elbow. Patients usually present with complaint of sensory deficit of the 4th & 5th digit of affected hand, sensitive medial elbow, and forearm and hand pain.[14] Diabetic patients tend to present with less sensory symptoms and more motor symptoms such as weakness and wasting.[14] According to a retrospective study conducted at a single tertiary center, some of the early signs of CuTS are numbness and tingling of the ring and 5th finger or hand weakness due to the ulnar nerve compression at the elbow.[15] The weakness is due to muscular atrophy seen in cubital tunnel syndrome. This study hypothesized that young patients belonging to certain demographic group may experience muscular atrophy quicker than others.[15] The study also reported that gender is a determining factor in prediction of atrophy as a presentation of CuTS. In this study, the age of the patient did not predict presentation with muscular atrophy, although, young patients with muscular atrophy recovered earlier than older patients with muscular atrophy.[15] In a study comparing the presentation of CuTS between older patient and younger patients, Naran et al described that older patients tended to present with motor symptoms of chronic onset. Slow onset prevented early diagnosis in older patients compared to younger patients who primarily presented acutely with sensory symptoms which lead to faster diagnosis.[16] Furthermore, the study stated that chronic onset of symptoms in the elderly may be due to increased fibrosis around the nerve over a long period of time. Younger patient's early presentation can be attributed to increased activity at the elbow.[16] A retrospective study which compared the onset of symptoms of CuTS to carpal tunnel syndrome established that regardless of factors such as age, gender or diabetes status, muscle atrophy in CuTS presents later. This indicates that significant damage would have occurred to the ulnar nerve at presentation.[17] This late presentation may lead to dissatisfaction with the outcome of surgery by patients undergoing ulnar nerve decompression. Andrew et al reported sensory symptom such as paresthesia in the 4th and 5th fingers as the early presentation of CuTS.[18] Pain and point tenderness at the medial aspect of the elbow are also seen due to inflammation resulting from repeated flexion of the elbow such as when sleeping or when holding a gadget like a phone.[18] Patients may complain of pain with elbow flexion and activities involving rotational movement of the hand such as opening a jar. Intrinsic muscular weakness and atrophy are symptoms seen in the chronic nerve compression and lead to the clawed hand position.[18]

DIFFERENTIAL DIAGNOSIS

Multiple nerves coming from the brachial plexus course through the elbow and the hand. Therefore, when pain at the elbow, weakness and atrophy of the hand and paresthesia present, multiple pathologies must be considered. Carpal tunnel syndrome, a disease caused by the compression of the medial nerve at the wrist by the flexor retinaculum is the number one cause of sensory and motor symptoms at the hand. Its symptoms can present like CuTS, therefore it should be on the differential diagnosis. Other pathologies to consider include lower trunk compression, C8 & T1 radiculopathies, diabetic neuropathy, hypothyroidism, Vitamin deficiency and Complex regional pain syndrome. Guyon canal syndrome which is an ulnar neuropathy at the hand is crucial to rule out because CuTS also affects the ulnar nerve but at a more proximal site (elbow).

DIAGNOSTIC PROCESSES

Several studies have been conducted on the use of clinical exam to diagnose CuTS. Some of these studies focused on inducing provocative actions at the elbow or wrist along the nerve to elicit symptoms to aid in diagnosis. Some of these actions include Tinel's sign, flexion-compression tests, palpating the ulnar nerve for thickening presence of local tenderness along the nerve. These studies were compared to other methods of diagnosis of CuTS such as Ultrasound or nerve conduction studies. Beekman et al reported a sensitivity (SN) of 62%, specificity (SP) of 53%, Positive predictive value (PPV) of 77% & Negative predictive value (NPV) of 30% for Tinel's sign, SN of 32%, SP of 80%, PPV of 80% & NPV of 32% for palpation for nerve tenderness, SN of 61%, SP of 40%, PPV of 72% & NPV of 29% for flexion-compression test & SN of 28%, SP of 87%, PPV of 84% & NPV of 33% for palpation for nerve thickening.[19] These results showed that physical exam alone may not be sufficient to diagnose CuTS.

A scratch collapse test involves scratching the patient's skin at the point of nerve entrapment, then a resisted shoulder external rotation. In a positive test, the arm collapses into internal rotation against the resistance. Studies have shown that the rate of positivity of this test is similar regardless of the examiner performing the test.[20-22] Nevertheless, the sensitivity of the test is not high enough to serve as a reliable diagnostic test to rule out CuTS, but specificity was higher than other clinical exams such as Tinel's sign and flexion-compression exam.[23] Therefore, the scratch collapse test is not reliable enough to diagnose pathologies associated with peripheral neuropathies.[20,23]

The use of Sonography to diagnose CuTS has also been examined. Increased cross-sectional area of the ulnar nerve at different points around the elbow indicates a positive test. Several studies have reported ultrasound to have a high sensitivity in diagnosing ulnar neuropathies at the elbow.[24-26] Therefore, ultrasound can serve as a complementary tool for the physician to use in the quick assessment of patients with CuTS during follow-up appointments.

The use of electrodiagnostic studies such as nerve conduction studies are highly used in the diagnosis of ulnar nerve pathologies. A blinded prospective study comparing the use of electrodiagnostic nerve conduction studies to ultrasound in the diagnosis of ulnar nerve neuropathy at the elbow reported an increased accuracy of diagnosis in the nerve studies.[27] Visser *et al* reported that the use of short segment nerve conduction studies should be encouraged in all patients with suspected ulnar nerve neuropathy at the elbow due to the study's ability to locate lesions on the nerve.[28]

In summary, there is no universally accepted exam for the diagnosis of CuTS. This is due to the limitations in accuracy of tests, interrater differences seen in multiple tests and positive tests seen in individuals without symptoms.[29] Therefore, a combination of clinical suspicion, physical exam and testing are indicated in the diagnosis of CuTS.

TREATMENT OPTIONS

Management of CuTS includes both operative and non-operative options. Staging systems devised by McGowan and Dellon have been used to gauge degree of ulnar nerve dysfunction.[30,31] Generally, mild CuTS demonstrates intermittent paresthesias and subjective weakness, moderate CuTSshows intermittent paresthesias with measurable weakness and positive provocative testing, and severe CuTS consists of persistent paresthesias with prominent muscle weakness/atrophy and positive provocative testing. Conservative treatment may offer benefit in mild to moderate cases of CuTS, while surgical approaches are generally reserved for more severe cases.

CONSERVATIVE MANAGEMENT

Multiple non-surgical interventions have been proposed to aid in relieving symptoms of ulnar nerve entrapment at the elbow. Careful history taking is important in assessing whether certain activities or movements aggravate the condition. For these individuals, education on elbow anatomy and provocative movements may help to reduce pain and paresthesia.[32,33]

Elbow splints and braces have been used to restrict patient positioning. These orthoses may serve to rest the area by limiting repetitive movements or prolonged elbow flexion. The evidence for the clinical benefit of splinting is unclear. Two prospective studies have reported improvement in symptoms of CuTS with elbow splinting. Hong et al. analyzed splinting alone vs splinting with a single local steroid injection. They found that splinting alone for CuTS resulted in improvement in both symptoms and ulnar nerve conduction at 1- and 6-month follow-ups. There was no additional benefit in the group that received steroid injection along with casting.[34] A separate investigation conducted by Shah et al. followed patients managed with night splinting and activity modification. They tested 24 extremities and found that 88% of them were able to be treated non-surgically at 1-year. Patient reported outcomes were significantly improved at 6-week, 3-month, and 1-year follow-ups. Average grip strength increased following treatment, and 82% of patients with positive provocative ulnar nerve testing achieved resolution.[35]

A conflicting study by Svernlov et al. examined the efficacy of adding night splinting or nerve gliding exercises to simply informing patients about their condition and its triggers.[36] A total of 51 individuals were informed about CuTS and probable causes of their symptoms, such as positioning and repetitive elbow flexion. They were then split into three groups consisting of elbow bracing, nerve gliding exercises, and a control group. The authors discovered all groups demonstrated improvement in symptoms, daytime pain, and grip strength. However, there was no difference between groups, which may suggest nighttime splinting and nerve gliding exercises do not provide additional benefit.

Other considerations to make when using elbow splints are the lack of well-established protocols for degrees of flexion and duration of treatment. Most studies have ranged from 30-45° of flexion.[34,35] This is partially based on cadaveric findings by Gelberman et al., who after assessing changes in pressure within the cubital tunnel as the elbow is flexed, postulated that 45° may be optimal positioning for immobilization and rest of the ulnar nerve.[37] The most common duration of splinting appears to 3 months, but there is no evidence at this time supporting this interval compared to other lengths of time.[34-36] Further, a study assessing the ROM capabilities of elbow orthoses performed by Apfel and Sigafoos demonstrated varying aptitude of splints to restrict movement at the proposed ideal position of 45°.[38]

Nerve gliding exercises have been suggested as a conservative treatment for CuTS. This is a technique that has shown promise in the treatment of carpal tunnel syndrome. One case report by Coppieters et al. described improvement of CuTS in a 17-year-old female treated with nerve gliding exercises.[39] However, the previously mentioned study by Svernlov et al. found adding these mobilization exercises offered no additional benefit over simply informing patients about the condition and avoidance of triggers.[36]

SURGICAL MANAGEMENT

Surgery for CuTS is indicated if the condition is refractory to conservative management or if the patient demonstrates severe deficits. The two main techniques are in situ decompression and decompression with anterior transposition of the ulnar nerve. Both approaches are aimed at freeing the ulnar nerve from any compression or tension present in the cubital tunnel of the elbow. Medial epicondylectomy is a supplemental procedure occasionally used with in situ decompression.

In situ decompression of the ulnar nerve is accomplished by releasing tissue from the ulnar nerve at the level of compression. Open and endoscopic procedures have been described to achieve decompression. Open decompression was the first surgical technique utilized in the management of CuTS.[40] The procedure consists of making a longitudinal incision ranging from 8-10cm over the cubital tunnel to ex-

pose the medial aspect of the elbow. Surgeons are then able to directly visualize the course of the nerve and identify sites of compression. A review by Carlton and Khalid found that combined good and excellent (CGE) outcomes for this procedure ranged from 65.3-100%.[40]

Endoscopic methods for decompression of CuTS utilize a 2-3cm incision between the medial epicondyle and the olecranon. An endoscope and retractors are maneuvered through the incision site to inspect the course of the ulnar nerve. When the point of compression is identified, the surgeon can cut overlying tissue to alleviate pressure on the nerve. CGE scores range from 69.6-96% in studies documenting this technique.[40]

To this point, there has been no definitive evidence showing improvement in long-term outcomes between open vs endoscopic techniques for CuTS. A prospective randomized double-blind study by Schmidt et al. comparing endoscopic vs open cubital tunnel decompression found no difference in effectiveness between the two techniques, both in short-term and long-term follow-up.[41] This has been substantiated by systematic reviews and meta-analyses which have not shown a difference in patient reported outcomes and neurophysiologic testing between the two methods.[42-44]

Several differences exist in complication rates between the two procedures. Open decompression is associated with higher risk of iatrogenic injury to the median antebrachial cutaneous nerve, which can result in loss of sensation over the elbow and medial aspect of the forearm.[40,45] There are also the expected complications of increased post-operative pain and infection with a larger incision. An important risk unique to the endoscopic group is the development of post-operative hematoma at the incision site.[44-46] This may be related to poor visualization of bleeding vessels at the time of closure.

Medial epicondylectomy is a procedure sometimes performed with in situ decompression. Techniques include total, partial, and minimal medial epicondylectomies depending on how much bone is removed. Outcomes for medial epicondylectomy have shown promise in improving CuTS. A retrospective review found that partial removal of the medial epicondyle resulted in improvement of CuTS by at least one McGowan Grade in 86.2% of patients.[47] Minimal epicondylectomy may be preferable over partial removal, as evidenced by similar efficacy with greater maintenance of stability.[48] One prospective randomized study by Geutjens et al. compared in situ decompression with medial epicondylectomy to anterior transposition. They found no significant differences in elbow function, motor power, or nerve conduction studies. Patients with in situ decompression plus medial epicondylectomy reported significantly greater satisfaction and less pain.[49]

Anterior transposition of the ulnar nerve is a procedure in which the ulnar nerve is mobilized anterior to the medial epicondyle. Various sites have been described for placement of the ulnar nerve, including subcutaneous, intramuscular, and submuscular.[40] This technique involves releasing the ulnar nerve from the cubital tunnel, arcade of Struthers, and any other tissues that restrict passage of the ulnar nerve over the medial epicondyle. Subcutaneous transposition consists of creating a sling out of muscular fascia to hold the ulnar nerve below the subcutaneous tissue. Intramuscular and submuscular methods result in placement of the nerve within or deep to the pronator teres and flexor carpi ulnaris muscles, respectively.

Evidence mostly shows that there is no benefit in opting for either in situ decompression vs anterior transposition for the treatment of CuTS. Two prospective randomized studies by Bartels et al. and Nabhan et al. found no difference in patient outcomes for CuTS when treated with in situ decompression compared to subcutaneous anterior transposition.[50,51] Submuscular anterior transposition also showed no clinical benefit over in situ decompression in two prospective randomized investigations.[52,53] Two major systematic review and meta-analyses contradict on whether there is no clinical difference or if in situ decompression is more advantageous.[44,54] Regardless, there is overwhelming evidence that anterior transposition is not more efficacious than in situ decompression for the management of CuTS.

Decompression with anterior transposition of the ulnar nerve has been found to significantly increase the risk of complications, such as superficial and deep soft tissue infections, recurrence of CuTS symptoms, and necessity of reoperation.[44,52,54] At this time, in situ decompression is generally utilized as the operative option for CuTS due to similar improvement of symptoms with lower associated risks.

CONCLUSION

CuTS is a surprisingly common disease with a wide range of presentations and symptoms such as paresthesia, clumsiness of the hand, hand atrophy and weakness. CuTS is also a uniquely diverse disease in that it affects a large and diverse population base. While most patients affected are white, there are very few other hard and true epidemiological or risk factors that predisposes certain individuals to developing CuTS. CuTS often goes undiagnosed in the general population due to lack of precise diagnostic techniques and patients not seeking treatment for symptoms. However, a careful history and physical exam combined with various diagnostic studies facilitate accurate diagnosis of CuTS. Fortunately, for most individuals with CuTS, there are non-operative treatment options. These include positional manipulations; reducing elbow flexion, especially at night; non-steroidal anti-inflammatory medications; and the use of a splint or brace. However, for those with a more severe disease, surgical intervention may be necessary. There are various types of techniques for surgical intervention, however, the main goal of surgical correction is to decompress the nerve. This can be done either by releasing the nerve in its current course or by diverting the course of the nerve away from the compression. Current literature suggests that decompression of the nerve in its current course is the best option for most patients. In review, CuTS is a prevalent disease that, if left untreated, can significantly alter an individual's quality of life. Therefore, an

accurate diagnosis and appropriate treatment is paramount in reducing further damage and preventing worsening or future symptoms.

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