MRI imaging of nerve injury after surgical release of the carpal tunnel

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Learning objectives

Complications of operative carpal tunnel release may occur in the clinical practice of hand surgery. In some cases, nerve damage may result from surgery yielding to neuroma (1).

With time, the proximal injured nerve fascicles sprout in an attempt to unite. However, due to surrounding lattice disruption, disorganized regeneration, hypertrophy of nerve fascicles, and associated fibrosis, the proximal and distal nerve fibers at the site of injury may fail to appose and thereby lead to neuroma in continuity (NIC) formation (2).

End-bulb neuromas occur anywhere a nerve is completely divided and is unopposed by another neural tissue.

Clinically, NIC may lead to a dysfunctional nerve, disabling pain, and progression to chronic pain syndromes. The Tinel sign (local tenderness over the injured nerve with distally radiating tingling) is usually evident on clinical examination (2).

We propose to illustrate MRI imaging of nerve injury after surgical release of the carpal tunnel.
Background

Post traumatic neuroma of the median nerve is usually clinically strongly suspected

The aim of imaging the carpal tunnel is

1. To confirm the clinical diagnosis of post operative median nerve neuroma
2. To localize precisely the neuroma for surgical planning
3. To detect any anatomic variation of the carpal tunnel (median nerve variation, accessory muscle) which may lead to injury of the median nerve during an open or endoscopic carpal tunnel release

High resolution Magnetic resonance imaging (MRI) with dedicated wrist coil is specially suitable to fulfill these 3 goals

The MRI protocol includes the following sequences

1. Axial spin-echo T1-weighted sequence
2. Axial fast spin-echo T1-weighted sequence with fat suppression after IV injection of gadolinium
3. Axial fast spin-echo T2-weighted sequence with fat suppression
The MRI appearance of **median nerve neuroma** include

1. Enlarged median nerve
2. T2 nerve signal increase
3. T1 nerve enhancement after intravenous injection of gadolinium
4. Disappearance of the normal fascicular appearance of the nerve

Median nerves with increased T2-weighted signal intensity are not specific of neuroma. After carpal tunnel release, it has been shown that increases T2 signal of the median nerve can be found in patients with good clinical outcome (3). For this reason the criteria for T2-weighted signal intensity of the median nerve can not be used alone to differentiate pathologic and healthy nerves after surgical release.

In contrast, focal enlargement with enhancement of the median nerve after IV of gadolinium, and disappearance of the normal fascicular appearance of the nerve are highly specific of post traumatic neuroma.

**Case n°1**: 56-year-old woman, 2 years after open surgical release of the median nerve

The MRI appearance of median nerve neuroma

- T1: enlarged median nerve
- T2: nerve signal increase. The normal fascicular appearance of the nerve has disappeared

The MRI appearance of median nerve neuroma: T1 nerve enhancement after intravenous injection of gadolinium. In this case the neuroma occupy the entire transversal section of the nerve (white arrow)

The MRI appearance of median nerve neuroma: T1 nerve enhancement after intravenous injection of gadolinium (white arrow).
In case of post traumatic neuroma occupying the entire transversal section of the median nerve, a differential diagnosis must be raised with **recurrent carpal tunnel syndrome (CTS)** after surgery (secondary to incomplete resection or regrowth of the flexor retinaculum of the carpal tunnel)

In case of recurrent CTS, the nerve can have an edematous morphology, proximal to the area of compression representing a neuroma in continuity.

The key MRI findings for the diagnosis of **recurrent CTS** are (3)

1. At the level of compression: flattening of the median nerve
2. Proximal to the compression: enlargement of the median nerve
3. Increase abnormal T2 hyperintensity of the nerve fascicles
4. Persistence of the normal fascicular appearance of the nerve

**Case n° 2**: 56-year-old woman. Recurrent CTS 1 year after open surgical release of the median nerve

In case of recurrent CTS, the nerve can have an edematous morphology, proximal to the area of compression

Axial T2 SE with fat suppression : increase T2 signal intensity of the median nerve: persistence of the normal fascicular appearance of the nerve

Axial T1 SE with fat suppression after IV injection of gadolinium: diffuse enhancement of the median nerve

Persistence of the normal fascicular appearance of the nerve

**Case n°3**: 45-year-old woman, 1 year after endoscopic surgical release of the median nerve.
In some cases, only a part of the fascicles of the nerve are traumatized and involved by the neuroma.

In this case, only the ulnar fascicles of the median nerve in the carpal tunnel are involved by the neuroma, with increase T2 nerve signal, T1 nerve enhancement after intravenous injection of gadolinium, and disappearance of the normal fascicular appearance of the nerve.

**Case n°4**: 52-year-old woman, 18 months after endoscopic surgical release of the carpal tunnel

Small traumatic neuroma (yellow arrow) of the radial fascicles of the median nerve.

**Case n°5**: 52-year-old woman, 1 year after open surgical release of the median nerve

Normally, the median nerve splits into its terminal branches as it exits distally from the carpal tunnel. The neuroma may involve only one of its main branch.

Only the ulnar branch of the median nerve distally from the carpal tunnel is involved by the neuroma (red arrows), with enlargement of the ulnar branch, increase T2 nerve signal, T1 nerve enhancement after intravenous injection of gadolinium.

There are number of variants in the course of the median nerve through the carpal tunnel. Because of anatomic variation, the median nerve can be iatrogenically injured during the operation

Lanz classifies these variants in fours groups (4)

Group 1 includes division into a thenar branch of the median nerve.

Most often (in 46% of all subjects), one of its main branches (the common palmar digital nerve) emits an extraligamentous branch to the thenar muscle. This branch arises distal to the flexor retinaculum.
In 31% of all subjects, a subligamentous branch is emitted from the first common digital nerve in the carpal tunnel. The muscular branch courses independently through the entire length of the carpal tunnel and then curves off into the thenar musculature.

In 23% of all cases, a transligamentous branch arises from the common palmar digital nerve in the carpal tunnel, but perforates the flexor retinaculum and the tendinous origin of the thenar musculature after a short distance.

Transligamentous and subligamentous thenar branch of the median nerve arise under the flexor retinaculum, and can be accidentally injured during carpal tunnel release.

**Case n°6**: 49-year-old woman, 2 years after open surgical release of the median nerve.

Traumatic neuroma (yellow arrows) of the subligamentous thenar branch of the median nerve

T1 nerve enhancement after IV injection of gadolinium (yellow arrows)

Normal fascicles of the median nerve (white arrow)

**Case n°7**: 56-year-old woman, 2 years after surgical release of the median nerve.

Traumatic neuroma (yellow arrow) of the subligamentous thenar branch of the median nerve

increase T2 nerve signal (yellow arrow)

Normal fascicle of the median nerve (white arrow)
T1 nerve enhancement after IV injection of gadolinium (yellow arrow)

Normal fascicle of the median nerve (white arrow)

There are number of variants in the course of the median nerve through the carpal tunnel. Lanz classifies these variants in fours groups (4)

Group 3 (2.8% of all subjects) consist of a far proximal division in the nerve trunk occurring at the level of the forearm.

Case n° 8: 55-year-old woman with recurrent carpal tunnel syndrome and clinical evidence of neuroma of the ulnar branch of the median nerve.

The median nerve split into 2 roots at the level of the forearm surrounded by a rare accessory muscle the palmaris profundus muscle (A). Compare with (B) axial view through the distal forearm without accessory muscle

The median nerve split into 2 roots (yellow arrows) at the level of the forearm surrounded by a rare accessory muscle the palmaris profundus muscle belly (red arrow) and tendon (*)

The median nerve is clearly separated into 2 branches (yellow arrows) at the level of the wrist surrounded by the palmaris profundus muscle belly (red arrow) and tendon (*)

The median nerve is clearly separated into 2 branches (yellow arrows) at the level of the wrist surrounded by the tendon (*)

Enlargement and increase T2 nerve signal of the ulnar side of the ulnar branch, which corresponds to the painful neuroma (yellow arrow).

The radial branch of the split median nerve (white arrow) is still compressed by the palmaris profundus tendon (*), which explains the recurrent carpal tunnel syndrome.
Painful neuroma (yellow arrow) of the ulnar side of the ulnar branch of the median nerve: T1 nerve enhancement after IV injection of gadolinium.

The radial branch of the split median nerve (white arrow) is still compressed by the palmaris profundus tendon (*), which explains the recurrent carpal tunnel syndrome.

In this case, there is an important ulnar displacement of the ulnar branch of the split median nerve at the level of the carpal tunnel. This unusual anatomic variation explains that this branch was iatrogenically injured during the operation.
Fig. 1: Axial T1 et T2FS : T1: enlarged median nerve T2: nerve signal increase. The normal fascicular appearance of the nerve has disappeared

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Fig. 3: Axial T2FS: In this case, only the ulnar fascicles of the median nerve in the carpal tunnel are involved by the neuroma, with increase T2 nerve signal, T1 nerve enhancement after intravenous injection of gadolinium, and disappearance of the normal fascicular appearance of the nerve.

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**Fig. 2:** Sagittal T1FS after IV injection of contrast Median nerve neuroma enhancement after intravenous injection of gadolinium.

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Conclusion

• Post traumatic neuroma of the median nerve is usually clinically strongly suspected

• High resolution MR imaging of the carpal tunnel with dedicated coil is specially suitable
  1. To confirm the clinical diagnosis of post operative median nerve neuroma
  2. To localize precisely the neuroma for surgical planning
  3. To detect any anatomic variation of the carpal tunnel (median nerve variation, accessory muscle) which may lead to injury of the median nerve during an open or endoscopic carpal tunnel release

• The MRI appearance of post traumatic median nerve neuroma include
  1. Enlarged median nerve
  2. T2 nerve signal increase
  3. T1 nerve enhancement after intravenous injection of gadolinium
  4. Disappearance of the normal fascicular appearance of the nerve

