



# **CARPAL TUNNEL SYNDROME**

**DR Zakeri**

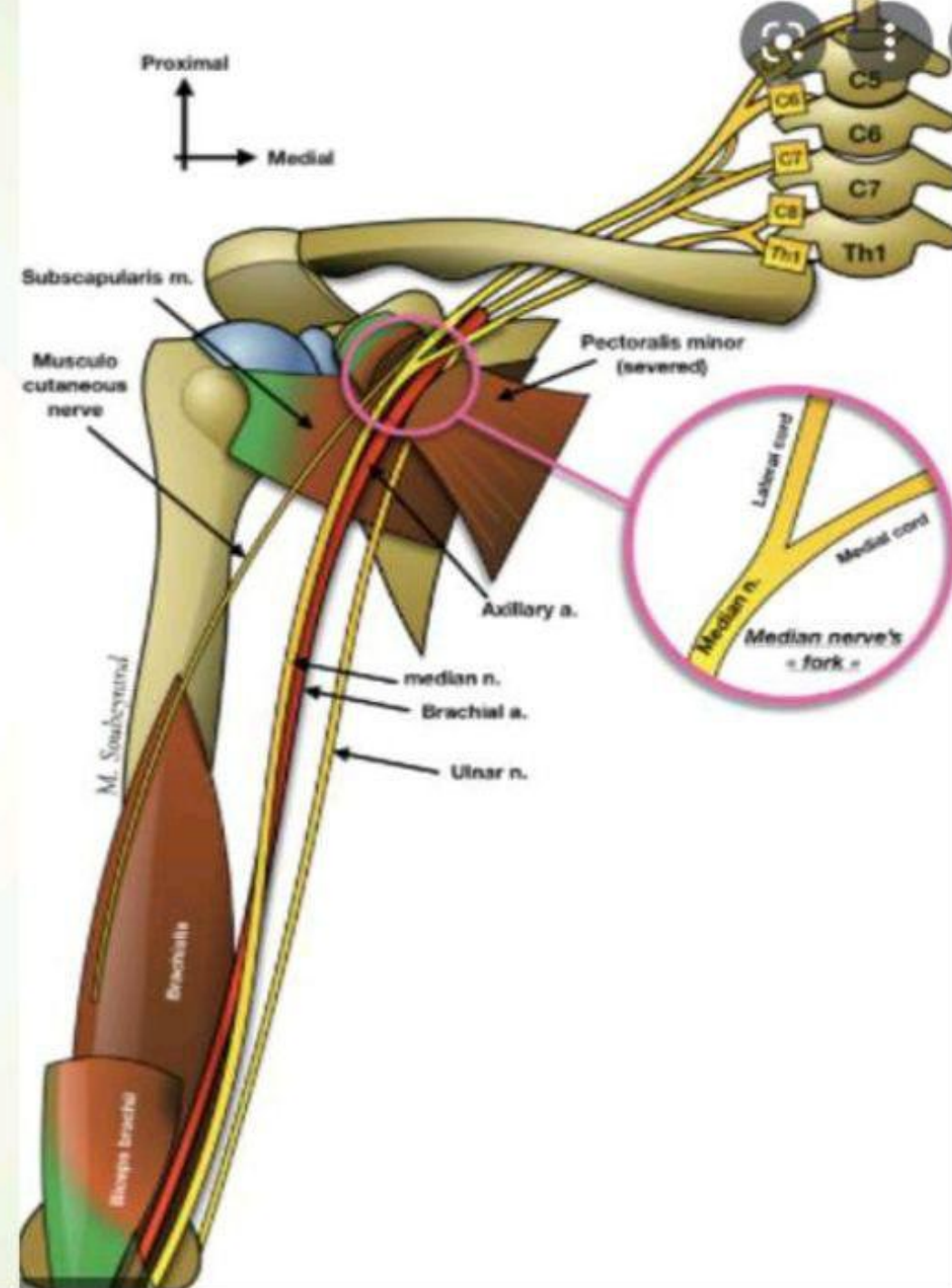


Carpal tunnel syndrome is the most common entrapment neuropathy encountered in clinical practice.

It is caused by compression of the median nerve as it passes through the carpal canal at the wrist.

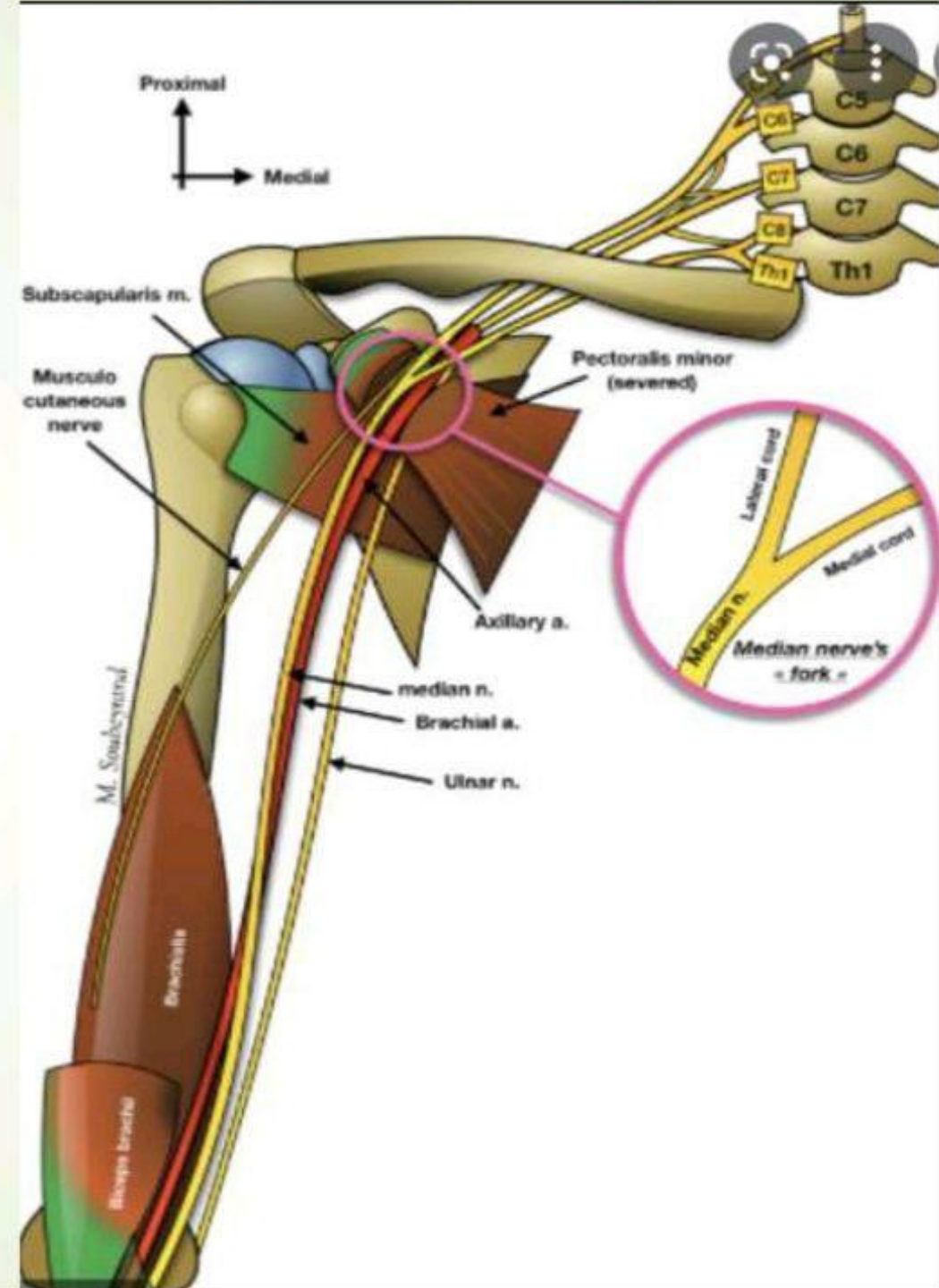
# median nerve

- ▶ The **median nerve** arises at the brachial plexus with origins from the medial and lateral cords (encompassing nerve roots C5-T1).
- ▶ The median nerve travels in the anterior compartment, medial to the humerus down to the forearm, and enters into the hand by passing through the carpal tunnel.

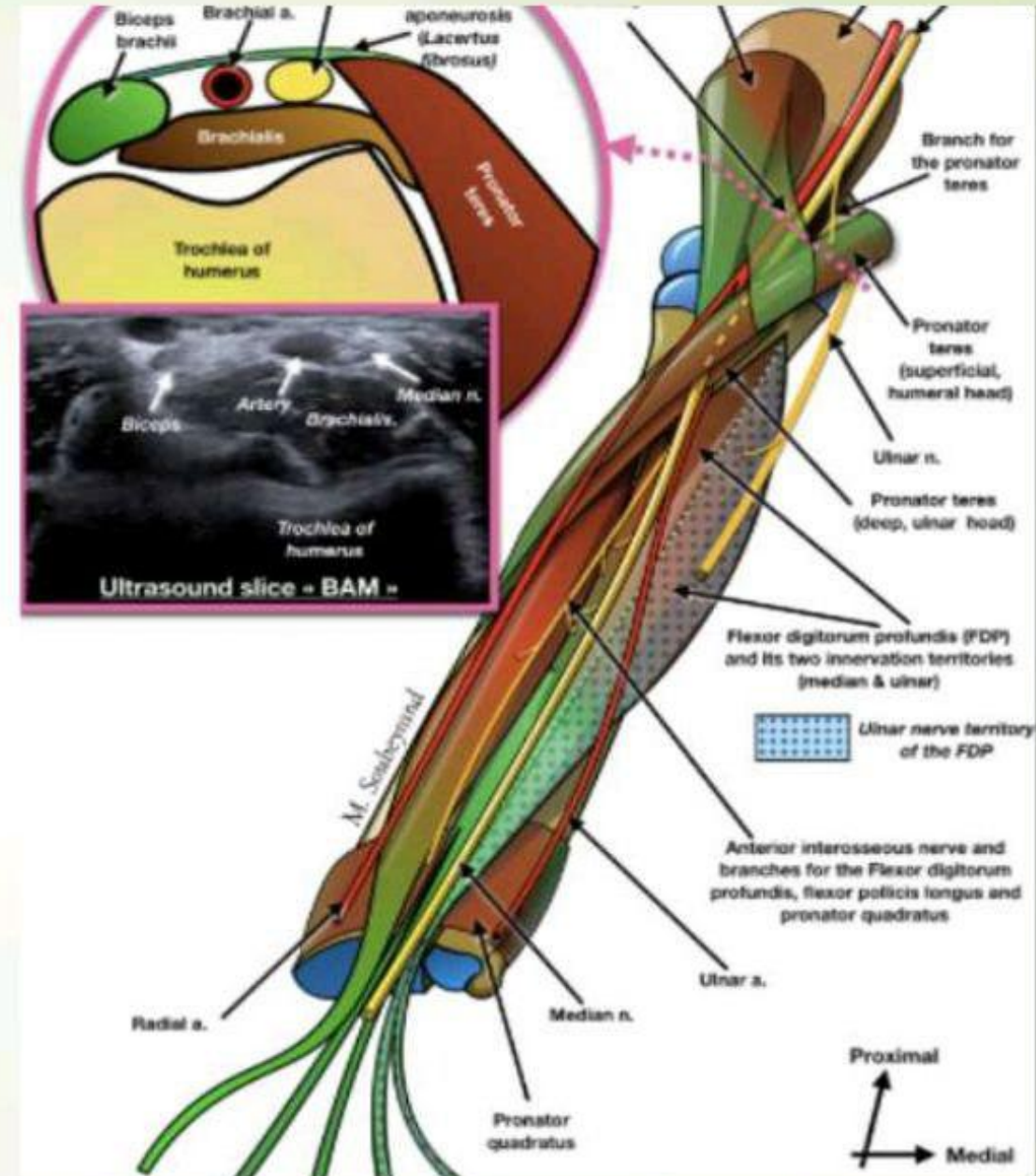


# median nerve

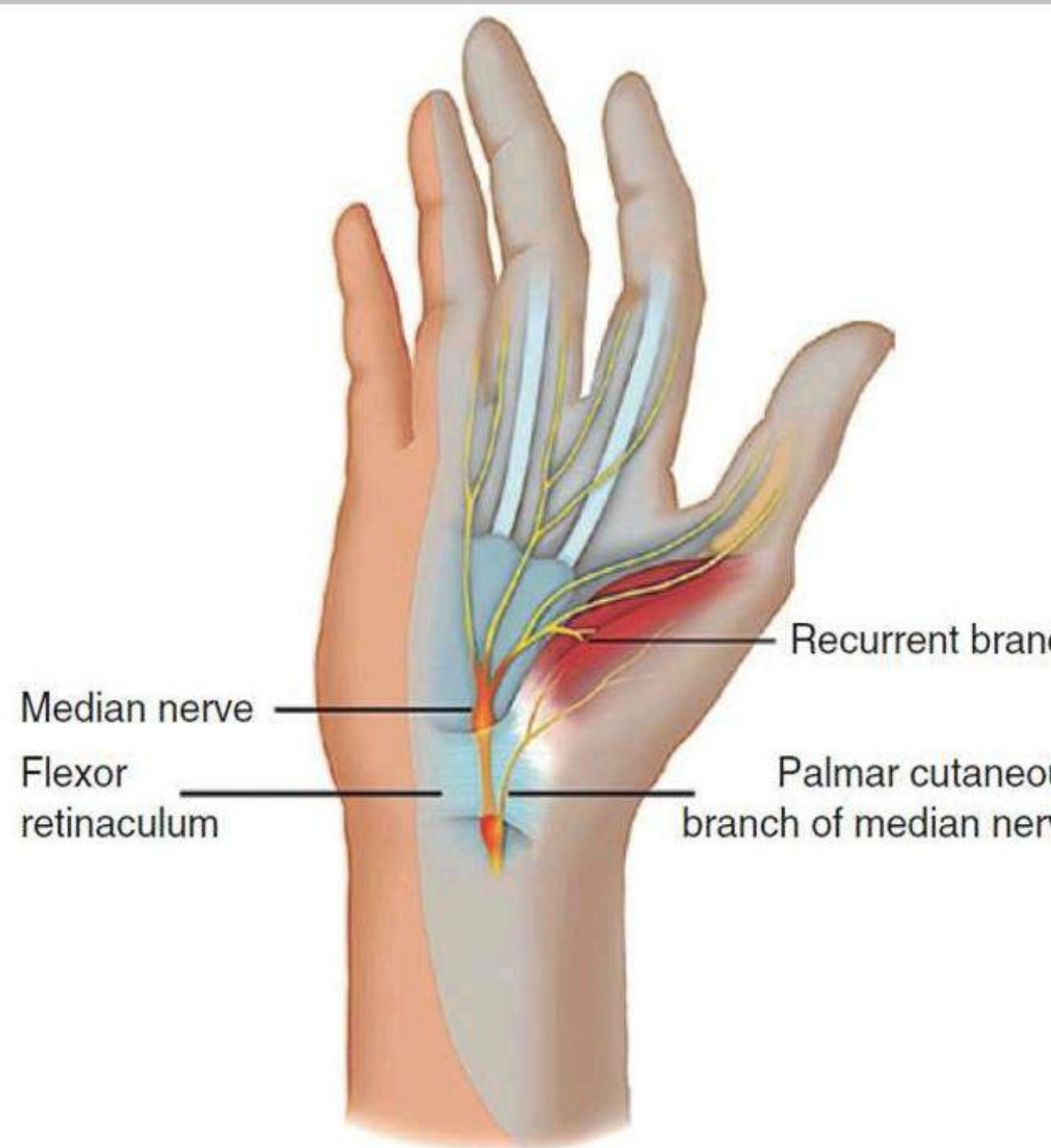
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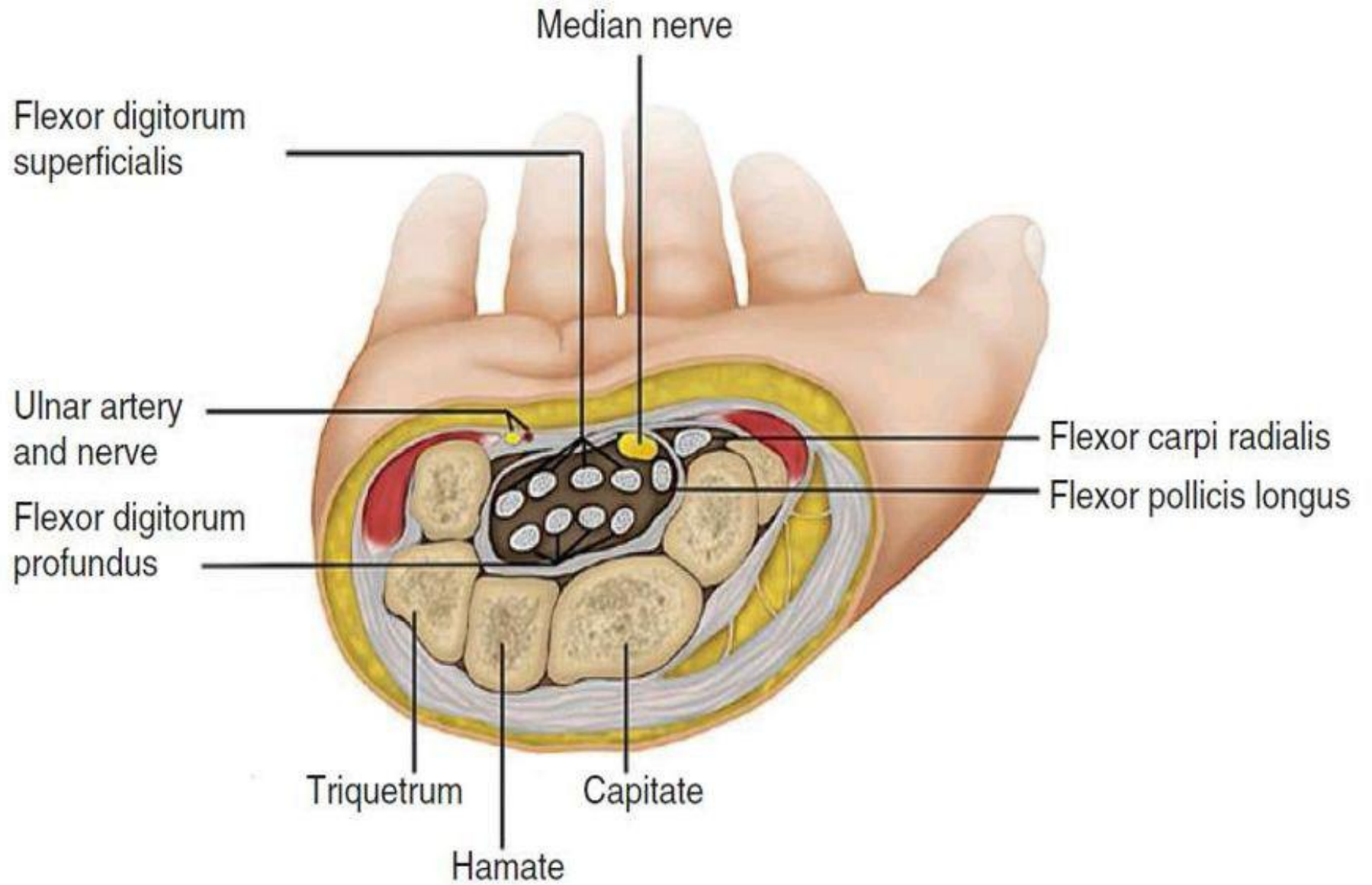



- At the forearm, it gives off two branches:
- the anterior interosseous nerve and palmar cutaneous nerve.



- After passing through the carpal tunnel, it gives off an additional two branches:
- the recurrent branch (provides motor to the thenar muscles)
- digital cutaneous branch (provides sensory to the lateral three and half digits and provides motor to the lumbricals)
- Of note, the palmar branch (provides sensory to the palm) is often spared as it comes off proximally and then travels superficially to the flexor retinaculum.








## The most common causes of compression

- Tenosynovitis
- rheumatoid arthritis
- pregnancy
- amyloidosis
- and other space-occupying lesions that compromise the median



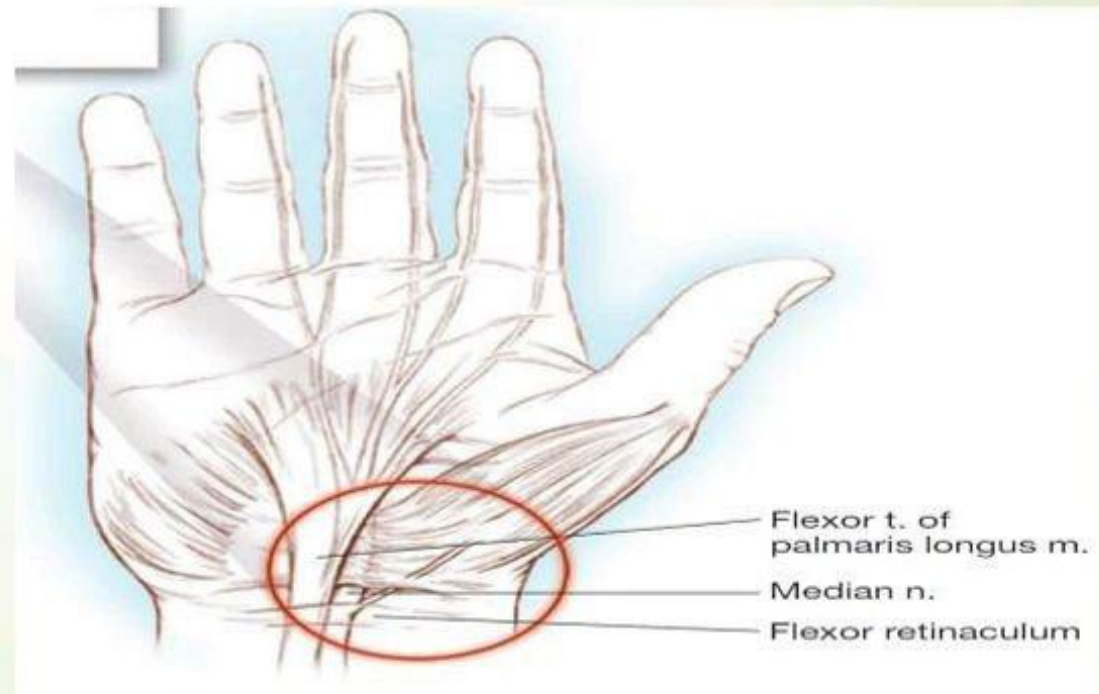
- ▶ It occurs more commonly in women.




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- ▶ symptoms may also radiate *proximal to the entrapment into the forearm.*
  - ▶ The palm and **little finger** are often spared.
  - ▶ Symptoms often worsen at **night** and after repeated use.
  - ▶ Untreated, progressive motor deficit and, ultimately, flexion contracture of the affected fingers can result.  
When untreated, weakness and atrophy of the **flexor pollicis brevis**, **opponens pollicis**, and **abductor pollicis brevis** may occur.

This entrapment neuropathy presents

- ***pain, numbness, paresthesias, and associated weakness in the hand and wrist that radiate to the thumb, index finger, middle finger, and radial half of the ring finger.***



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- The background features a series of concentric, overlapping circles in shades of light green, yellow, and white, creating a tunnel-like effect. In the top-left corner, there is a solid red arrow pointing to the right. On the left side, there are several thin, dark, curved lines that resemble stylized grass or reeds.
- Recent studies have suggested a higher incidence of abnormalities of connective tissue coding genes in patients suffering from carpal tunnel syndrome when compared with normal controls.



### Structural/Anatomic

- Persistent median artery
- Aneurysm
- Lipoma
- Ganglion
- Neuroma
- Acromegaly
- Fracture

### Inflammatory

- Tenosynovitis
- Collagen vascular disease
  - Rheumatoid arthritis
  - Scleroderma
- Gout
- Crystal deposition disease

### Neuropathic/Ischemic

- Diabetes
- Alcoholism
- Vitamin abnormalities
- Ischemic neuropathies
- Peripheral neuropathies
- Amyloidosis

### Shifts in Fluid Balance

- Pregnancy
- Hypothyroidism
- Obesity
- Kidney failure
- Menopause

### Repetitive Stress Related

- Abnormal hand and wrist position
- Excessive flexion
- Microtrauma
- Vibration

## SIGNS AND SYMPTOMS



Phalen maneuver



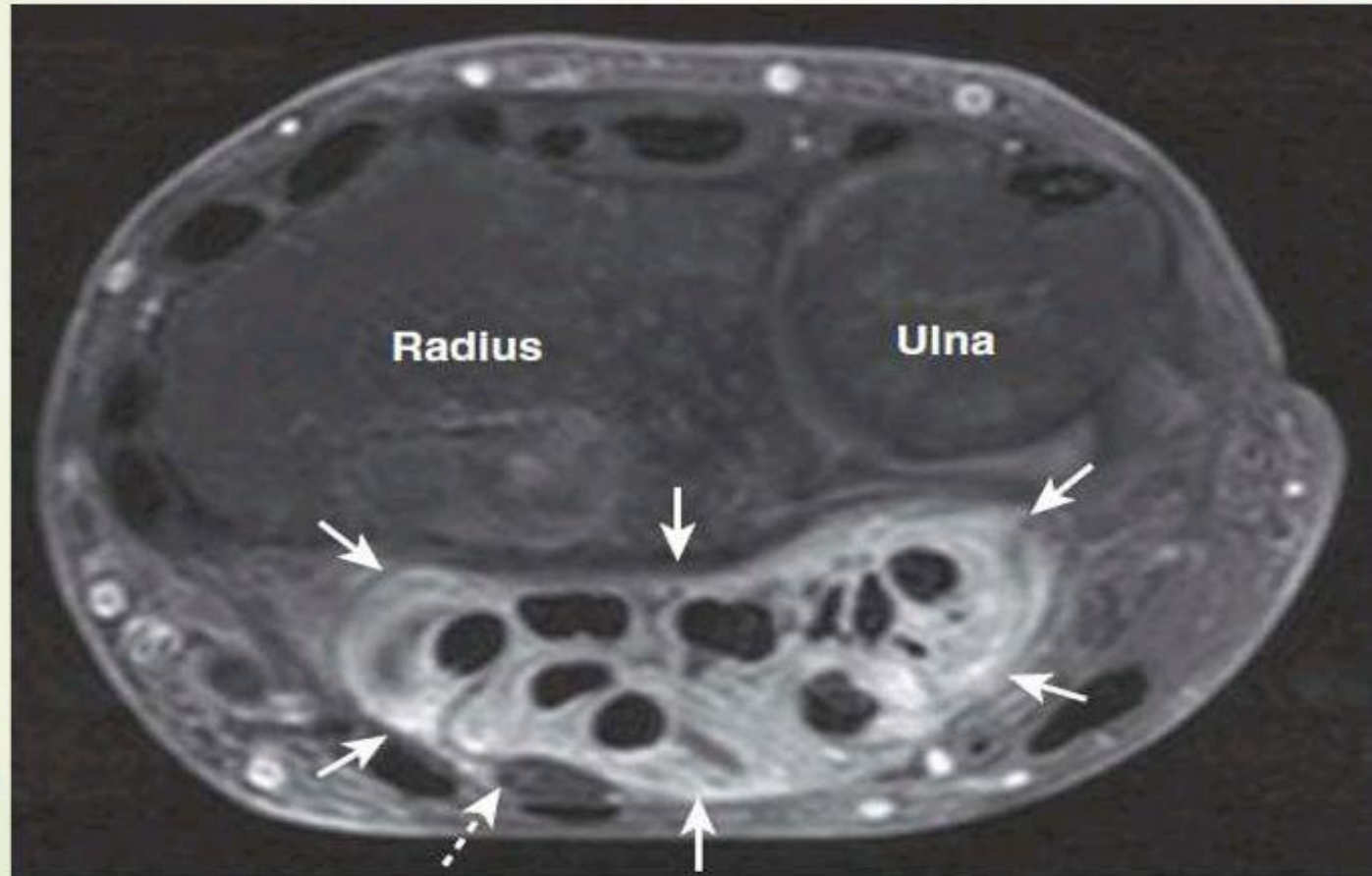
Tinel's sign



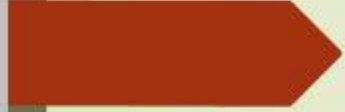
# TESTING

- ▶ **Electromyography** can distinguish cervical radiculopathy and diabetic polyneuropathy from carpal tunnel syndrome.
- ▶ **Plain radiographs** are indicated in all patients who present with carpal tunnel syndrome, to rule out occult bony disorders.
- ▶ Based on the patient's clinical presentation, additional testing may be warranted, including a **complete blood count, uric acid level, erythrocyte sedimentation rate, and antinuclear antibody testing**.
- ▶ **Magnetic resonance imaging** of the wrist is indicated if joint instability or a space-occupying lesion is suspected or to confirm the actual cause of median nerve compression



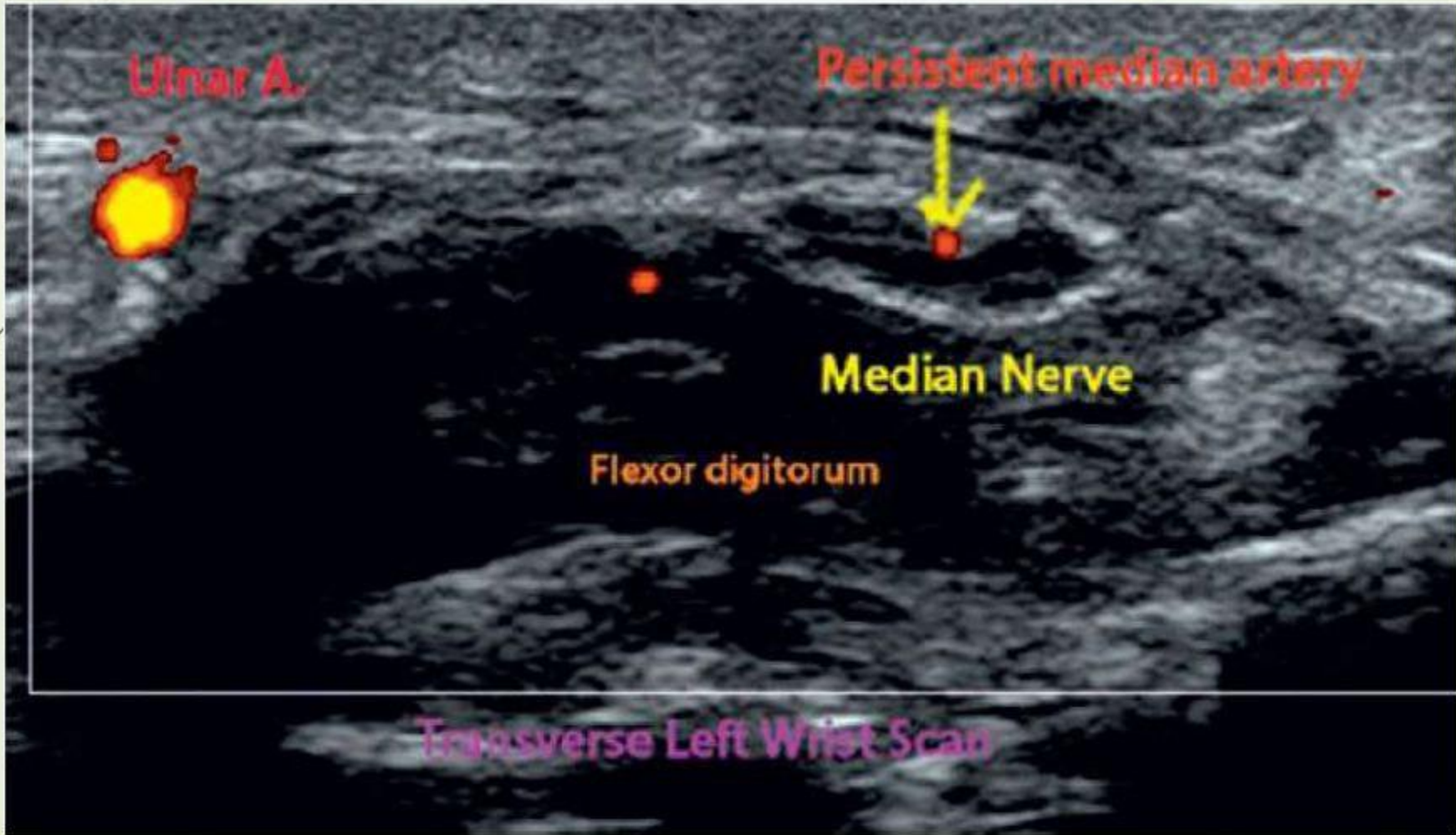


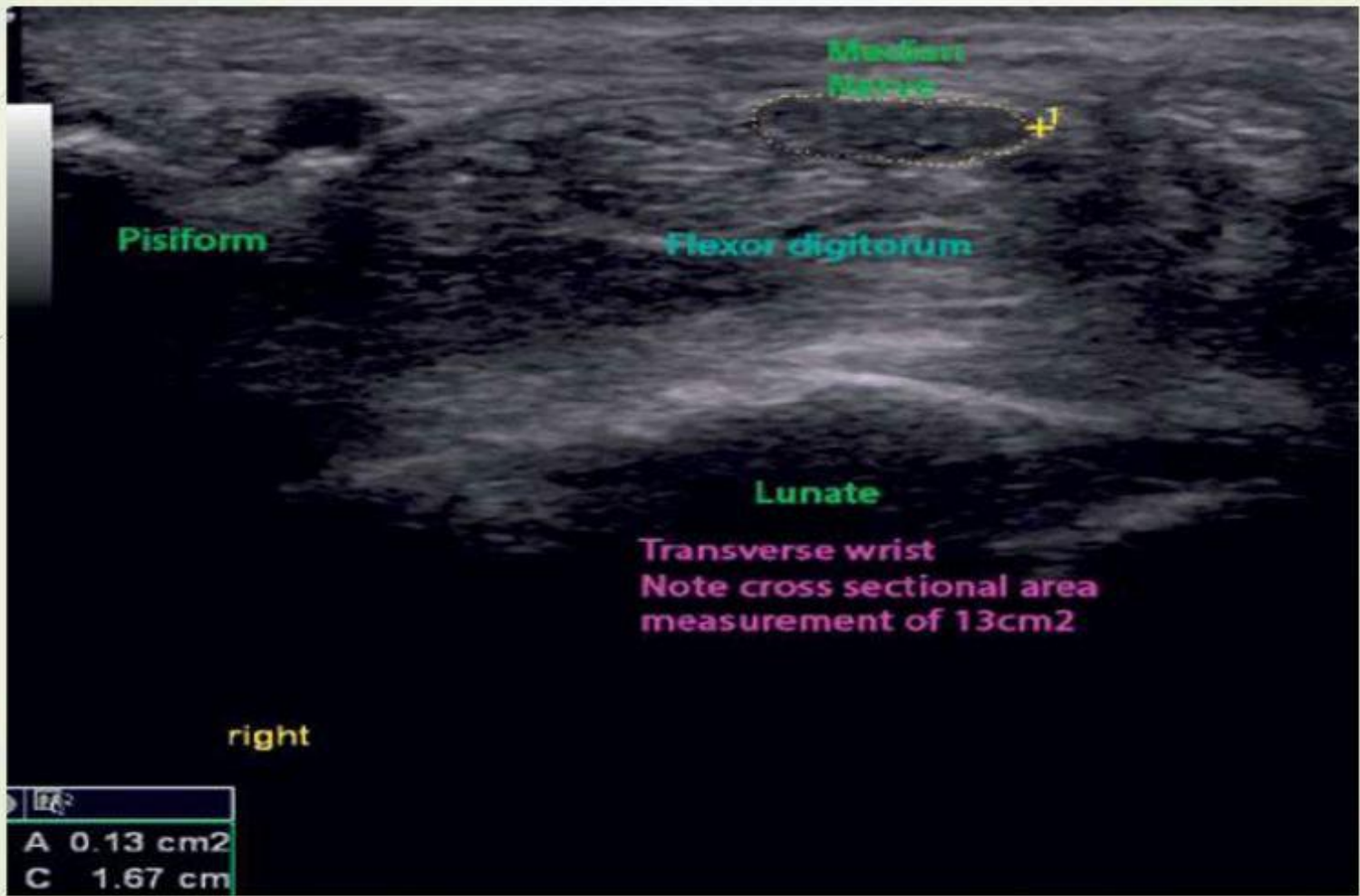
Axial fast-spin T2-weighted (FST2W) magnetic resonance (MR) image of the wrist in a patient with rheumatoid arthritis and symptoms of carpal tunnel syndrome.



# Ultrasound

- ▶ Ultrasound imaging may also be useful in the evaluation of the median nerve as it passes through the carpal tunnel
- ▶ Studies have suggested a strong correlation between the cross-sectional area of the nerve and clinical carpal tunnel syndrome
- ▶ The injection technique described later serves as both a diagnostic and a therapeutic maneuver.








# DIFFERENTIAL DIAGNOSIS

- ▶ Carpal tunnel syndrome is often misdiagnosed as *arthritis of the carpometacarpal joint of the thumb, cervical radiculopathy, or diabetic polyneuropathy.*
- ▶ Patients with arthritis of the **carpometacarpal joint** of the thumb have a positive **Watson test** and radiographic evidence of arthritis.



# cervical radiculopathy

- ▶ Most patients suffering from cervical radiculopathy have reflex, motor, and sensory changes associated with neck pain; in contrast, patients with carpal tunnel syndrome have no reflex changes, and motor and sensory changes are limited to the distal median nerve.

Cervical radiculopathy and median nerve entrapment may coexist as the double-crush syndrome.



# Diabetic polyneuropathy

- Diabetic polyneuropathy generally manifests as a symmetric sensory deficit involving the entire hand, rather than being limited to the distribution of the median nerve.

Further, carpal tunnel syndrome is commonly seen in patients with diabetes, and it is not uncommon for diabetic polyneuropathy to be present as well.



# TREATMENT



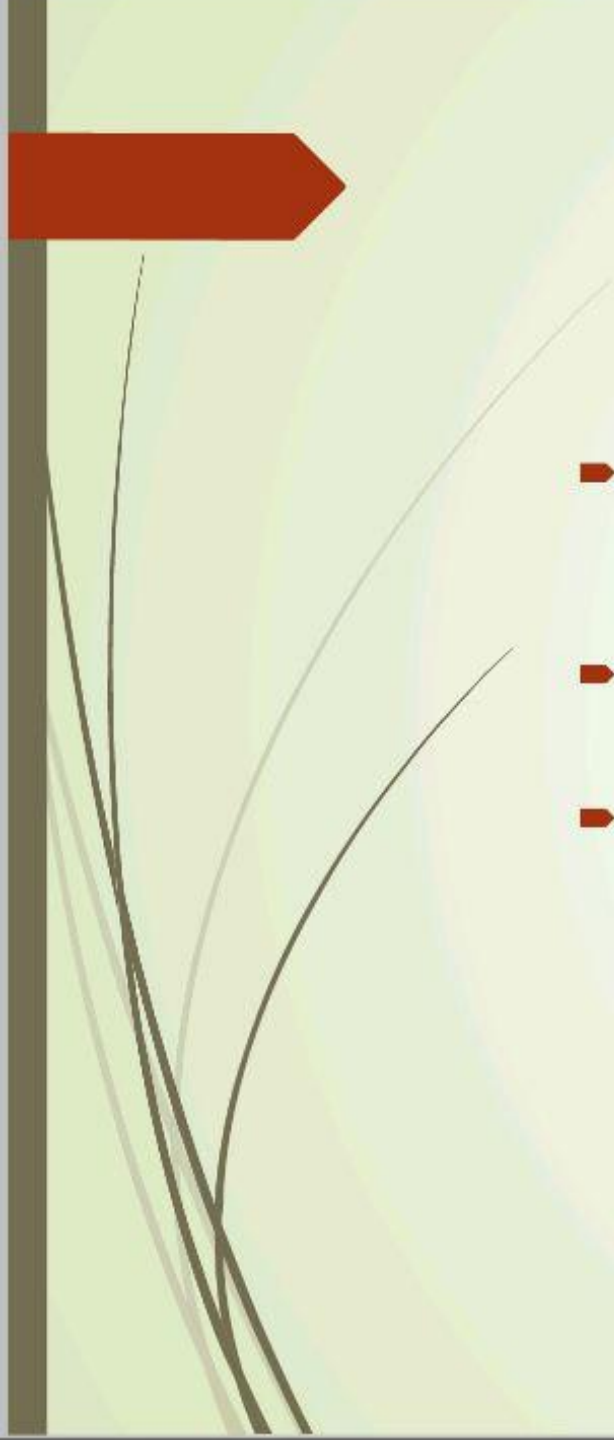
## Mild

- conservative therapy; *surgery should be reserved for more severe cases.*
- simple analgesics
- nonsteroidal antiinflammatory drugs or cyclooxygenase-2 inhibitors
- splinting of the wrist. At a minimum, the splint should be worn at night, but wearing it for 24 hours a day is ideal.
- Avoidance of the repetitive activities that are thought to be responsible for carpal tunnel syndrome (e.g., keyboarding, hammering) can also help ameliorate the patient's symptoms.



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- ▶ If the patient fails to respond to these conservative measures, a next reasonable step is **injection** of the carpal tunnel with local anesthetic and steroid.
  - ▶ When these treatment modalities fail, surgical release of the median nerve at the carpal tunnel is indicated. Endoscopic techniques appear to result in less postoperative pain and dysfunction.
  - ▶ **Recent studies suggest that a trial of extracorporeal shock wave therapy may be considered as an alternative treatment for carpal tunnel syndrome.**



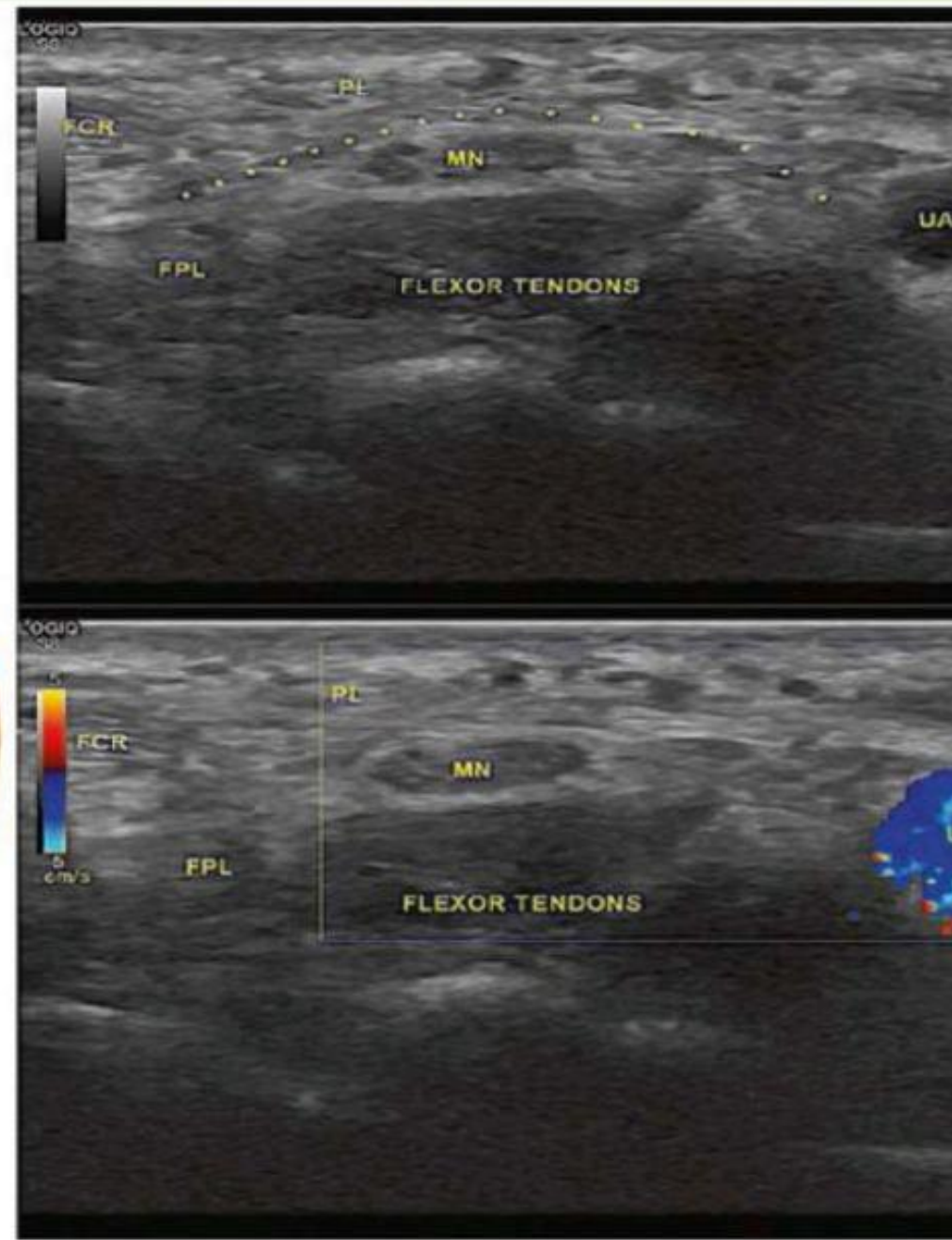
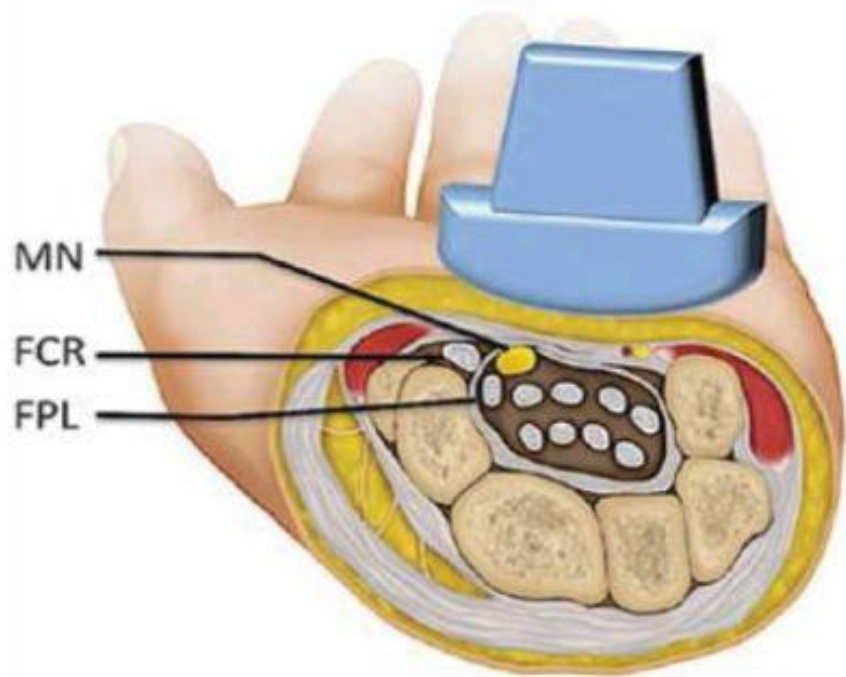
- 
- ▶ This technique can be safely performed in the presence of anticoagulation by using **a 25- or 27-gauge needle**, albeit with an increased risk of hematoma formation.
  - ▶ The incidence of this complication can be decreased if **manual pressure** is applied to the area immediately after injection.
  - ▶ The application of **cold packs for 20 minutes** after injection can also decrease the degree of postprocedure pain and bleeding.



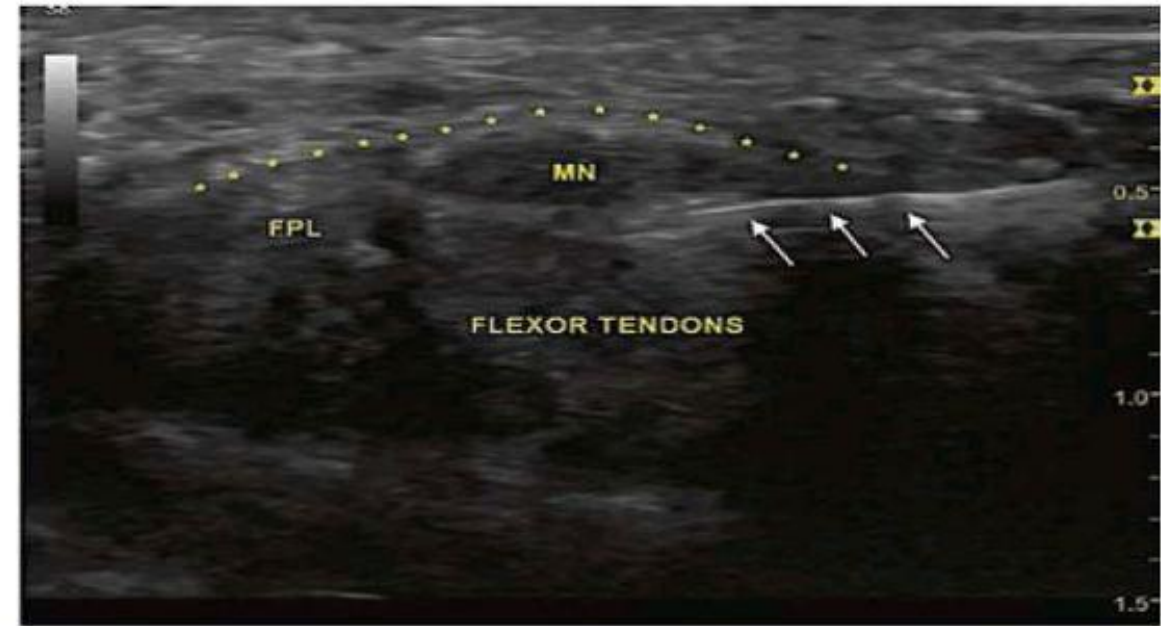
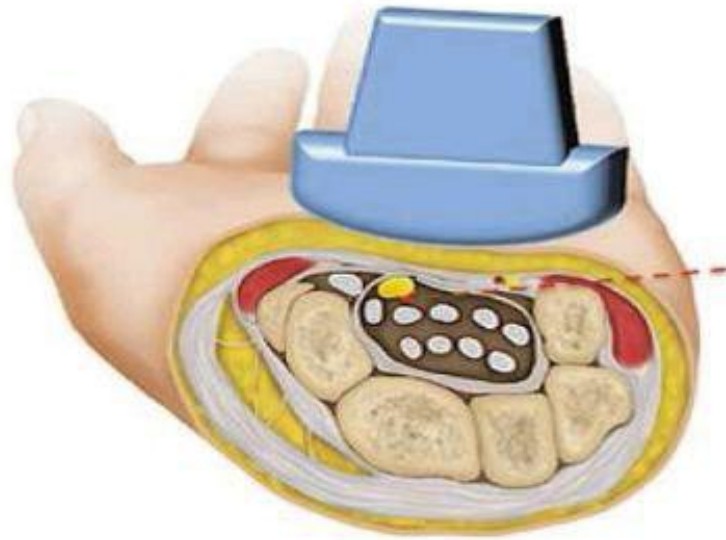
# Ultrasound

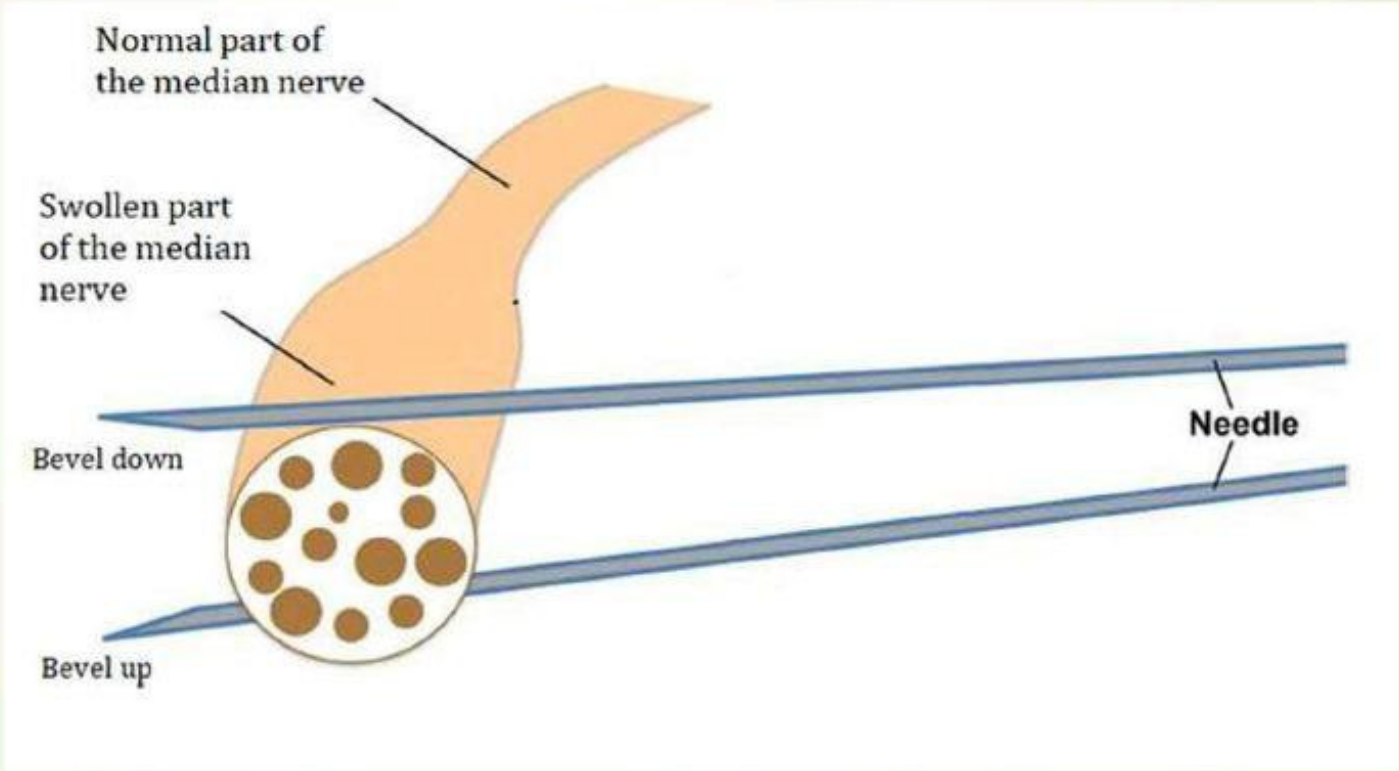
- Position: Seated with forearm supinated with hand resting comfortably on the table. Rolled towel can support wrist in mild extension.
- Probe: High-frequency linear array transducer (10 MHz+); Hockey stick linear probe is preferred.

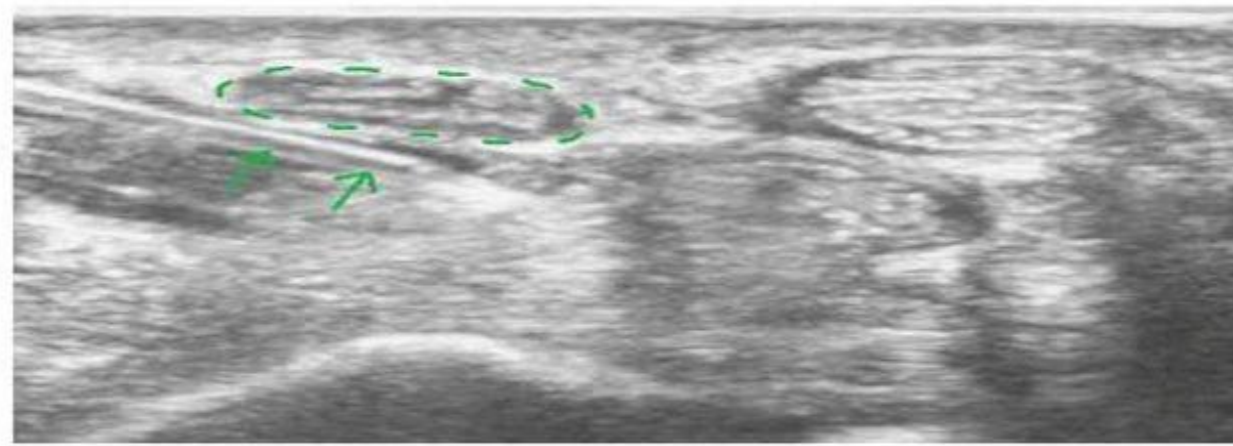
- Needles: 25G–27G 1.5 inch needle
- Drugs: 1–3 mL local anesthetic (0.25% plain bupivacaine)  
0.5 mL steroid (depomedrol)



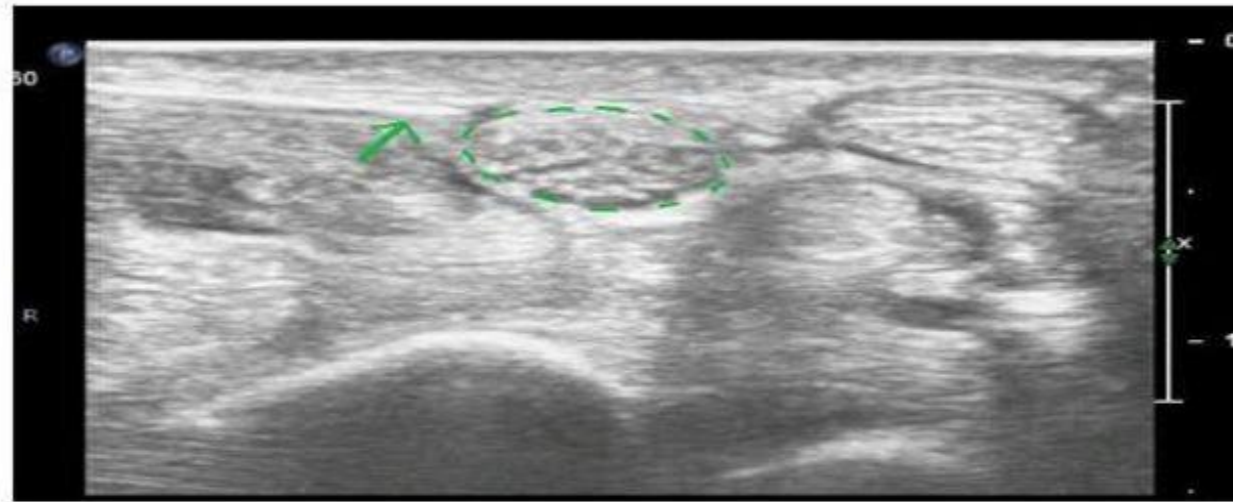
In-plane approach is performed from ulnar to radial inserting the needle 1–3 cm away and parallel to probe just radial or deep to the ulnar nerve and artery at a shallow angle (Fig. 21.4). The needle (arrows) will be visualized in the canal. Here, the needle is next to and under the median nerve (MN). The injectate can now be administered. As the space is enclosed, the medicine will spread and saturate the nerve.








**Fig. 3** Ultrasound image of the carpal tunnel in the axial plane during Step 4 of the hydrodissection. *Legend:* circle in dotted line: median nerve; arrow: injection needle



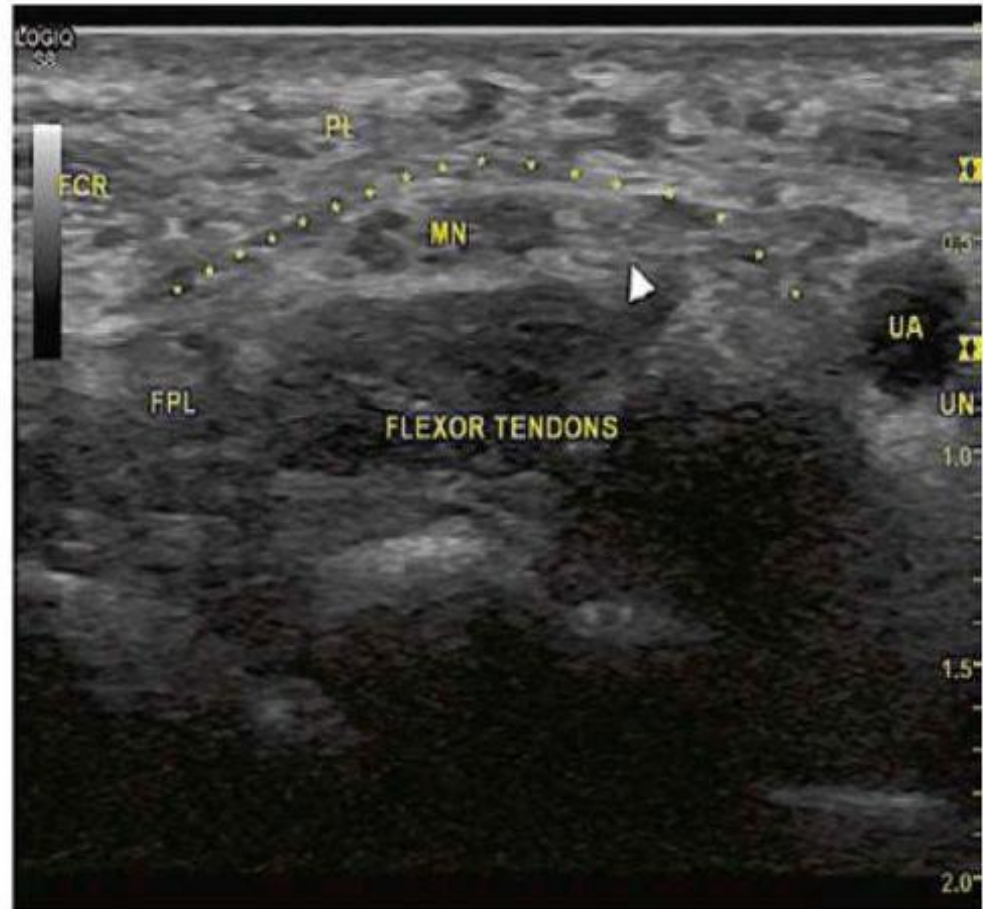
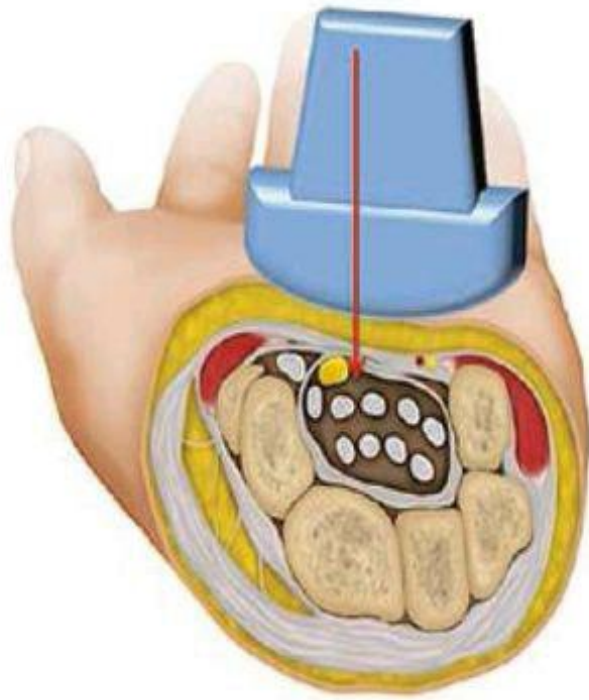
**Fig. 4** Ultrasound image of the carpal tunnel in the axial plane during Step 5 of the hydrodissection. *Legend:* circle in dotted line: median nerve; arrow: injection needle





## . Out-of-Plane Injection


- ▶ Short axis over the distal wrist crease
- ▶ With the probe target just ulnar to the median nerve, an out-of-plane approach is performed by inserting needle perpendicular to the probe at a steep angle directed just off to the ulnar side of the median nerve (MN). A small hyperechoic dot will be seen on the ulnar side of the nerve (needle tip depicted by arrowhead). Use caution with out-of-plane injections to ensure tip is under the transducer. Inject next to the nerve.





## Clinical Pearls

1. To visualize the median nerve, isolate a relatively hypoechoic area surrounded by hyperechoic tendons in cross-sectional view.
2. Tilt/angle the probe or have patient flex and extend their hand: the nerve will remain relatively unchanged because the tendons are more subject to anisotropy.
3. Look for adhesions, which can be treated by hydrodissection.
4. Track nerve proximally up the arm if difficult to visualize.
5. Use gel standoff technique if wrist is too small to achieve a shallow needle trajectory.
6. Use color flow to aid in identifying vascular structures such as a persistent medial artery.
7. Advise patients to refrain from driving secondary to possible temporary hand numbness/weakness.

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- The American Academy of Orthopedic Surgeons suggests the use of local steroid injections prior to considering surgery for carpal tunnel syndrome.
  - Recent studies demonstrate that in-plane ulnar approach proves to be superior over out-of-plane injection.



# DIAGNOSTIC ULTRASOUND

- Sonography can help to differentiate the so-called idiopathic CTS from a variety of local conditions with external nerve compression (e.g. ganglia, tumors, tenosynovitis, accessory muscle tissue and vascular anomalies)

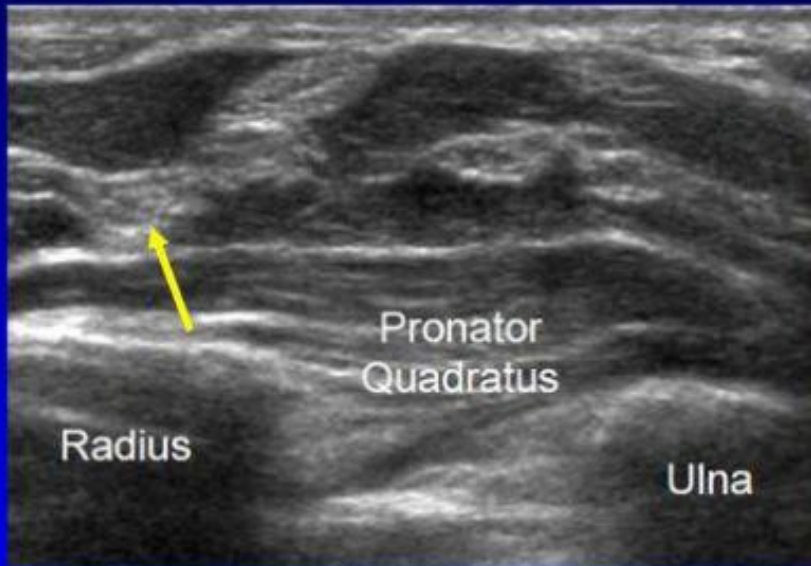
## Median Nerve vs. Flexor Tendons

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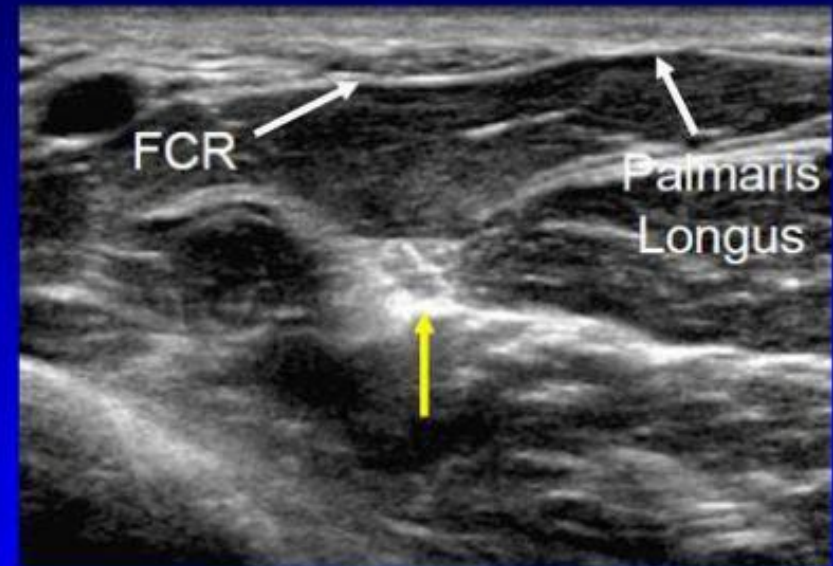
- Nerve: fascicular or honeycomb vs brush-like or fibrillar tendon
- Tendon: more anisotropy
  - Nerve: connective tissue layers
- Move transducer proximal in axial plane
  - Median nerve becomes relatively hyperechoic between flexor digitorum superficialis & profundus muscles
- Flexor tendons become hypoechoic muscles

Silvestri et al. Radiology 1995; 197:291

## Volar Wrist: median nerve & flexors



Short Axis: proximal

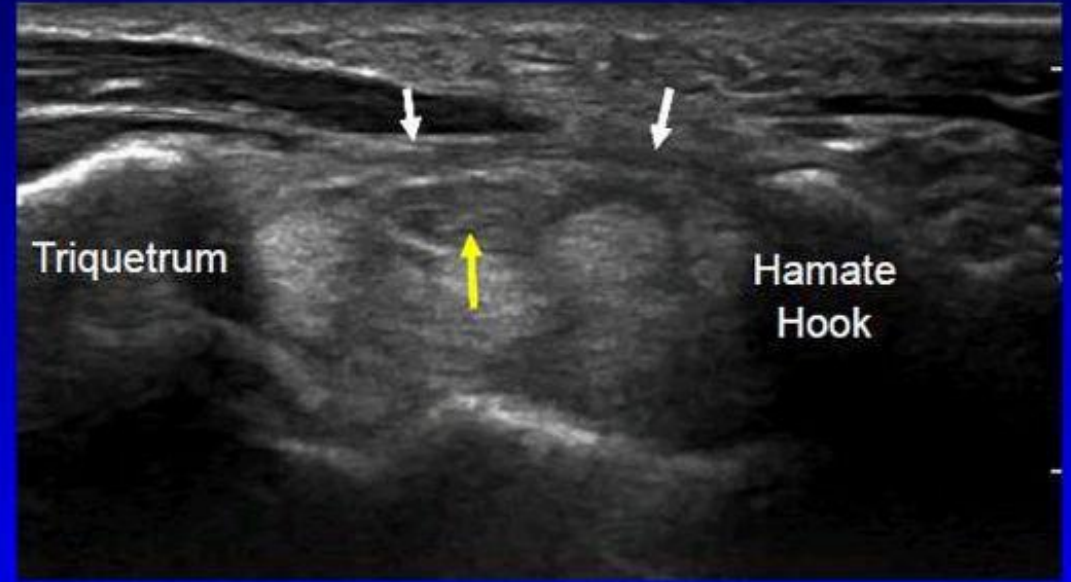


Short Axis: more proximal

# Carpal Tunnel: boundaries



Proximal



Distal

*Note: transverse carpal ligament (white arrows)  
and median nerve (yellow arrows)*



## Median Nerve

- Palmar cutaneous branch
- Outside of carpal tunnel and retinaculum (white arrowheads)
- Adjacent to flexor carpi radialis

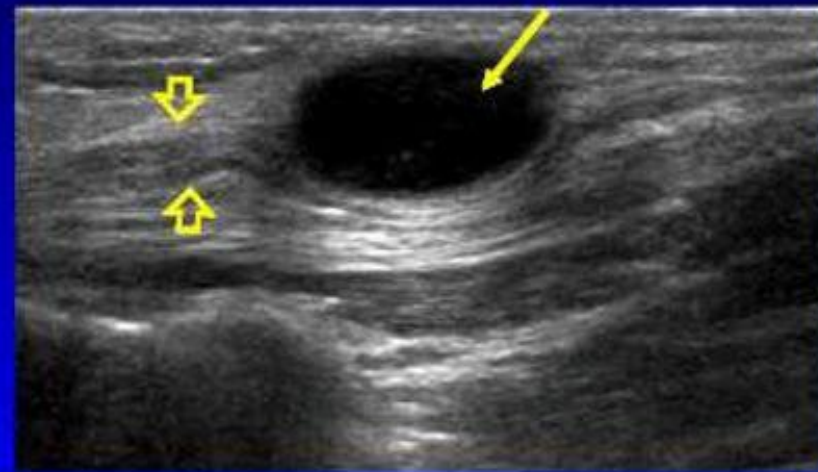


Tagliafico et al. AJR 2008; 197:107

## Carpal Tunnel Syndrome: ganglion



Case #1



Case #2



## Pitfall: bifid median nerve

- Bilobed or two separate trunks
- Interposed persistent median artery
- Incidence: 2.8%

Propeck *et al.* AJR 2000;175:1721

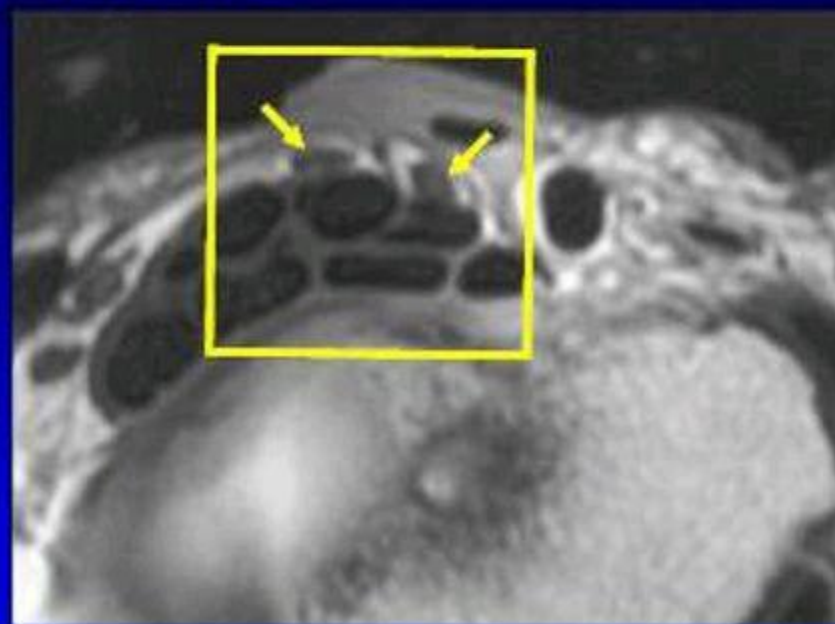
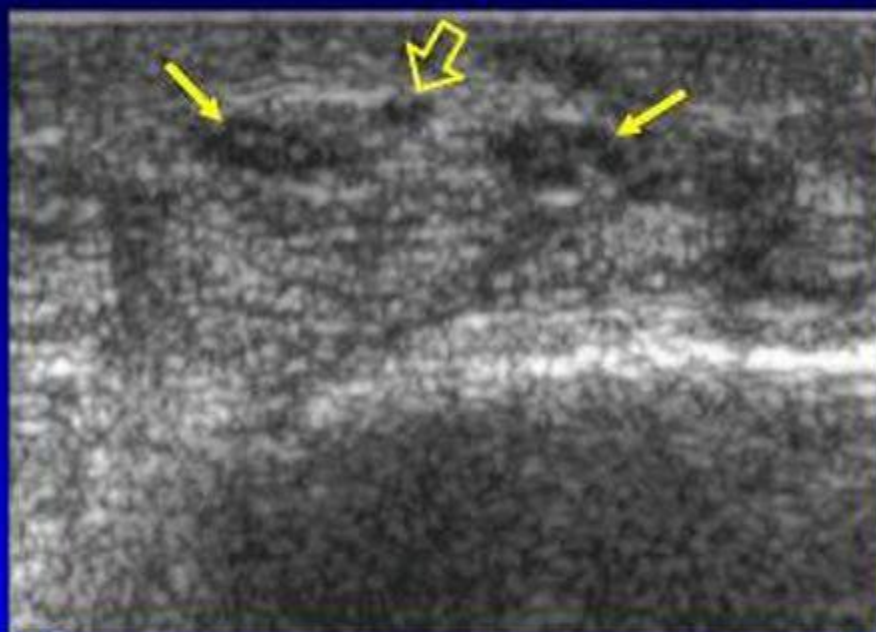


## Pitfall: bifid median nerve

- Bilobed or two separate trunks
- Interposed persistent median artery
- Incidence: 2.8%

Propeck *et al.* AJR 2000;175:1721

## Bifid Median Nerve

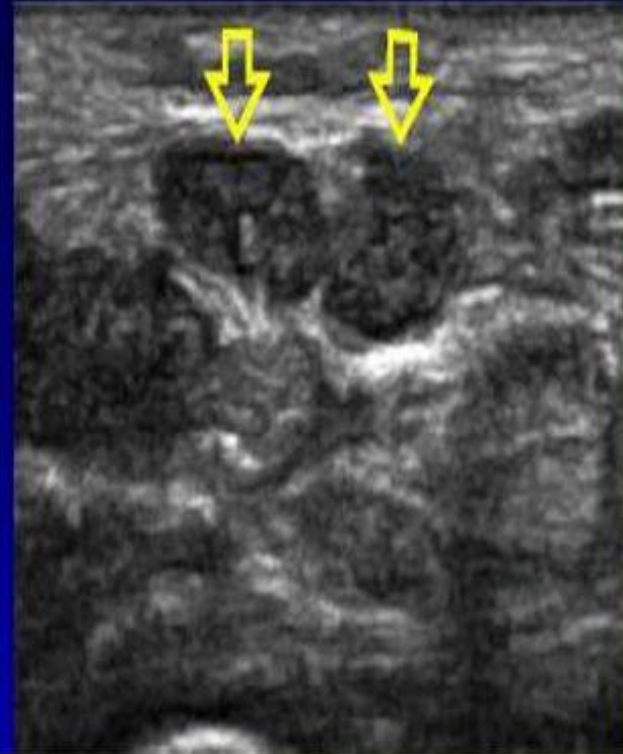


- Bilobed or two separate trunks
- Interposed persistent median artery
- Incidence: 2.8%

Propeck *et al.* AJR  
2000;175:1721

## Bifid Median Nerve + CTS

- Carpal tunnel syndrome<sup>1</sup>
  - Increase in cross-sectional area of  $\geq 4 \text{ mm}^2$



# cross-sectional area measurements

- ▶ 9
- ▶ 9-12
- ▶ 12 ▲

## Carpal Tunnel Syndrome:

- Proximal median nerve swelling
  - Area: circumferential trace
  - Normal:  $< 9 \text{ mm}^2$
  - Borderline:  $9 - 12 \text{ mm}^2$
  - Abnormal:  $> 12 \text{ mm}^2$ 
    - $12.8 \text{ mm}^2$  = moderate (83% sens, 95% spec)
    - $14.0 \text{ mm}^2$  = severe (77% sens, 100% spec)



Klauser AS et al. Sem Musculoskel Rad 2010; 14:487  
Ooi et al. Skeletal Radiol 2014; 43:1387

# wrist-to-forearm ratio

- ▶ difference between the median nerve area measured at the wrist and proximal forearm was calculated, whereby a difference of 2MM or greater was used to diagnose CTS

## Carpal Tunnel Syndrome

- Compare areas:
  - Proximal: pronator quadratus
  - Distal: carpal tunnel
- $\geq 2 \text{ mm}^2$  = carpal tunnel syndrome
- 99% sensitivity
- 100% specificity

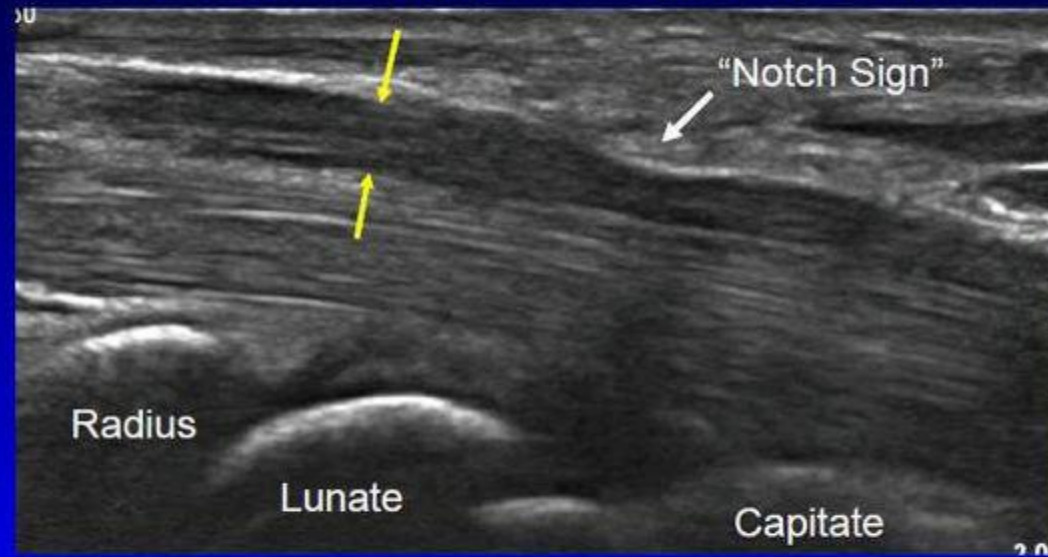


Klauser AS. Radiology 2009; 250:171

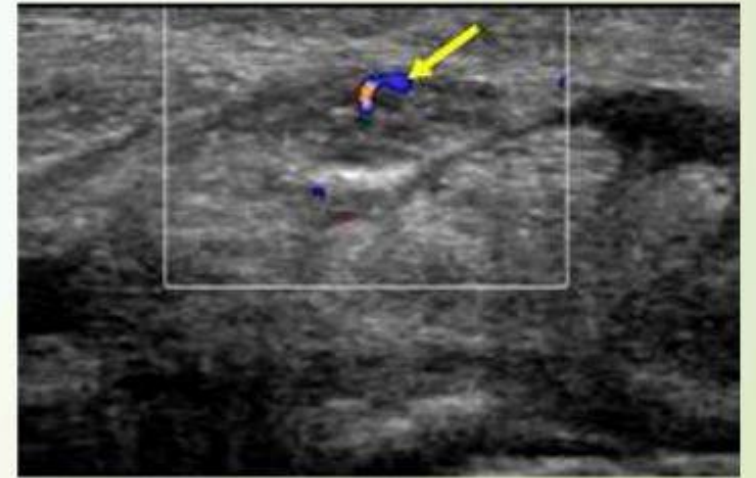
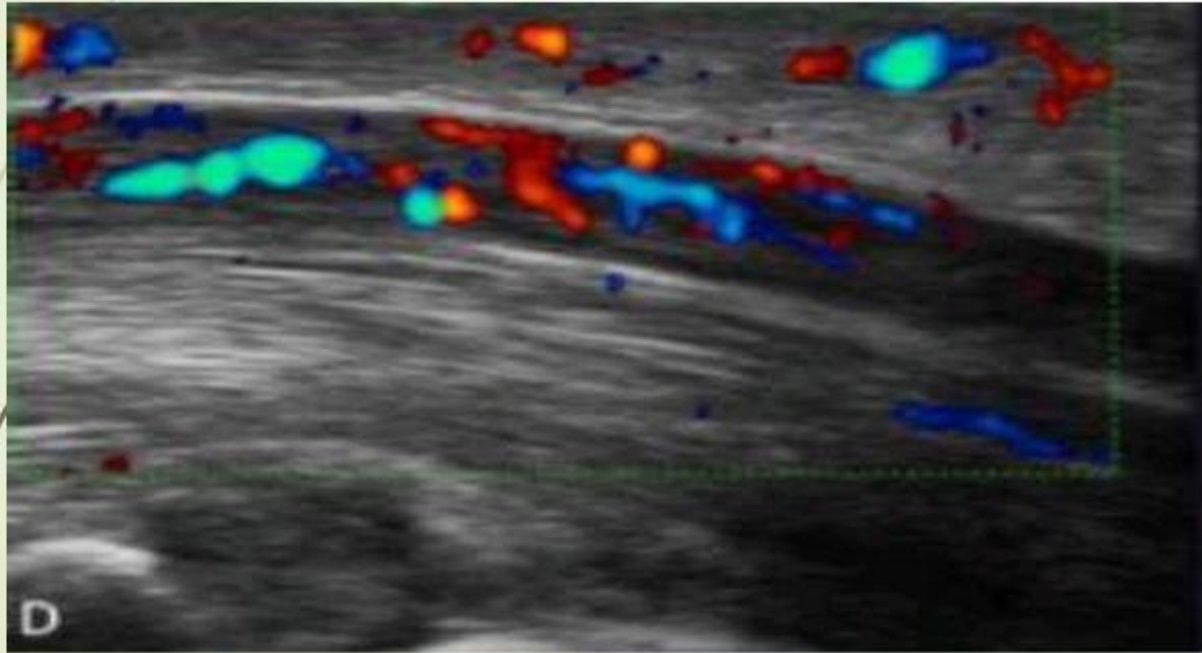


# NOTCH SIGN

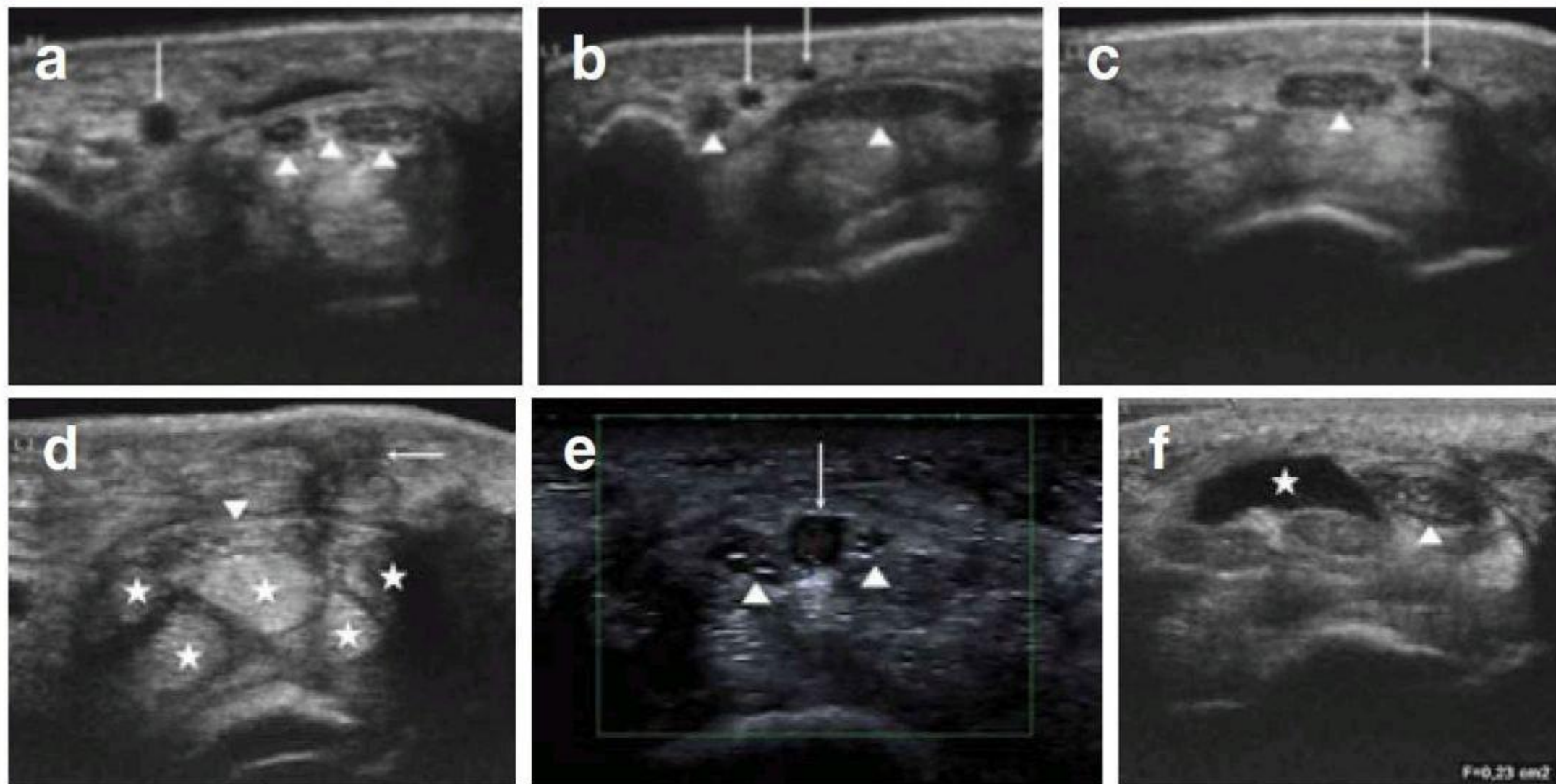
## Carpal Tunnel Syndrome




# vascularization of the median nerve in CTS



# DIAGNOSTIC ULTRASOUND





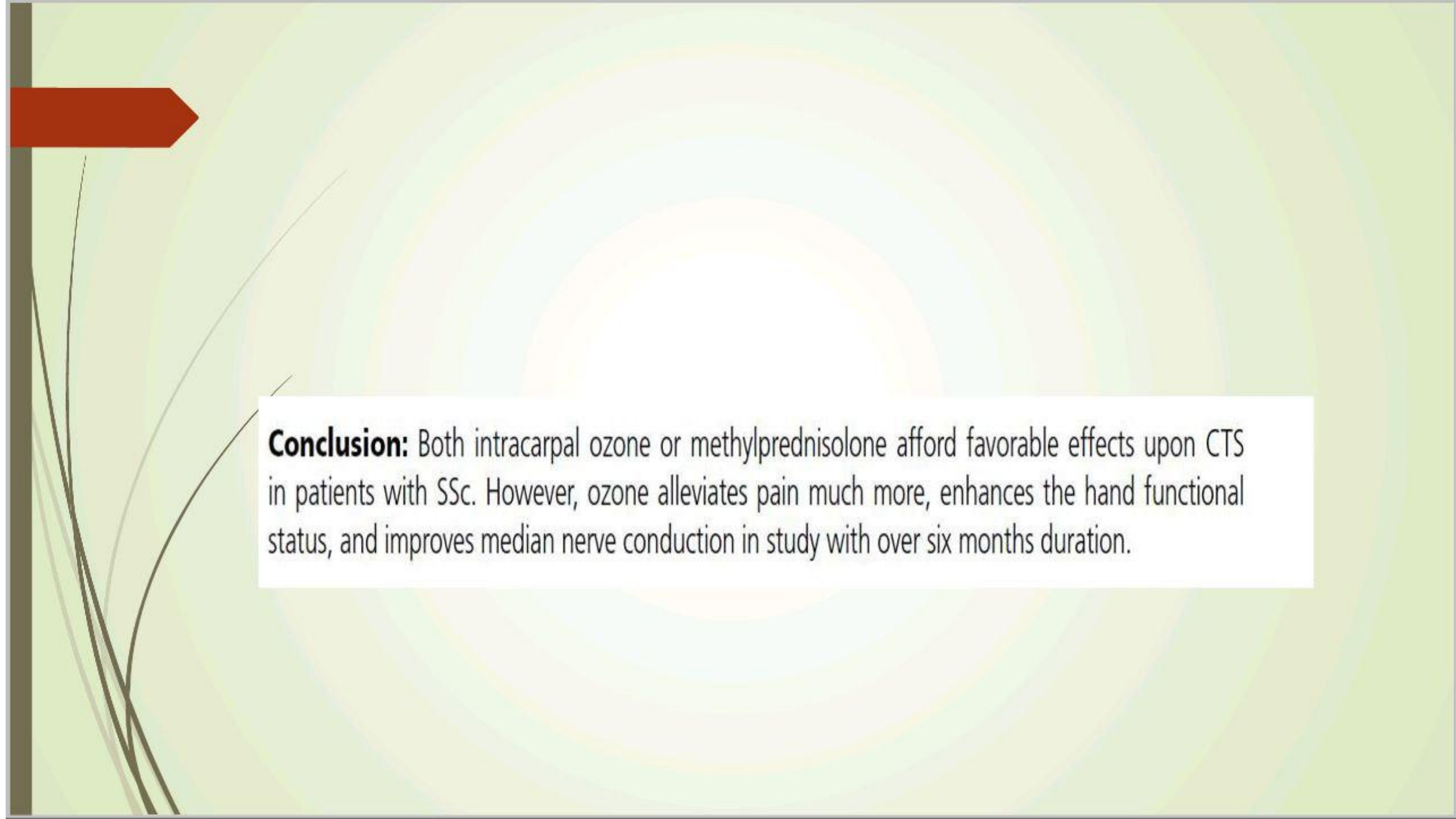
Pain Physician 2021; 24:E453-E458 • ISSN 2150-1149

Randomized Trial

 **Intra-Carpal Injection of Ozone versus  
Methylprednisolone in Carpal Tunnel Syndrome  
of Systemic Sclerosis Patients: A Randomized  
Single-Blind Clinical Trial**

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Abdelraheem Elawamy, MD<sup>1</sup>, Manal Hassanien, MD<sup>2</sup>, Esraa A Talaat, MD<sup>2</sup>,  
Anwar M. Ali, MD<sup>3</sup>, Al Shimaa Ismael Roushdy, MD<sup>4</sup>, and Emad Zariief Kamel, MD<sup>1</sup>



**Conclusion:** Both intracarpal ozone or methylprednisolone afford favorable effects upon CTS in patients with SSc. However, ozone alleviates pain much more, enhances the hand functional status, and improves median nerve conduction in study with over six months duration.

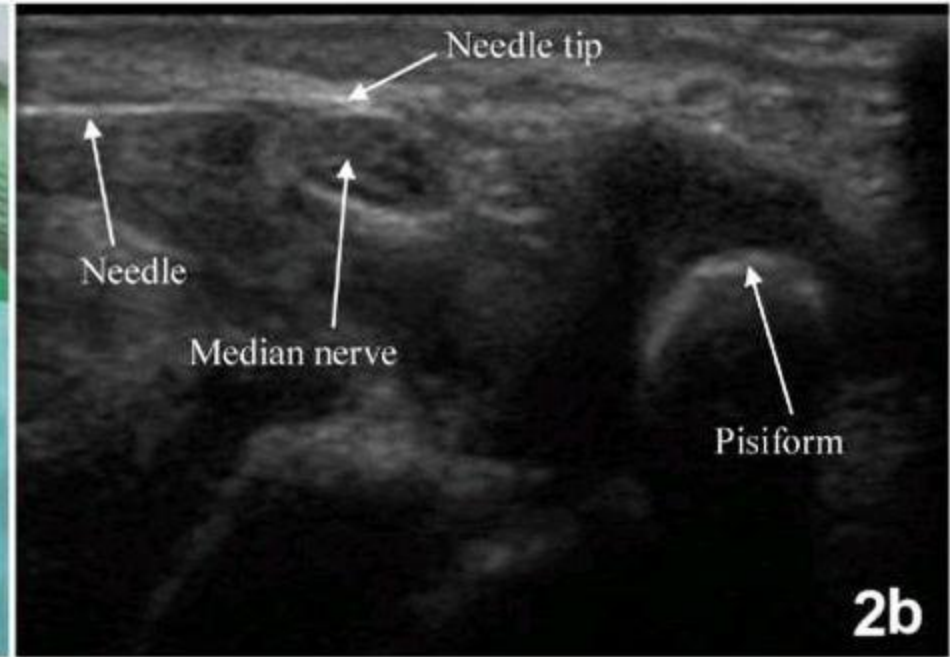
RESEARCH ARTICLE

# Ultrasound-Guided Pulsed Radiofrequency for Carpal Tunnel Syndrome: A Single-Blinded Randomized Controlled Study

Liang-Cheng Chen<sup>1,2</sup>, Cheng-Wen Ho<sup>3</sup>, Chia-Hung Sun<sup>1</sup>, Jiunn-Tay Lee<sup>4</sup>, Tsung-Ying Li<sup>1</sup>, Feng-Mei Shih<sup>1</sup>, Yung-Tsan Wu<sup>1</sup>\*


**1** Department of Physical Medicine and Rehabilitation, Tri-Service General Hospital, School of Medicine, National Defense Medical Center, Taipei, Taiwan, Republic of China, **2** Department of Physical Medicine and Rehabilitation, Hualien Armed Forces General Hospital, Hualien County, Taiwan, Republic of China, **3** Graduate Institute of Aerospace Medicine, School of Medicine, National Defense Medical Center, Taipei, Taiwan, Republic of China, **4** Department of Neurology, Tri-Service General Hospital, School of Medicine, National Defense Medical Center, Taipei, Taiwan, Republic of China





**Fig 2. a: Positioning of the ultrasonographic transducer and radiofrequency needle. b: Real-time imaging of the ultrasound-guided needle insertion.**

doi:10.1371/journal.pone.0129918.g002



7.37; 95% CI, 3.04–17.87) compared to the control group ( $p < 0.001$ ). Significant improvement in VAS and BCTQ scores ( $p < 0.05$ ) was detected in the intervention group at all follow-up periods compared to the controls (except for the severity subscale of BCTQ at week 1). Ultrasound-guided PRF treatment resulted in a lower VAS score and stronger finger pinch compared to the control group over the entire study.

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129918 June 12, 2015

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Pulsed Radiofrequency for Carpal Tunnel Syndrome

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## **Conclusions**

Our study shows that ultrasound-guided PRF serves as a better approach for pain relief in patients with CTS.




Randomized Trial

**e** **Efficacy of Hyalase Hydrodissection in the Treatment of Carpal Tunnel Syndrome: A Randomized, Double-Blind, Controlled, Clinical Trial**

Abdelraheem Elawamy, MD<sup>1</sup>, Manal Hassanien, MD<sup>2</sup>, Ahmed Hamed, MD<sup>3</sup>,  
Al Shimaa Ismael Roushdy, MD<sup>4</sup>, Nisreen Adel Abass, MD<sup>5</sup>, Ghada Mohammed, MD<sup>1</sup>,  
Mohamed Raouf Abdel Razek Hasan, MD<sup>2</sup>, and Emad Zariief Kamel, MD<sup>1</sup>

From: <sup>1</sup>Anesthesia, Intensive  
Care, and Pain Management  
Department, Faculty of

**Background:** Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy, which results from median nerve compression. A lot of nonsurgical modalities are available for the



**Results:** Statistically significant lower postinjection values of VAS ( $1 \pm 1.8$ ,  $2 \pm 1.1$ ,  $2 \pm 1.2$ ,  $2 \pm 1.1$ ) in group 1 versus ( $2 \pm 1.2$ ,  $3 \pm 1.7$ ,  $4 \pm 1.5$ ,  $5 \pm 2.6$ ) in group 2 by the end of the first week, and the first, third, and sixth months, and significantly lower FD scores ( $15.3 \pm 1.2$ ,  $13 \pm 1.3$ ,  $10.2 \pm 1.3$ ,  $10.2 \pm 1.3$ ) in group 1 versus ( $17.5 \pm 1.8$ ,  $16.6 \pm 2.8$ ,  $19.4 \pm 3.2$ ,  $21.2 \pm 2.5$ ) in group 2 during the same time intervals. Nerve conduction study parameters have shown significantly higher velocity and lower latency in the Hyalase group than in the saline solution group by the 3 and 6 month follow-up.

**Limitation:** We suggest a longer period could be reasonable.

**Conclusions:** Carpal tunnel HD with Hyalase with saline solution is considered as an efficient technique offering a rapid onset of pain relief and functional improvements, and better median nerve conduction in patients with CTS over 6 months follow-up duration.