



This article has been reviewed by the NeuroWiki Editorial Board

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## Classification of Nerve Injury

There are two classification schema used to describe nerve injuries. The first was published by **Seddon** in 1943, and separated injuries into three categories - *neuropraxia*, *axonotmesis*, and *neurotmesis* - largely based on the scale of injury from microscopic to macroscopic. In 1978, **Sunderland** expanded upon this idea, subdividing *neurotmesis* into three additional grades. The Seddon classification is useful to understand the anatomic basis for injury, while the Sunderland classification adds information useful for prognosis and treatment strategies.

### Seddon Classification:

#### Neuropraxia

The integrity of the axon is preserved, but there is disruption of *conduction* (both electrical and chemical) due to derangement of axonal transport and selective demyelination. Supportive structures (endoneurium, perineurium, epineurium) are all intact.

- Patients can expect *full* recovery, without surgical intervention, in a matter of days to weeks.
- Typically, there is **motor > sensory** deficit.
- Autonomic function is rarely affected.
- EMG/NCV Key Findings:
  - ◆ Because the axon is anatomically intact, NCV studies will show **normal electrical conduction** while EMG studies show **absent MAPs** (motor action potentials).

#### Axonotmesis

The integrity of the axon is interrupted (usually by section or shear). Intact endoneurium provides a guide for axonal regeneration.

- Wallerian degeneration takes place, with nerve regeneration along the endoneural tubules taking place at *~1mm/day*. The proximal regeneration (recovery of the retrograde degenerative segment) takes place at 2-3mm/day, and regeneration of the distal segment takes place at 0.5-1mm/day.
  - ◆ The clinical correlation of nerve healing is a "creeping" Tinel's Sign. If Tinel's does not progress at a rate approximating 1mm/day (3-4 cm/month), surgical repair should be considered.
- Patients should expect a *variable* recovery, largely based on the distance from injury to the muscle(s) innervated. *Full recovery* is possible without surgical intervention. More proximal injuries, and injuries which do not successfully re-implant in the muscle within 18 months have a worse prognosis.
- All modalities are equally affected. Motor, sensory, and autonomic deficits are all present.
- EMG/NCV Key Findings:

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◆ NCV studies show **no conduction distal to injury**. EMG studies show **fibrillation potentials** and **absent MAPs**.

◇ EMG takes **1-2 weeks to show abnormalities**, as Wallerian Degeneration must take place prior to fibrillation occurring in muscle.

## Neurotmesis

The integrity of the supporting structures are disrupted, ranging from disruption of the endoneurium preventing axonal regrowth and reimplantation, to complete transection of the nerve. The Sunderland classification (see below) further defines the range of injury, prognosis, and treatment strategies.

- Patients should expect an *incomplete and variable* recovery. In most cases, surgical intervention is required.
- All modalities are equally affected.
- EMG/NCV is *no different* from axonotmesis.

## Sunderland classification:

### Grade I

- Same as Seddon's **neuropraxia**.

### Grade II

- Same as Seddon's **axonotmesis**.

### Grade III

- Neurotmesis with *preservation of the perineurium*. The endoneurium is disrupted, with loss of growth guides for axonal regeneration.
  - ◆ Patients should expect a 60-80% recovery.
  - ◆ Fibrosis occurs within the perineurium due to influx of inflammatory cells and fibroblasts, which hinders axonal regeneration.

## Grade IV

- Neurotmesis with *preservation of the epineurium*. Everything else is disrupted.
  - ◆ The nerve will grossly appear edematous.
  - ◆ Nerve grafting is required.

## Grade V

- Complete transection of the nerve trunk.
  - ◆ Bypass/jump grafting is required.

## Treatment Strategies

Treatment is largely dictated by the *mechanism of injury* and *time to diagnosis*.

## Compression

Acute compression injuries (eg. Saturday Night Palsy, PIN Syndrome, etc) typically resolve within hours to days without intervention. They are largely due to vascular insufficiency to the nerve, which is relieved with repositioning. Longer compressions may lead to **neuropraxic**-type injury, with complete resolution over days to weeks. Sensory deficits are often significant compared to motor deficits, except in motor-exclusive nerves. Iatrogenic compression injuries can occur due to inadequate positioning during surgery, especially prone procedures. Chronic compression, (eg. Carpal Tunnel Syndrome) requires surgical intervention, usually neurolysis or nerve transposition.

## Focal Contusion

Current recommendations are to delay treatment, to allow extent of injury to be apparent. Crush injuries may vary in their extent, from **neuropraxic** injuries, to **axonotmetic**. Injuries that fail to heal at 1mm/day may require grafting.

## Laceration

Acute surgical repair (*neurorrhaphy*) is preferred. This may take place within a few days. Surgical goals are to re-align the supporting structures via epineural stitches (10-0 prolene), and to provide for a tension free repair. If the laceration does not result in clean edges, mobilization of the nerves and sequential slicing of the edges

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to shave back to normal nerve may be required. If a tension free repair can not be performed (two to three epineural stitches should reapproximate the edges without tension), then a segmental graft is recommended.

### **Stretch/Traction/Shear Injury**

Recommendations for repair vary depending on the extent of injury. This mechanism can result in any Sunderland Grade injury. Grade III and higher require surgical repair, usually in the form of a bypass or jump graft. Root avulsions may require nerve transfer or re-implantation (*neurotization*) to restore functional status to a limb.

### **Drug Injection Injury**

Most direct nerve injections are neurotoxic, including local anesthetics. If healing does not occur at 1mm/day (implying a Grade II injury or less), then surgical intervention may be required to preserve limb function.

### **Electrical Injury**

Electrical burns typically result in a functional Grade V injury. While anatomic integrity may be preserved, cellular integrity at all levels is destroyed. If the limb can be preserved (depending on the extent and degree of burn), multiple significant grafts and transpositions may be required.