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Research Article

Neurophysiological Grading of Ulnar Nerve Entrapment Across wrist and Across Elbow

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Abstract

Ulnar nerve entrapment across the elbow (UNEAE) and across the wrist (UNEAW) is the second most common entrapment of the hand after carpal tunnel syndrome. There are few grading available for UNEAE and fewer in UNEAW. None of those gradings compares the involvements of both (wrist and elbow). None of the literature looks at the involvement of sensory axonal neuropathy in different stages.

The aim of this research are;

1. To see the relation of sensory nerve involvement across the wrist with the entrapment across the elbow and to evaluate its effectiveness in each level without going for any invasive tests like needle EMG examination.

2. To identify the lesion below and across the wrist in terms of support, the clinical Physiologist (CP) grades them properly and helps the consultant decide to treat with conservative or surgical treatment.

3. To compare the recording from the first dorsal interosseous (FDI) muscles with the abductor digiti minimi (ADM) muscle to see which muscle is more sensitive and shows early changes in ulnar nerve entrapment.

4. To differentiate the grading of Guyon's canal with sensory entrapment below the wrist.

5. To analyse the severity of entrapment in both areas (below/across wrist and elbow).

The proposed revised grading system is based on more nuanced, descriptive categories, ranging from "early", "mild", "moderate" and "severe". To create a full grading system of UNEAW and UNEAE some additional clinical grading is proposed.

Method: Data was collected based on the extensive and detailed grading system previously described by Padua. The tests were performed by a qualified clinical physiologist (neurophysiology) using a Key Point 9033A07 machine, used in line with the departmental protocol (peripheral protocol 1, 2022). The Association of Neurophysiological Scientists (ANS) and British Society of Clinical Neurophysiology (BSCN) (2014) guidelines and minimum standards for the practice of clinical neurophysiology in the United Kingdom were followed. All data was recorded numerically to ensure methodological reliability.

Result: The data was collected over one year six months from January 2022 till June 2023. A total of 313 abnormal hands and 200 normal hands were included in this study. Martin Gruber anomalies, which are normal variant, are not included in this study. Out of 313 abnormal hands, 149 hands were right hands and 164 were left hands. 46 hand shows lesion below the wrist and 56 hands shows lesion around Guyon's canal. Across the elbow shows more mild cases as compared to early, moderate, and severe cases. Moderate ulnar nerve lesion across the elbow are more associated with sensory axonal and double crush cases, which were seen more in mild and moderate cases compared to early and severe cases.

Conclusion: Findings show that FDI is more sensitive compared to ADM to recording early changes in ulnar nerve entrapment across the elbow. Additionally, the results show that sensory axonal involvement and double

crush syndrome need to be included in the grading system which is not accounted for in any present research publication.

Key words: endoscopic third ventriculostomy; cerebrospinal fluid; vp shunt; obstructive hydrocephalus

Introduction

The ulnar nerve is the second most common compressed nerve at the elbow in the region of the cubital tunnel and less frequently at the wrist in Guyon's canal or below5. With the compression of the ulnar nerve, patient complaints can include paranesthesia, numbness, or both, in the small or the ring finger, or in both. In more severe cases, ulnar nerve motor dysfunction will lead to weakness, atrophy, pain across the elbow, and hand clumsiness6. Using crutches or walking sticks or pliers-type tools or riding a bicycle on a mountain could cause compression below the wrist, which was neglected by most of the researchers.

Reason:

The aim of this research is to establish

1.To see the relation of sensory nerve involvement across the wrist with the entrapment across the elbow and to evaluate its effectiveness in each level without going for invasive tests like needle EMG examination.

2.To identify the lesion below and across the wrist in terms of support, the clinical Physiologist (CP) grades them properly and also helps the consultant in deciding to treat with conservative or surgical treatment.

3.To compare the recording from the first dorsal interosseous (FDI) muscles with the abductor digiti minimi (ADM) muscle to see which muscle is more sensitive and shows early changes in ulnar nerve entrapment.

4.To differentiate the grading of Guyon's canal with sensory entrapment below the wrist.

5.To analyse the severity of entrapment in both areas (below/across wrist and elbow).

This could support the Surgeon to ascertain the level of severity and decide on a conservative or surgical approach to treatment. Surgeons have to make their own decision about the treatment if they want to consider the treatment on the basis of a Nerve conduction study.

There are several primary grading tests mentioned in the literature, such as placing paper between digits IV-V, Tinel sign at wrist or elbow, flexion elbow at 90°, supination of the forearm, and extension of the wrist. These are subjective tests based on the patient's clinical response. Other tests like Ultrasound, Nerve conduction study (NCS) and Electromyogram (EMG) needle examination are objective tests that have been used for ulnar nerve entrapment (UNE). These are reliable, evidence-based, objective tests that are not dependent on the patient's clinical response8.

Electrodiagnostics are proving to be an important tool in identifying ulnar nerve lesions across the wrist, between digits V to mid-palm, in cubital tunnel syndrome, compression across elbow, and correlation of entrapment in both areas simultaneously (double crush syndrome) at different levels, while excluding other disorders in the differential diagnosis such as brachial lower trunk plexopathy and C8–T1 radiculopathy11. To ascertain the severity and level of entrapment of the ulnar nerve, specific neurophysiological testing is required. There are several investigations specifically related to UNE, including [Karvelas11, Daniele Coraci6, Solange G. Garibaldi13, Magdalena Lewanska12, Laboratoire d'e´lectromyographie10, Anthony Chiodo2, and Carisa Pearce4]. Most of the grading studies are subjective. Some lack a neurophysiological focus on objectivity during data collection. My previous research paper was associated with lesions across the elbow and other research paper show the level of ulnar nerve entrapment across the wrist with insufficient clarification in grading9.

There is no clear guidance to diagnose the ulnar nerve at or below the wrist and in relation to across the elbow published by the British Society for Clinical Neurophysiology (BSCN) or (the Association of the Neurophysiological Scientists (ANS) which are professional bodies in the UK.

No clinical assessments will be conducted during the Neurophysiological test so as to eliminate bias of the patient's condition.

Method:

The test will be performed by a qualified Clinical Physiologist (Neurophysiology) using Key Point 9033A07 (Skovlunde, Denmark) machine, on the basis of departmental protocol (Ulnar nerve screening protocol1.2, 2022). A quantitative method will be used for collecting data, to ensure accuracy and to avoid bias. The sample size of patients in the study will be used for all those tested for NCS over a period of one year six months from January 2022 to June 2023, across the population of North Wales. The data will be collected from patients who would be referred to the Neurophysiology department from the Orthopaedics and Neurology departments within the local Health Board, as well as General Practices (GPs) in North Wales. No individual patient will be recruited in this research. The inclusion criteria would be considered only on the basis of the referral diagnosis. No clinical assessment will be conducted prior to the study in the department. Referral will be considered based on paraesthesia, pain, and swelling in the ulnar distribution area or digits IV-V or in all fingers.

Data will be analyzed on certain widely accepted assumptions of sensory amplitude and CV and distal motor latency (DML), amplitude, and CV1,3.

Cervical radiculopathy, polyneuropathy or other clinical significance other than ulnar nerve entrapment would be excluded from this research.

The procedure began by carrying out the sensory testing, by placing the stimulating ring electrodes on digit III for the median nerve and digit V for the ulnar nerve4 and the recording electrode on the WRIST surface corresponding to the nerve. The orthodromic technique was used for both sensory and motor NCS tests. A maximal current is applied to record the full response of the nerve, at the digits III for median sensory and digit V for ulnar sensory recording1. A maximal current is applied to record the full response from median nerve pathways at the wrist and at the elbow for motor recording from abductor pollicis brevis (APB), ulnar nerve pathways from First dorsal interosseous (FDI), and Abductor digiti minimi (ADM) at the wrist, below the elbow and above the elbow. Recording was made from the wrist by stimulating the mid-palm of the ulnar side at a distance of 8cm from the recording electrode, to test if the response from digit V was normal or less than 5µV or absent. If the response from mid-palm is less than 5µV or absent, the response was recorded from the dorsal ulnar cutaneous nerve (DUCN). Amplitude was recorded from peak to peak for sensory responses, and base to peak for motor responses.

All patient data was collected fulfilling the criteria mentioned in the above paragraph depending on the severity. The reason for using the above criteria is to describe the full range of severity, which was not fully covered by other

researchers mentioned earlier except in my previous research paper. The criteria mentioned are intended to be more reliable from a Clinical Physiologist prospective.

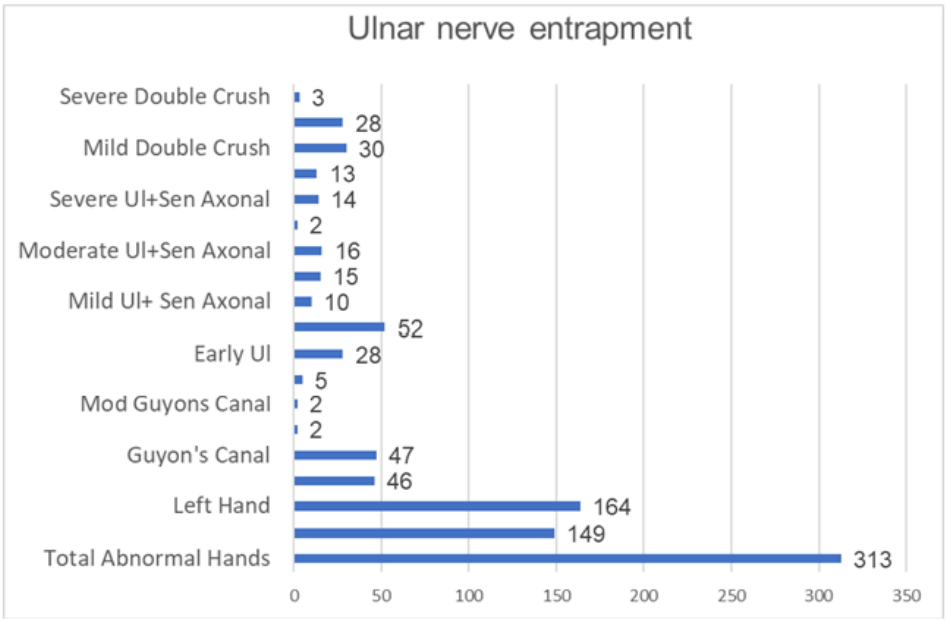
Data collected from elbow lesion in ulnar nerve pathways and shows signs of Martin Gruber anastomosis was not included in this research.

Results:

The data will be collected for a period of one year six months from January 2022 to June 2023. A total of 200 normal hands and 313 abnormal hands were included in this study. Out of 313 abnormal hands, 149 were right hands and 164 were left hands. 46 hands showed lesion between digit V to mid-palm, 56 hands showed lesions around Guyon's canal at different levels i.e. 47 hands showed lesions at Guyon's canal with low amplitude between palm to wrist and digit V to wrist with normal CV, 2 hands showed involvement of superficial area of Guyon's canal, where CV was slow and amplitude was normal, 2 hands showed moderate Guyon's canal lesion, where there was slow CV, low amplitude potentials between digit V to mid-palm and digit V to wrist and normal amplitude and CV in dorsal ulnar cutaneous nerve and normal CV across elbow, 5 hands showed absent amplitude and CV between digit V to wrist including mid palm and normal amplitude and CV in dorsal ulnar cutaneous nerve. 28 hand fell into early entrapment across elbow where amplitude and CV between digit V to the wrist were normal and also normal CV and amplitude across elbow while recording made from ADM muscles and shows slow conduction velocity with normal amplitude across elbow while recording from FDI muscles. 52 hands fell into the mild category where there was normal amplitude and CV in sensory nerve and slow conduction between 49-41m/s from FDI and ADM both with normal amplitude. 10 hands showed mild ulnar nerve entrapment across elbow in both FDI and ADM muscles with absent sensory potential including digit V to wrist, palm to digit V, and dorsal ulnar cutaneous nerve. 15 hands fell into moderate grading where sensory studies were normal including CV and amplitude and slow CV between 40-31m/s across elbow with normal amplitude. 16 hands showed moderate ulnar category with sensory axonal involvements in digit V-wrist including dorsal ulnar cutaneous nerve. 2 hands showed severe ulnar nerve entrapment across elbow with CV below 30 m/s and normal sensory potentials. 14 hands showed severe ulnar nerve entrapment with absent sensory potentials, and 74 hands were found to have double crash syndrome where the patient has lesions below and across the wrist and across the elbow at different levels i.e. 13 hands fell into early double crush where sensory nerve showed low amplitude either only between digit V to mid-palm or / and low amplitude between mid-palm to wrist with only FDI across elbow showing slow CV and normal CV with ADM. 30 hands fell into the category of mild double crush where there was low amplitude either between digit V to mid palm or digit V to wrist with normal DUC and slow CV in both FDI and ADM across elbow. 28 hands fell into moderate double crush syndrome where either low amplitude and normal or slow sensory CV was seen between digit V-to mid-palm or digit V to the wrist and normal DUC with slow motor CV (30-39 m/s) between both FDI and ADM muscles. Only 3 hands fell into the severe category where sensory potentials showed either low amplitude potentials between digit V to mid-palm or digit V to wrist and/or slow CV in that area with severe slow CV (<30m/s) across elbow in both FDI and ADM muscles. One case appears to moderate sensory motor Guyon's Canal with moderately slow CV across the elbow. Researcher saws only 2-3 cases of that type in past 20 years. Researcher consider it as a rear case and give it the title "Type I sensory-motor Guyon's canal".

Hirani Ulnar Grading	Findings
Normal	Motor conduction velocity (MCV) ≥50 m/s in FDI and ADM, distal motor latency ≤4.2 ms, amplitude ≥ 5 mV, sensory amplitude ≥ 5μv, and sensory conduction velocity (SCV) ≥ 50 m/s.
Type 1- rare case Sensory-motor Guyon's canal	**Distal motor latency** >4.5ms, Sensory amplitude >5μv, SCV <45m/s, Normal motor amplitude and conduction velocity.
Type II Superficial branch of ulnar nerve entrapment	SCV <45m/s between palm-wrist and digit V to wrist with normal amplitude. Normal DUC amplitude and CV. Normal DML, amplitude, and MCV.
Grade 1 Ulnar Sensory Nerve Entrapment (USNE) between digit V - palm	Ulnar Sensory Nerve Entrapment (USNE) between digit V - palm; Low amplitude sensory potential (<4μV), normal amplitude between palm and wrist; normal SCV (>50/sec) across wrist; and normal motor distal latency, amplitude, and MCV across elbow.
Grade 2 USNE at Guyon's canal	USNE at Guyon's canal; Low amplitude sensory potentials (<4μV) between palm to wrist and palm to digit V with normal SCV between palm to wrist and between digit V to palm and normal motor response at wrist and elbow with normal Dorsal Ulnar Cutaneous nerve amplitude and SCV
Grade 3 UNEAE - early stage	UNEAE - early stage; MCV across elbow 41-45m/s in FDI or more than 20% drop of CV across elbow and normal in ADM. Normal distal latency, amplitude in ADM and FDI with normal sensory potentials from V and SCV.
Grade 4 UNEAE mild motor stage	UNEAE mild motor stage; MCV across elbow 41-49m/s in both FDI and ADM or more than 20% drop of CV across elbow, normal distal motor latency with normal sensory potentials form digit V and normal SCV.
Grade 5 UNEAE in a moderate sensory-motor stage	UNEAE in a moderate sensory-motor stage; MCV across the elbow of 30–40 m/s in both FDI and ADM; normal distal motor latency. Sensory potentials shows low amplitude between digit V and mid-palm, palm to wrist. Dorsal ulnar cutaneous nerve may show normal or slow SCV.
Grade 6 UNEAE in severe sensory-motor stage	UNEAE in severe sensory-motor stage; MCV across elbow <30m/s, normal distal motor latency with absent sensory nerve potentials from digit V, palm to wrist and dorsal ulnar cutaneous nerve.

Table 1



Conclusion:

Despite the relatively small region of involvements of ulnar nerve entrapment at or below the wrist in moderate to severe levels either across or below the wrist and across the elbow, it has a wide range of clinical presentation that may result in frequent misdiagnosis. The reason is that it is anatomically difficult to differentiate the lesion due to the presence of other nerves in the region of the ulnar nerve. Furthermore, alternative etiologies need to be considered in cases of ulnar neuropathy at or below the wrist including double crush involvements. Accurate clinical examination, knowledge of ulnar nerve, and wrist anatomy, and familiarity with possible clinical patterns are essential to making the diagnosis which can then be confirmed with neurophysiology tests and Neuro-imaging. By considering all the above information, Researcher grade them into 6 grading i.e. Type 1-rare case sensory motor Guyon's Canal, Type II – Superficial branch of ulnar nerve entrapment, Grade 1- Ulnar sensory nerve entrapment (USNE) between digit V to mid-palm, Grade 2 USEN at Guyon's Canal, Grade, 3 -UNEAE – early stage, Grade 4- UNEAE mild motor stage, Grade 5- UNEAE in moderate sensory-motor stage and Grade 6- UNEAE in severe sensory-motor stage. The grading system with explanation is provided in chart form for clarity. Researcher also added a value chart.

Abbreviations:

Ulnar nerve entrapment (UNE), Ulnar nerve entrapment across wrist (UNEAW), Dorsal Ulnar cutaneous (DUC), Nerve Conduction Studies -NCS, Betsi Cadwaladr University Health Board -BCUHB, General Practices -GPs, Association of Neurophysiological Scientists - ANS, abductor polices braves - APB, First dorsal interosseous (FDI), sensory conduction velocity - SCV, conduction velocity -CV, Distal Motor Latency - DML, normal sensory amplitude - NSA, Sensory nerve action potentials -SNAP, normal motor amplitude - NMA, Motor nerve action potentials -MNAP, motor conduction velocity – MCV, Normal (N), Palm to wrist (P-W), across elbow (AC/Elbow), Abductor digiti minimi (ADM)

Competing Interests:

The authors declare that he has no competing interests.

Author's Contribution:

The Author will contribute by the collection, analysis, and interpretation of data and in writing the manuscript.

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