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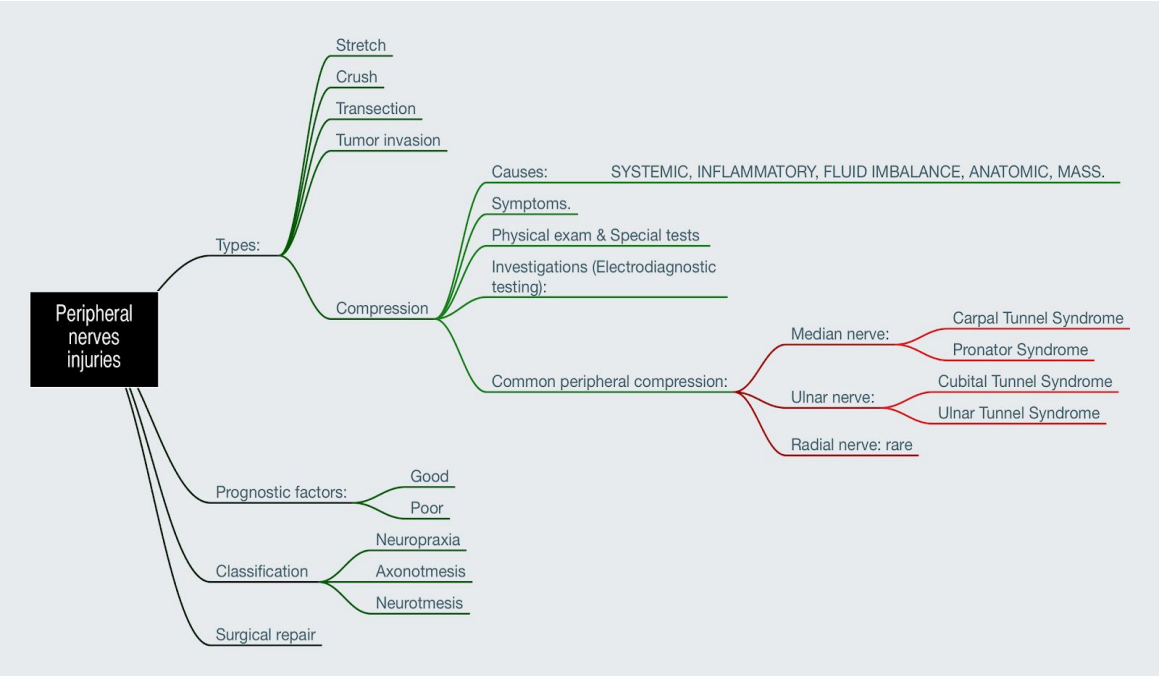
Peripheral Nerve Injuries

Objectives:

★ Peripheral nerve injury.
★ Compression neuropathy.

Done by: Shahad Alanazi
Edited By: Bedoor Julaidan
Revised by: Dalal Alhuzaimi
References: 435 Lectures And Notes \ Apley's \ 435 Team

Lecture outline:

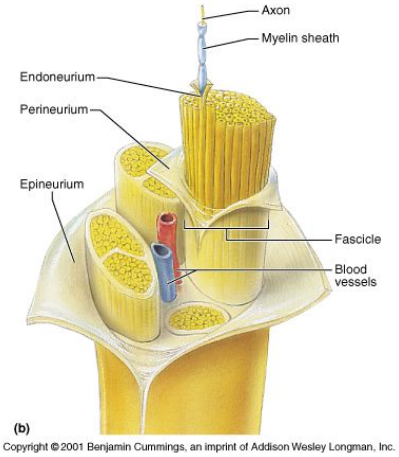


Peripheral nerve injury

Peripheral nerves sheaths:

The nerve fibers are arranged in bundles (fascicles) that are embedded in loose connective tissue:

- **Epineurium:** The outermost dense irregular fibrous connective tissue protective sheath surrounding each peripheral nerve, composed of various nerve fascicles/bundles; this outer layer contains some adipocytes and small blood vessels.
- **The perineurium:** The intermediate layer of dense irregular fibrous connective tissue protective sheath surrounding each nerve fascicle/bundle within a peripheral nerve, composed of various nerve fascicles/bundles.
- **Endoneurium:** The innermost loose irregular fibrous connective tissue protective sheath surrounding each nerve fiber (axon or dendrite) within each fascicle/bundle of a peripheral nerve; this layer will be external to the myelin sheath of a myelinated axon; this inner layer contains some mast cells and small blood capillaries.



Causes of peripheral nerve injuries:

1. **Compression.** أغلب التركيز في هذه المحاضرة بيكون على هالنوع (acute fracture of the distal radius is associated with carpal tunnel syndrome),
2. **Stretch.** (After surgery, for example humorous surgery and the patient present post-op with drop-wrist due to stretching of the nerve) لمن يكون الشخص بالسيارة، ويصير عليه حادث و الرست حقه يتمدد، حتى لو ما انقطع العصبي بيتأثر بالنهاية
3. **Blast** (Gunshot wound or explosion)
4. **Crush.** (مثال لمن تطيح حجرة على منطقة الرسغ - The worst.)
5. **Transection.** (Knife stab or iatrogenic in the OR) يخيطونه وله قود ركفري
6. **Tumor invasion.** Worst

7. **Avulsion** (Gunshot wound when the bullet Penetrates the body it pulls some tissue with it or with retraction in the OR)

Prognostic factors:

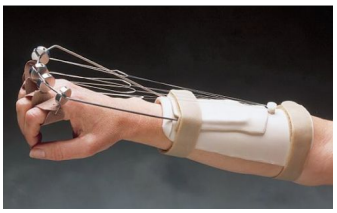
Good prognostic factors for recovery:	Poor outcome
• Young age: **most important factor.** • Stretch/ sharp injuries. • Clean wounds. • Direct surgical repair.	• Crush injuries. • Infected or scarred wounds. • Delayed surgical repair.

Classification:

Neurapraxia	Axonotmesis	Neurotmesis
Mild nerve **stretch or contusion**	Incomplete nerve injury. Associated with trauma and fractures	Complete nerve injury قطع كامل.
Focal conduction block		Conduction block
No wallerian degeneration[1]	Wallerian degeneration distal to injury.	Wallerian degeneration distal to injury.
• Disruption of myelin sheath • Epineurium, perineurium, endoneurium: intact. Physiological changes. مثل اللي جلس فترة طويلة على رجوله وقام و شعر بتنميل بساقه.	• Disruption of axons. الاكسون متأثر.	• Disruption of all layers, including epineurium • Proximal nerve end forms neuroma • Distal end forms glioma.
Prognosis: excellent → full recovery	Recovery unpredictable	Worst prognosis
A reversible physiological nerve conduction block in which there is loss of some types of sensation and muscle power followed by spontaneous recovery after a few days or weeks. It is due to mechanical pressure causing segmental demyelination and is seen typically in 'crutch palsy', pressure paralysis in states of drunkenness ('Saturday night palsy') and the milder types of tourniquet palsy.	The term means, literally, axonal interruption. There is loss of conduction but the nerve is in continuity and the neural tubes are intact. Distal to the lesion, and for a few millimetres retrograde, axons disintegrate and are resorbed by phagocytes. This wallerian degeneration takes only a few days and is accompanied by marked proliferation of Schwann cells and fibroblasts lining the endoneurial tubes. The denervated target organs gradually atrophy, and if they are not reinnervated within 2 years they will never recover. These axonal processes grow at a speed of 1–2 mm per day, Eventually they join to end-organs, which enlarge and start functioning again.	As in axonotmesis, there is rapid wallerian degeneration, but here the endoneurial tubes are destroyed over a variable segment and scarring thwarts any hope of regenerating axons entering the distal segment and regaining their target organs. Instead, regenerating fibres mingle with proliferating Schwann cells and fibroblasts in a jumbled knot, or 'neuroma', at the site of injury. Even after surgical repair, many new axons fail to reach the distal segment.

[1] the process of antegrade degeneration of the axons and their accompanying myelin sheaths following proximal axonal or neuronal cell body lesions.

Surgical repair:



- Best performed within **2 weeks of injury**.
- Repair must be:
  - **Free of tension.** (any tension force will decrease blood supply)
  - Within clean, well-vascularized wound bed.
- Nerve length may be gained by neurolysis or transposition. (neurolysis: release the proximal and distal tension of the nerve).
- Direct end to end repair.
- Larger gaps → grafting.

Example1:
Humeral midshaft fracture that looked spiral on X-ray. The resident came in and checked the NV status, and found it intact. During his examination he noticed a little displacement. He called the consultant and asked him if he can realign it?
After realignment → Patient's **WRIST DROPPED!** (= Radial nerve injury!)

- المريض معد يقدر يحرك يده! و لا يقدر يحس بشيء! و لا حتى يحس بألم!

وش حصل هنا للمريض؟ كان مافيه إلا العافية قبل الري-اليانمنت! لا يعلم ذلك إلا الله!

- ايش المكانزم اللي ممكن حصلت للمريض وأثرت على عصب المريض؟

1. Stretching. 2. Compression (between 2 fragments of the fracture) 3. Transection.

- ماذا نفعل وكيف نتصرف؟ هذي تعتبر من الـ Dilemmas وعندنا خيارات عديدة:

1. Wait until he recovers: first thing will back is pain (numbness), motor will take time.
2. Nerve conduction study after 6 weeks (الـ NSC قبل هال6 أسابيع ما نقدر نستخدم): if it shows:
   a. Signals = nerve is intact = either Neuropraxia or Axonotmesis.
   b. No signals = Not functioning = Neurotmesis
      i. Explore and call plastics to suture it.
3. Wait for days, and if he doesn't recover:

نقول يا عمي أنا قلق على العصب. بندخل نشوف ايش وضع العصب وبنفس الوقت دامني فاتح فاتح بثبت لك الكسر بدال ما اعالجك conservative وبكلم زميلي جراح التجميل المناوب بأنه يكون متواجد قريب وفي حالة شفت العصب متضرر ومنقطع بكلمة يجي يصلحه.

- ماذا عن النتيجة هل فيه فرق بين اني انتظر 6 اسابيع لحد ما اقدر استخدم الـ NCS أو اني افتح بعد كذا يوم إذا ما لاحظت تحسن؟ غالبا ما فيه فرق لأن معظم الحالات تكون Neuropraxia.

Example 2:

زميل ماله خلق الجبس ويبي يتعافى بشكل أسرع وما عنده مشكلة مع وجود الندبات. طلب مني اني اسويله عملية واثبت له كسره.
بعد بقول له: "الرديل نرف جدًا حساس وخلال العملية لازم اوخره عن طريقي علشان اقدر ادخل الـ plates and screws وممكن تصحى وتلقى يدك dropped."

★ فرضا صحى من النوم ولقى يده dropped بهذي الحالة أنا عارف انه Neuropraxia لأني فاتح وشايف كل شيء قدامي وأخذت الحيطة والحذر.

- علشان ترجع يده لوضعها الطبيعي تحتاج من 6 الى 9 أشهر. (كل 1 مم يحتاج يوم كامل علشان يتجدد) هل اخليه كذا؟
  - الإجابة لا! بحطه على Splint.

- Why? to avoid contracture. (Static one is better than the dynamic one).
-

Compression Neuropathy:

Introduction:

Nerve compression impairs epineural blood flow and axonal conduction, giving rise to symptoms such as numbness, paraesthesia and muscle weakness; the relief of ischaemia explains the sudden improvement in symptoms after decompressive surgery. Prolonged or severe compression leads to segmental demyelination, target muscle atrophy and nerve fibrosis; symptoms are then less likely to resolve after decompression.

- ★ It is a condition with sensory, motor, or mixed involvement.
- ★ If mixed pathology, sensory function is affected first and then motor is affected "this is because Motor fibers have thick myelin sheath".
    - As a result, first symptom to appear is hypoesthesia and lastly atrophy of the muscles which means severe disease.
- ★ **The sensory functions lost are as follows:**
    - First lost → **light touch** – pressure – vibration (mild)
    - Last lost → **pain sensation loss – temperature** (severe)
- ★ **The pathophysiology of compression neuropathy:**
    - Microvascular compression due to any cause → neural ischemia → paresthesia → Intraneural edema → more microvascular compression → demyelination → fibrosis → axonal loss

Common systemic conditions leading to compression neuropathy:

SYSTEMIC	ANATOMIC
Diabetes – Alcoholism – Renal failure – Vit B deficiency	Fibrosis – Anomalous tendon – **Fracture deformity** (distal radial fracture with dorsal angulation may lead to median nerve compression)
FLUID IMBALANCE	**MASS**
Pregnancy (carpal tunnel is very common during pregnancy) – Obesity (They usually have bilateral numbness of the hand)	**Ganglion** – Lipoma – Hematoma
INFLAMMATORY	
Rheumatoid arthritis – Infection – Gout – Tenosynovitis	

Symptoms:

- ★ **Numbness.** Commonest
- ★ Night symptoms. المريض يقول اقوم الليل وانفض يدي
- ★ Dropping of objects. تطيح من يدي الأشياء ومقدر امسك فنجان القهوة
- ★ Clumsiness.
- ★ Weakness.

Physical examination

- ★ Examine individual muscle power → grades 0 to 5 → pinch strength - grip strength.
- ★ Neurosensory testing:
    - Dermatomal distribution
    - Peripheral nerve distribution

Special tests:

1. **Semmes-Weinstein monofilaments:** Very fine mono-filaments that evaluate light touch. FIRST THING TO BE LOST IS FINE TOUCH.
   - The best test - can detect very early neuropathy.
   - Cutaneous pressure threshold → function of large nerve fibers which is first to be affected in compression neuropathy.
   - Sensing **2.83** monofilament is normal.
2. **Two-point discrimination:**
   - Static function is lost first and then dynamic.
   - Performed with closed eyes.
   - Inability to perceive a difference between points **> 6 mm** is considered ABNORMAL **"Late finding".**

Investigations (Electrodiagnostic testing): Gives you an idea about the condition of the nerve (functional?), and helps you to localize the point of compression.

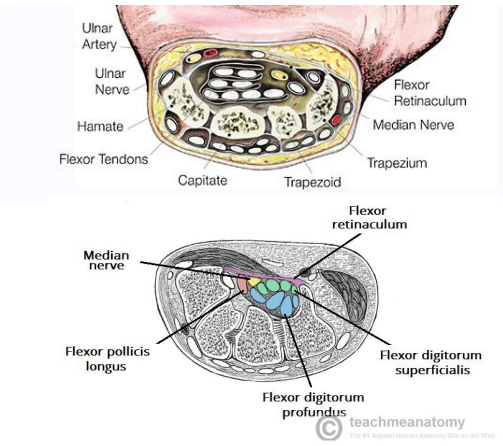
- ★ Sensory and motor nerve function can be tested through EMG and NCS.
- ★ **Done by: Neurophysiologists or technicians.**
- ★ Operator dependent (disadvantage).
- ★ Objective evidence of **neuropathic condition**.
- ★ Helpful in **localizing** point of compromise.
- ★ In the early disease, there is a High false-negative rate

NCSs (nerve conduction studies):	EMG (Electromyography):
Tests conduction **velocity**, distal latency and amplitude	Tests muscle **electrical activity**
Demyelination → ↓conduction velocity + ↑distal latency axonal loss → ↓ potential amplitude	Muscle denervation → fibrillations - positive sharp waves

Median nerve compression:

1- Carpal tunnel syndrome: Most common compressive neuropathy

Anatomy:	•**Boundaries:** ○ **Volar:** Transverse carpal ligament (TCL) (flexor retinaculum). ○ **Radial:** scaphoid tubercle +trapezium ○ **Ulnar:** pisiform +hook of hamate ○ **Dorsal:** proximal carpal row + deep extrinsic volar carpal ligaments. •**Carpal Tunnel Contents:** ○ **Median nerve** ○ **FPL** (Flexor Pollicis longus) ○ **4 FDS** (Flexor Digitorum Superficialis) ○ **4 FDP** (Flexor Digitorum Profundus)
What?	Compression of the median nerve as it travels through the wrist at the **carpal tunnel**. ● **Normal pressure** → 2.5 mm Hg ● **>20 mm Hg** → ↓↓ epineural blood flow + nerve edema ● **30 mm Hg** → ↓↓ nerve conduction

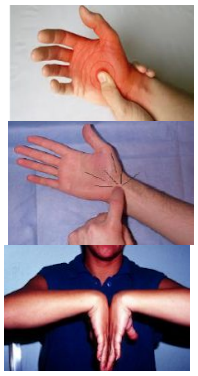


Risk factors:

1. **Obesity.** too much fat. (not that common)
2. **Pregnancy.** Very common but we don't do surgery because most of them will recover after pregnancy.
3. **Diabetes.** Can lead to neuropathy as well as carpal tunnel.
4. **Thyroid disease.**
5. **Chronic renal failure.**
6. **Others** → RA, storage diseases, alcoholism, **acromegaly** (Big bones = smaller space), advanced age.
7. **Repetitive strain injury** e.g. using computer, lady works on the kitchen and ortho trauma surgeons

Diagnosis:

1. **History:** the median nerve supplies 3 and half finger, the pt. will come to you complaining of numbness in 4 finger or the whole hand (which might confuse us with diabetic neuropathy or combined ulcer and median compression).
   a. **Numbness and pain**
   b. **Often at night**
   c. **Volar aspect → thumb - index - long** (middle) **- radial half of ring**
   d. **Risk factors**
2. **Physical examination:** (affected first → light touch + vibration , affected later → pain and temperature)
   a. **Special tests:**
      i. **Durkan's test: most sensitive**. Examiner presses thumbs over carpal tunnel and holds pressure for 30-60 seconds. An onset of pain or paresthesia in the median nerve distribution within 30-60 seconds is a positive result of the test.
      ii. **Tinel's test:** performed by lightly **tapping** (percussing) over the nerve to elicit a sensation of tingling or "electrical shock" in the distribution of the nerve. video
      iii. **Phalen's test:** the area will be tightened and the nerve will be compressed



   b. **Semmes-Weinstein monofilament testing** → early CTS diagnosis
   c. **late findings** → Weakness - loss of fine motor control - abnormal two-point discrimination
   d. **Thenar atrophy** → severe denervation
3. **Investigations: Electrodiagnostic testing**
   a. Not necessary for the diagnosis of CTS (we do it sometime to rule out other differential)
   b. Distal sensory latencies > 3.5 msec
   c. Motor latencies > 4.5 msec

Notes

★ Special examination tests are not very sensitive in picking up the diagnosis. They can be negative and when we do NCS it will show that the patient have carpal tunnel.

★ If you're confident with your hx, PE, and your patient doesn't have any risk factors → No need to do EMG or NCS.

★ If the patient is diabetic → order NCS (to know the cause of the numbness, diabetic neuropathy ? or CTS?)

★ Sometimes the patient has both CTS & neuropathy → surgery will improve his symptoms لكن ماراح يتحسن نهائيا

★ دائما أفضل اطلب NCS خصوصا إذا كنت بمستشفى خاص وذلك لسببين: 1- شركات التأمين الصحي: علشان تتأكد ان الشخص فعلا لازم يسوي العملية. 2- أسباب قانونية: اسوي للمريض قبل وبعد العملية علشان يبين له انه التنميل والتخدير اللي جاه ماهو بسبب عمليتي انما لأسباب اخرى (مثلا عنده سكري، عمليتي بتخفف من حدة الأعراض لكن ماراح تسكتها)

DDx:

★ **Cervical radiculopathy**
★ **Brachial plexopathy**
★ **TOS** (Thoracic outlet syndrome)
★ **Pronator syndrome**
★ **Ulnar neuropathy**
★ **Peripheral neuropathy of multiple etiologies.** Mainly diabetes! diabetes! diabetes!

Treatment:

1. **Nonoperative**

a. Activity modification. حاول انك ما تخلي يدك دائما هايبر اكستندد
b. Night splints. Very effective especially in early stages.
c. NSAIDs.
d. Steroid injection.

نعقم المنطقة وندخل بالإبرة. هل هي خطيرة على العصب؟ لا. بنقول للمريض "إذا حسيت بكهرباء علمنا" لو قال "اوه كهرباء" بنسحب الإبرة على طول وننتظر فترة ونرجع نحقن بعد فترة. الميدين يا بنات سمح! ماهو مثل الرديل إذا تحرك على طول رست دروب!! الكمن برنيل كذلك يا بنات أي شيء ممكن انه يسبب فوت دروب!

2. **Operative:** المريض متأذي , تقرير النرف كندشن وضح بأنه شديد , جلس فترة تقارب ال4 أشهر على العلاج التحفظي وما نفع

a. **Open.** Under local anesthesia. we make an incision → go through skin → Subcutaneous tissue → transverse carpal ligament → release it.
احيانا فتحة الجراح تكون صغيرة فما يسوي رليز كامل وبعد العملية يظل المريض يعاني

b. **Endoscopic.** Faster recovery (if the patient is a surgeon or نجار and needs his hand).
نسوي انسجن بعدين ندخل بالمنظار بحيث ان العصب يكون اسفله واللقمنت فوقه. نضغط زر ويطلع رأس حاد (مثل السكين) بعدين نمشي على اللقمنت ونسويله رليز. (لازم تكون بغرفة العمليات)

Short term:	Long-term:
• Less early scar tenderness • Improved short-term grip/pinch strength • Better patient satisfaction scores	• No significant difference • May have slightly higher complication rate • Incomplete TCL release

C. Release outcome:
★ **Pinch strength → 6 weeks**
★ **Grip strength → 3 months**

D. Persistent symptoms after release:
★ **Incomplete release.** Most likely
★ **Iatrogenic median nerve injury.**
★ **Missed double.**
★ **Crush phenomenon.**
★ **Concomitant peripheral neuropathy.**
★ **Wrong diagnosis.**

Acute CTS: pt. comes with Hx of acute numbness for the last few hours

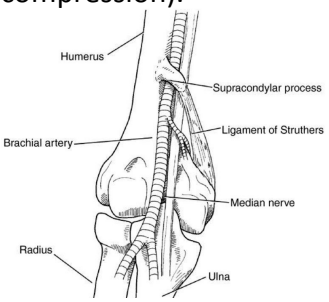
★ **Causes: high-energy trauma – hemorrhage – infection.**
★ **Requires emergency decompression**

2- Pronator syndrome: helpful link.

What?

Median nerve compression at arm/forearm "elbow"(5 potential sites of compression).

- Supracondylar process: residual osseous structure on distal humerus present in 1% of population
- Ligament of Struthers
  - travels from tip of supracondylar process to medial epicondyle
  - not to be confused with arcade of Struthers which is a site of ulnar compression neuropathy in cubital tunnel syndrome
- Bicipital aponeurosis (a.k.a. lacertus fibrosus)
- Between ulnar and humeral heads of pronator teres
- FDS aponeurotic arch

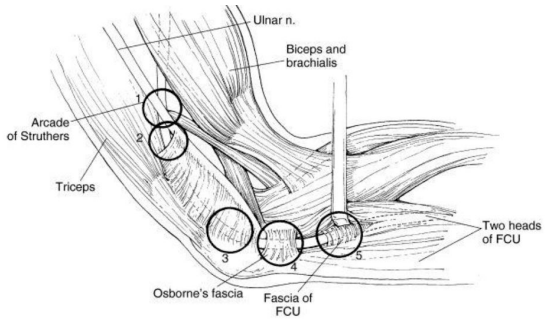


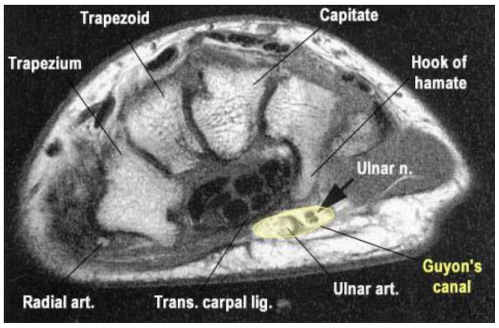
Symptoms:	★ Aching pain over proximal **volar forearm** .بالكاربل تنل مايجيب طاري المرفق على الإطلاق ★ Sensory symptoms → palmar cutaneous branch. ★ **Lack** of night pain.
Diagnosis:	1. **History** 2. **Physical examination** 3. **NCS/EMG** (if positive , we have to know the cause before intervening by ordering X-ray, CT, or MRI to know which area to release)
Treatment:	1. **Non-operative:** splints/ NSAIDs / activity modification. 2. **Operative:** if confersitive failed a. **Open.** b. **Endoscopic.**

Ulnar nerve compression:

	Cubital Tunnel Syndrome	Ulnar Tunnel Syndrome
Info:	**Second** most common compression neuropathy of the upper extremity. **Cubital tunnel borders:** **Floor** : MCL and capsule **Walls** : medial epicondyle and olecranon **Roof** : FCU fascia and arcuate ligament of Osborne	★ Compression neuropathy of ulnar nerve in the **Guyon's canal** (where the ulnar nerve and artery pass through) . • Causes: ○ **Ganglion cyst :** 80% of non-traumatic causes ○ **Hook-of-hamate nonunion.** pt comes with hx of trauma. ○ **Ulnar artery thrombosis or aneurysm –** ○ **Lipoma**
Symptoms	• **Numbness of ulnar half of ring finger and little finger.** (بيقول باصبعين مو اصبع ونص) • **Pain in the elbow that extends into the forearm and hand** • **Weakness of the hand and fingers** • **Provocative tests:** – Direct cubital tunnel compression – Tinel's test • **Froment sign:** thumb IP flexion (by FPL which is supplied by median nerve) during key pinch (weak adductor pollicis which is supplied by ulnar nerve)	• **Tingling sensation** within the **little finger and ring** • **Finger Pain** within the wrist • Difficulty **gripping objects** • **Loss** of ulnar nerve function. إذا قال المريض: "طحت على يدي ومن بعدها اصابعي صارت تنمل" فالغالب هنا هو حصول كسر بالـ hook of hamate.. بينكسر وبتصير عليه ازاحة وبينزل ويضغط على الالنار (شوفوا الصورة اللي بنهاية الجدول)
Investigations	★ **Electrodiagnostic tests:** diagnostic.	★ **CT:** hamate hook fracture. Hx of trauma → order X-ray and CT. ★ **MRI:** ganglion cyst or lipoma. No hx of trauma → MRI (cuz ganglion cyst accounts for 80% of the non-traumatic cases) (حتى لو ندري انها سيست ضروري الرنين علشان نعرف مكانها ونضبط الخطة الجراحية) ★ **Doppler ultrasonography:** ulnar artery thrombosis or aneurysm.
Treatment	**1. Nonoperative treatment:** • Activity modification • Night splints → slight extension – • NSAIDs **2. Surgical Release** → Numerous techniques	(Treatment success → identify cause) **1. Nonoperative treatment** • Activity modification • Splints • NSAIDs

	• **In situ decompression**, Anterior transposition, Subcutaneous, Submuscular, Intramuscular, Medial epicondylectomy • No significant difference in outcome between simple decompression and transposition	**2. Operative treatment**: decompressing by removing underlying cause. • Ganglion cyst, lipoma: excision. • Ulnar artery thrombosis or aneurysm: call vascular surgeon. • Hamate hook fracture: excise that piece of the bone.





Radial nerve compression:

Radial nerve compression: rarely compressed and mainly motor symptoms.

MCQs

1)A 23 year old patient comes with a symptoms of compression neuropathy of his ulnar nerve in the Guyon's canal. What is the investigation to be ordered in order to diagnose the most common cause of his condition?

A. CT scan.
B. X-ray.
C. MRI.
D. US

2)5 years old boy with cast for his wrist fracture that happened 3 days ago came to the ER with severe pain and numbness in his lateral 3 fingers, which one of the following conditions can explain his symptoms?

A. Carpal tunnel syndrome.
B. Compartment syndrome.
C. Cubital tunnel syndrome.
D. Drop wrist syndrome.

3)22 year old lady presented with small and ring fingers numbness, Tinel's sign was -ve, nerve conduction study showed ulnar nerve compression. what is the best next management?

A. X-ray.
B. US.
C. MRI.
D. CT.

4)Patient has an ulnar nerve injury how to confirm the diagnosis?

A. MRI.
B. CT.
C. Nerve conduction study.
D. X-ray.

Answers: 1: C - 2: A - 3: C -

SAQs:

Patient with carpal tunnel. what are the positive signs? and ddx?

- **Signs:** Durkan's test - Tinel's test - Phalen's test.
- **DDX:**
  - Cervical radiculopathy
  - Brachial plexopathy
  - TOS
  - Pronator syndrome
  - Ulnar neuropathy
  - Peripheral neuropathy of multiple etiologies