# Iatrogenic nerve/ root after spine surgery injury : lumbar (part II )

Surgical Management


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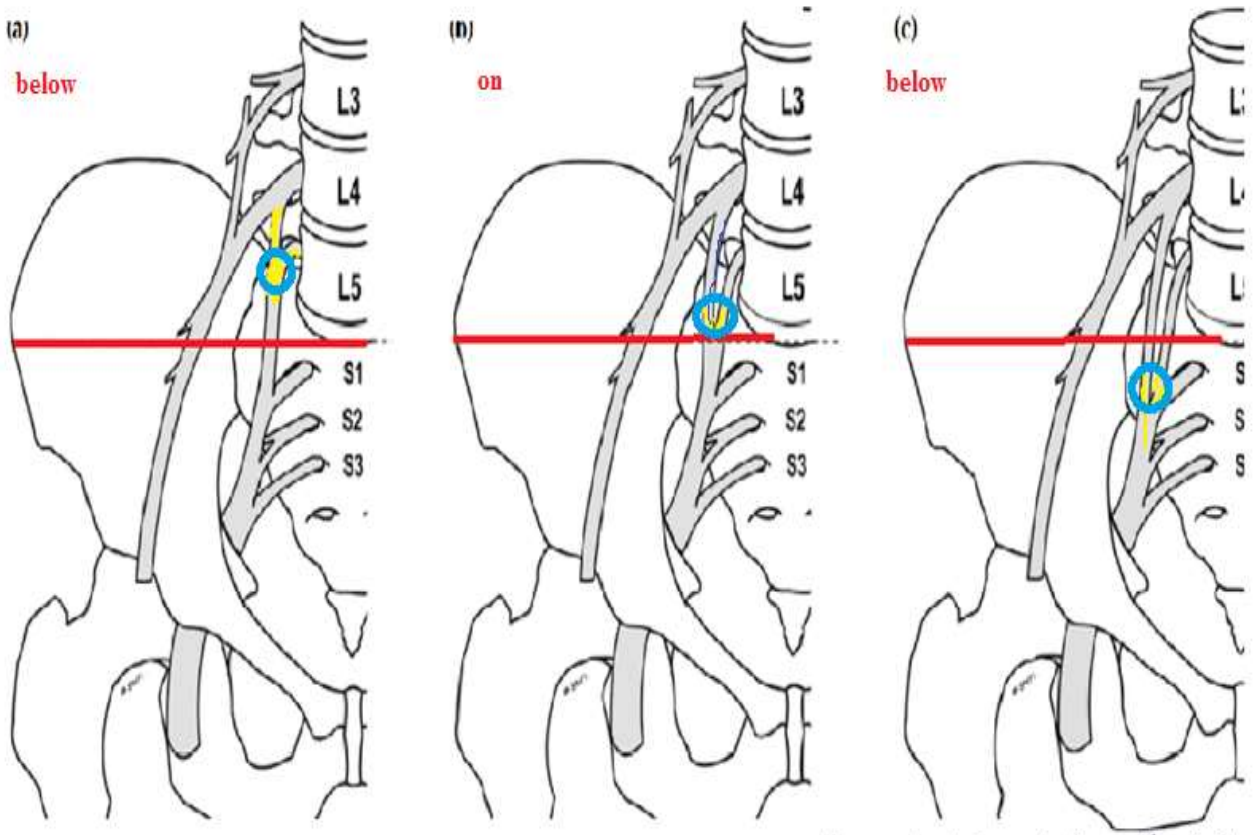
رشت


تهران بهمن ۱۴۰۱

# Anatomy of L4 to S3 nerve roots

Saranatra Waikakul,[1] Supichya Chandraphak,[2] Pichet Sangthongsil[1]

L4 and L5 nerve roots join together



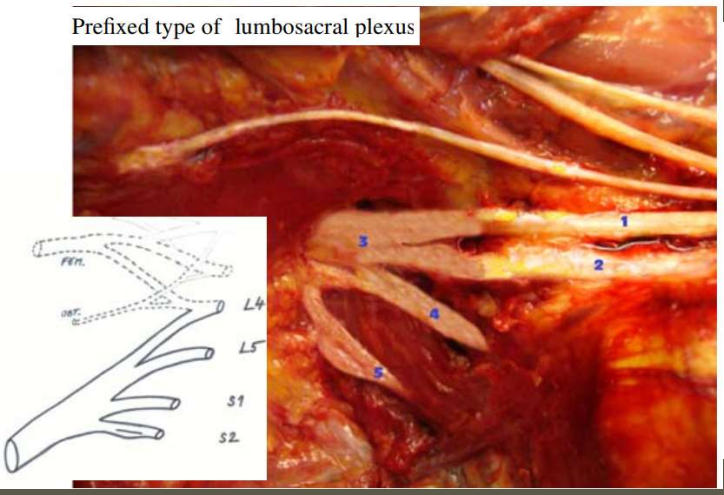

the most anterior part of sacroiliac joint.

Most L4 to S3 nerve roots lie close to the anterior surface of the sacroiliac joint and the ala of the sacrum.

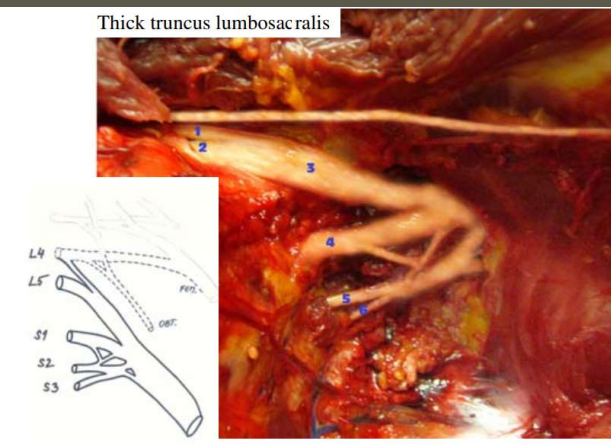
To prevent nerve root injury:

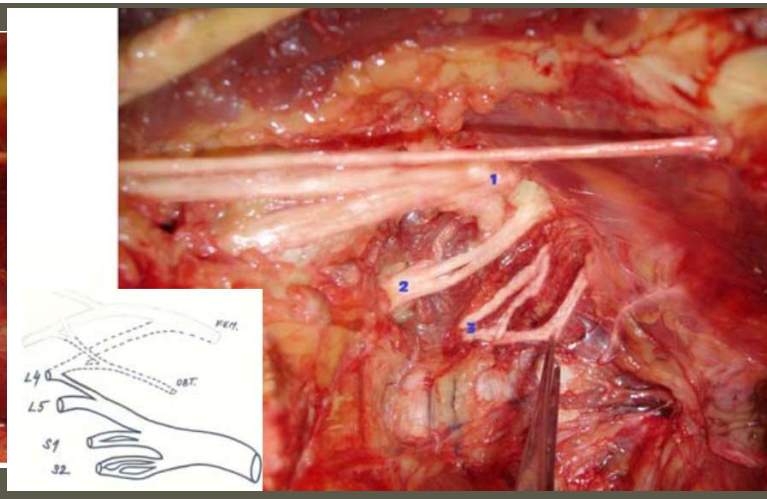
dissection with a sharp instrument should be avoided at such area and 5 to 7 mm medial to the sacroiliac joint.

Prefixed type of lumbosacral plexus

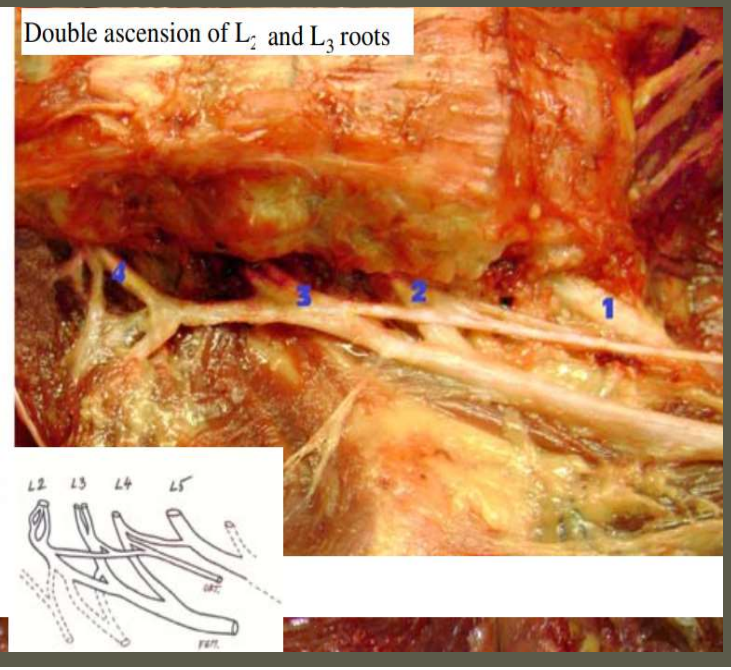



Thick truncus lumbosacralis

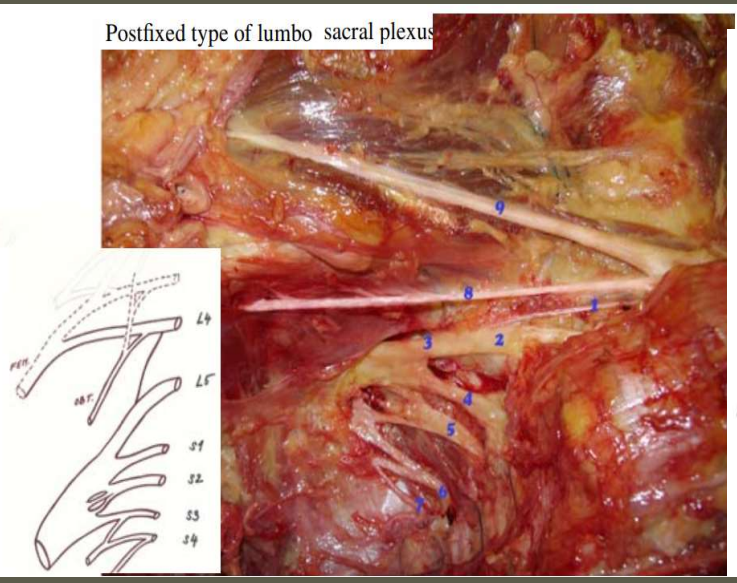


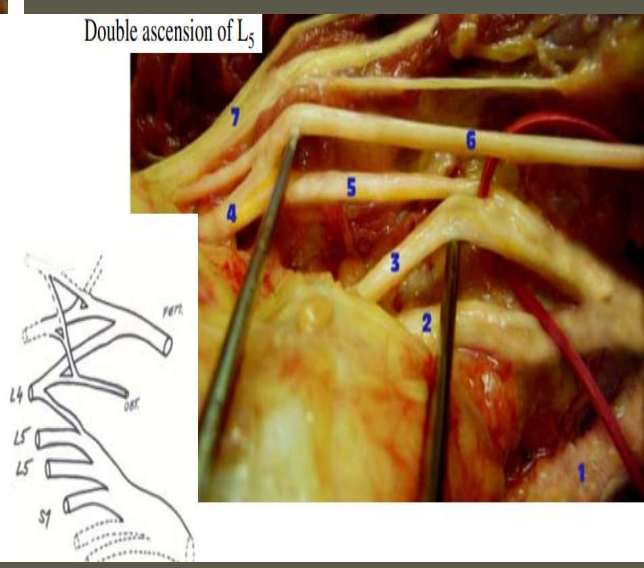

Double ascension of $L_2$ and $L_3$ roots



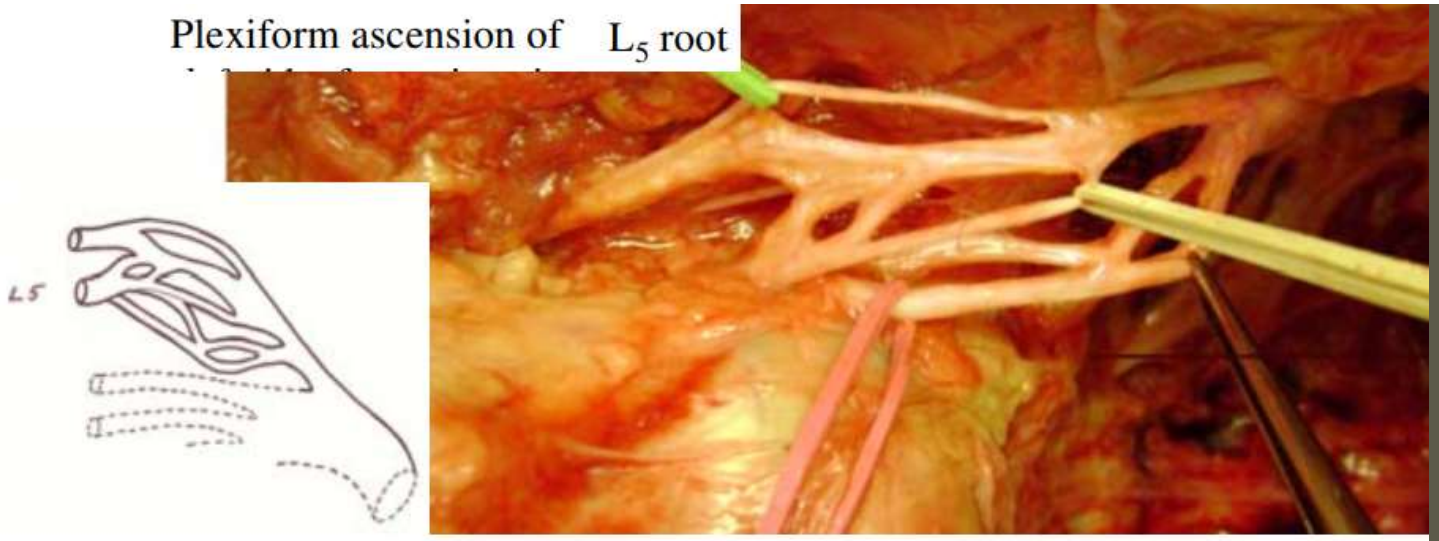

Postfixed type of lumbo sacral plexus



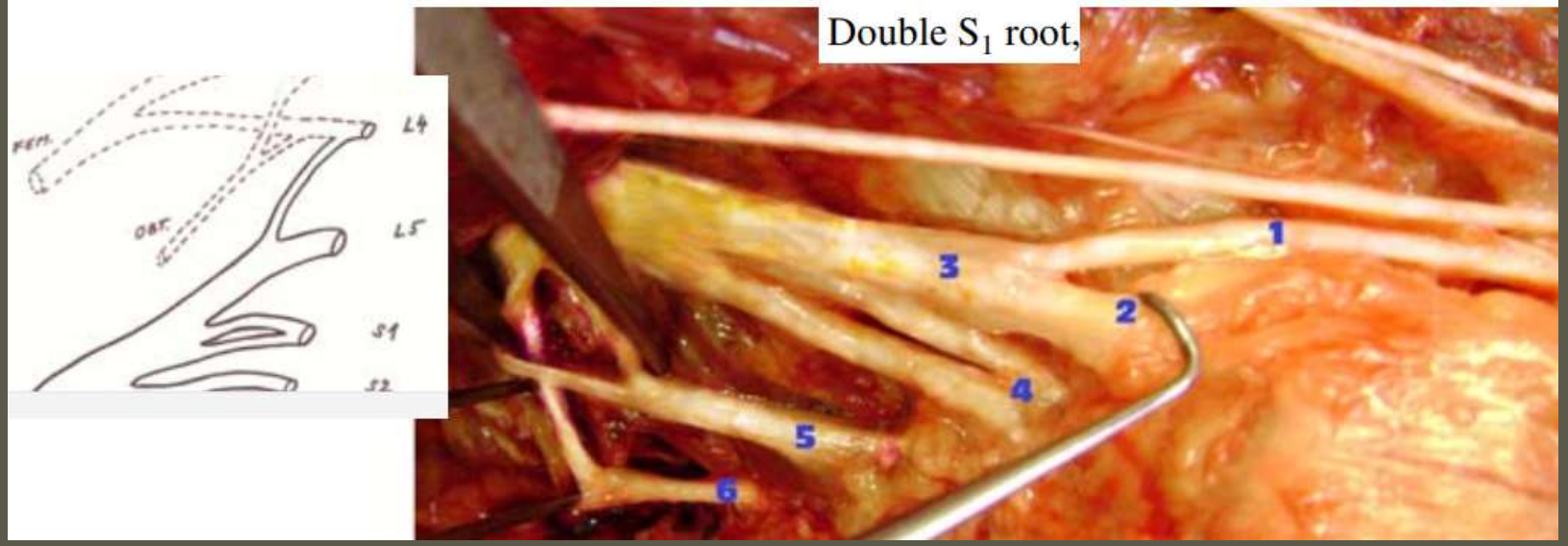

Double ascension of $L_5$



Plexiform ascension of $L_5$ root




Double $S_1$ root,



# Lumbar plexus

- iliohypogastric,
- ilioinguinal,
- Genitofemoral,
- Lateral cutaneous of thigh
- **Obturator**
- **Femoral**
-

# lumbosacral plexus ventral rami of L4-S4.

*superior gluteal nerve L4, L5, and S1
•inferior gluteal nerve L5, S1, and S2
•**Peroneal branch** of the sciatic nerve
•**tibial branch** of the sciatic nerve
•posterior cutaneous nerve
•pudendal nerve S2, S3 and S4

**sciatic nerve L4, L5, S1, S2, and S3**

# Causes of **nerve/root injury**

- inappropriate positioning
- hematoma
- improper hardware placement,
- direct injury **osteotome is likely to injure the L5 nerve root**

**S1 pedicle screws**

**1/due to perforation of the anterior cortex of sacral ala by S1 pedicular screws**

**2/S1 pedicle screws were inserted outwardly and induced radicular pain by impinging on an L5 root**

incidence lumbar nerve root palsy :

1.4% in primary surgery
3.8% in revision surgery
0.9%, for fusion of 5 levels
1.5%, fusion 5 to 10 levels
7.4%, 10 levels

L5 was the most commonly injured nerve root,
all other lumbar nerve roots were also involved.
There were no S1 injuries.

**Patient Demographic Data** **Nerve Root Palsy After Deformity Surgery • Pateder et al 2005**

| Age | Muscle Group Involved | Post-Operative Muscle Grade | 2-Year Follow- up Muscle Grade | Fusion Levels | Adjunctive Procedures | Neurophysiologic Monitoring | Primary vs. Revision |
|---|---|---|---|---|---|---|---|
| 73 | Quadriceps weakness | 3 | 3+ | T3-L5 | ALIF | Normal | revision |
| 38 | Quadriceps and hamstring weakness | 3, 3 | 3+, 3+ | T4-S1 | kyphectomy | Normal | revision |
| 74 | Quadriceps weakness | 4 | 5 | T4-L5 | ALIFs | Normal | revision |
| 85 | Foot drop | 3 | 3 | T10-L5 | ALIF; kyphectomy | Normal | revision |
| 86 | Foot drop | 3 | 3 | T5-L5 | kyphectomy | Changes in bilateral L5 EMG | revision |
| 22 | Foot drop | 3 | 4 | T6-S1 | kyphectomy | Normal | revision |
| 37 | Foot drop | 3 | 4 | T4-S1 | ALIFs; kyphectomy | Normal | revision |
| 47 | Foot drop | 3 | 4 | T5-S1 | ALIF; kyphectomy | Normal | revision |
| 48 | Foot drop | 4 | 4+ | T9-L5 | Anterior release | Normal | primary |
| 29 | Weak EHL | 4 | 4 | L3-S1 | ALIFs | Changes in unilateral L5 EMG | revision |
| 46 | Weak EHL | 4 | 5 | T4-L5 | kyphectomy | Normal | revision |
| 70 | Weak EHL | 4 | 5 | T9-S1 | Anterior release | Normal | primary |

# Nerve root palsy after spinal fusion surgeries for deformities

- 146 primary and 261 revision
- scoliosis 211
- kyphosis 65
- scoliosis + pseudarthrosis 89
- kyphosis + pseudarthrosis 42

average preoperative
thoracic kyphosis 42.4°(range: 0–104°)
lumbar lordosis -14.2° (kyphosis, range: - 60° to 19°)

average postoperative correction
thoracic + 37.7° (range 3–80°)
lumbar spine 10.7°(lordosis, range: - 46° to 62°)

| | | |
|---|---|---|
| Quadriceps weakness | L3-4 | 3cases |
| Foot drop | L4-5 | 6 cases |
| Hallux drop | L5 | 3 cases |

**NRP in Primary *Versus* Revision Surgery**

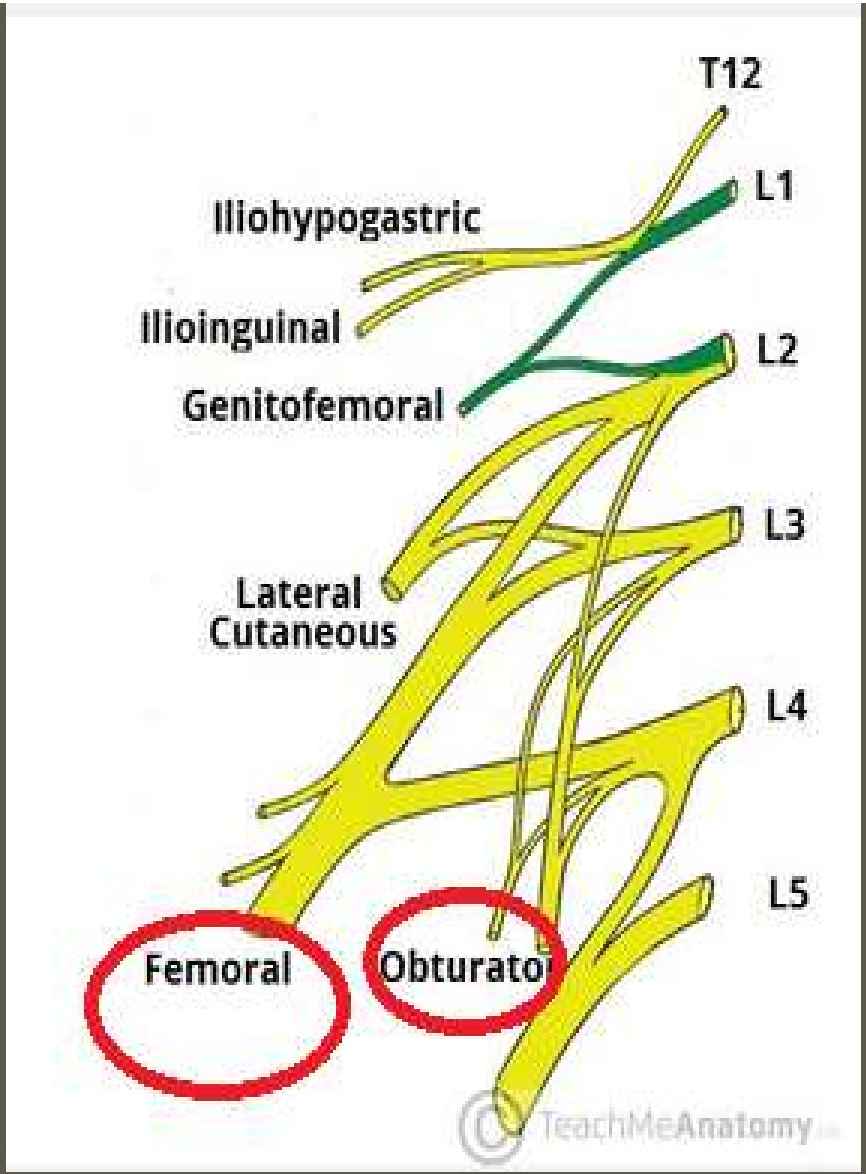
| | Primary Surgery | Revision Surgery |
|---|---|---|
| NRP cases | 2 | 10 |
| Total cases | 146 | 261 |
| Incidence | 1.4% | 3.8% |

foot drop (L4-5) : most common injury
other lumbar nerve roots were also involved
no gastro-soleus (S1) injuries

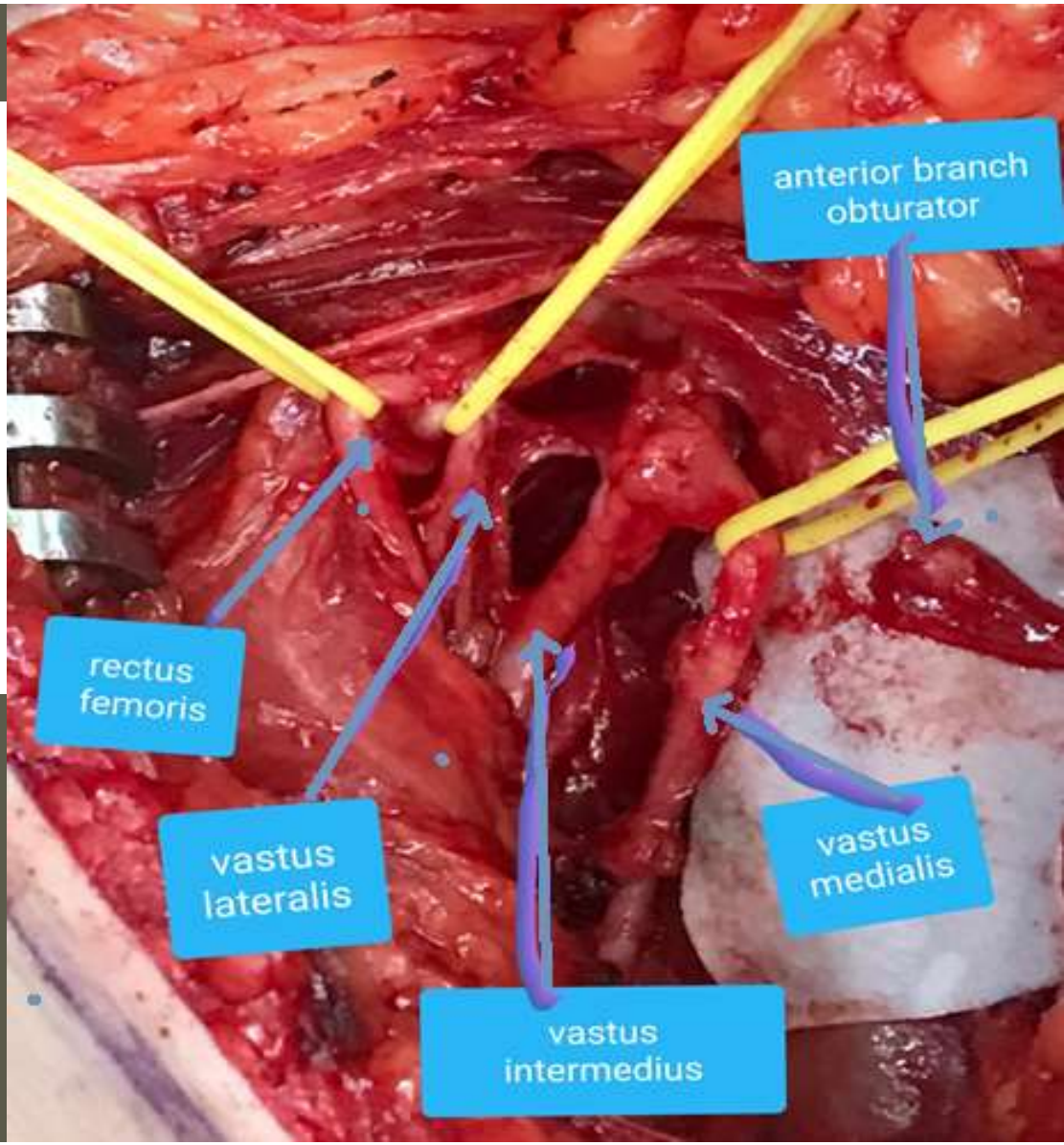
# INJURY to L3,L4 root

unilateral quadriceps weakness  or palsy

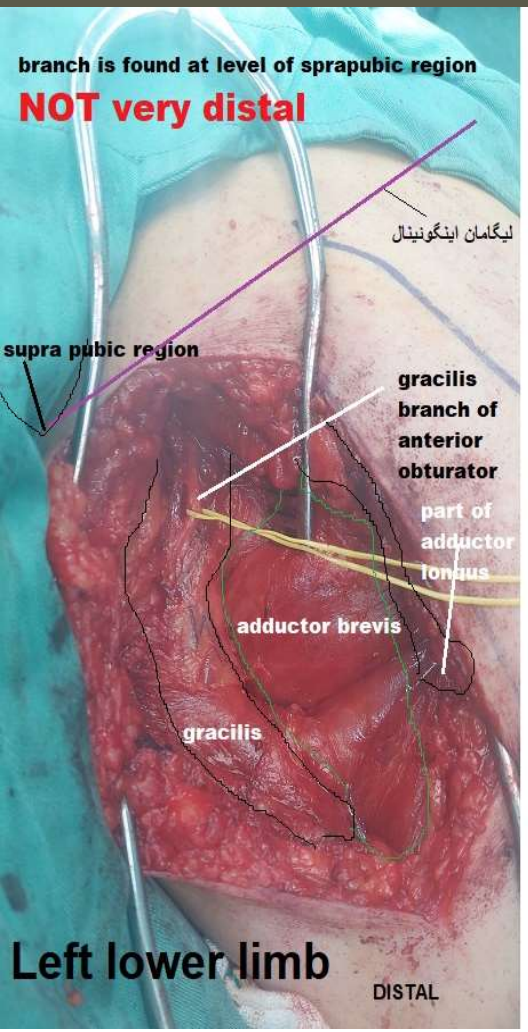
best detected : by a single leg
sit-to-stand test

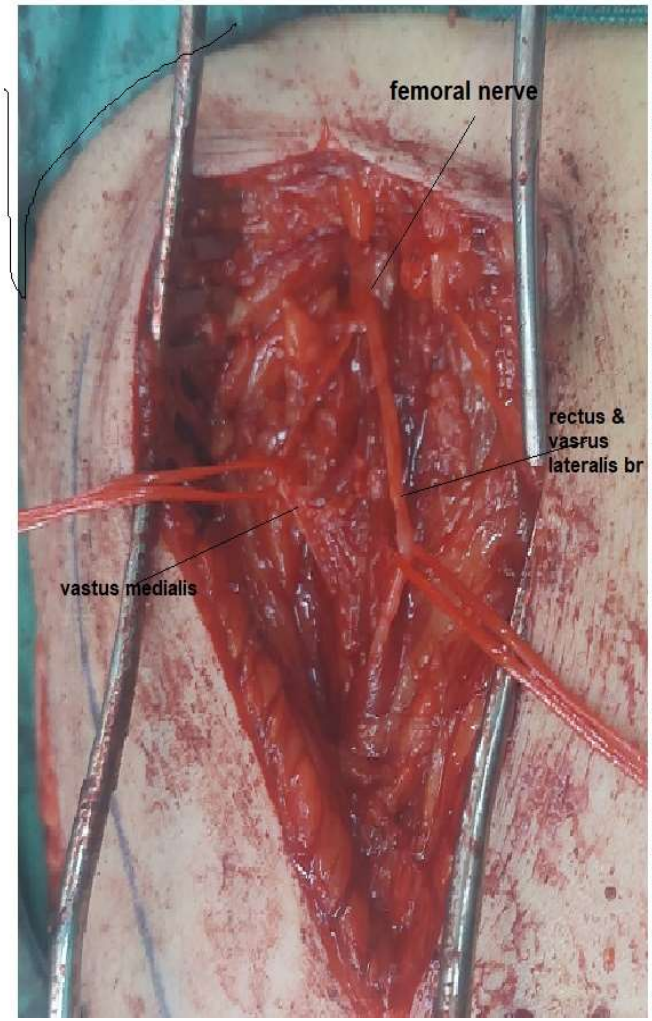


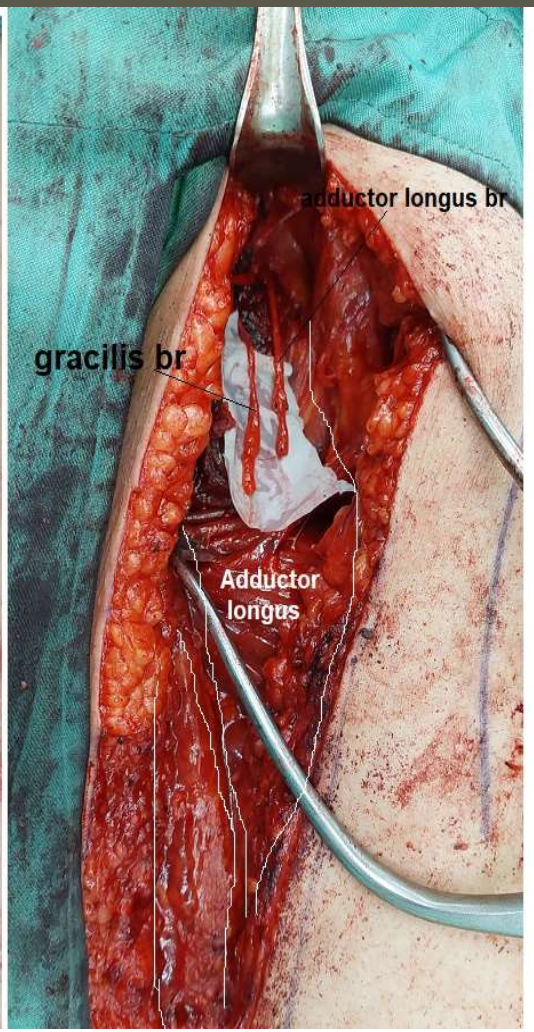
| Muscles | Nerve | Innervation | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | L1 | L2 | L3 | L4 | L5 | S1 | S2 | S3 |
| Quadriceps | Femoral | | O | X | X | | | | |
| Adductors | Obturator | | X | X | O | | | | |

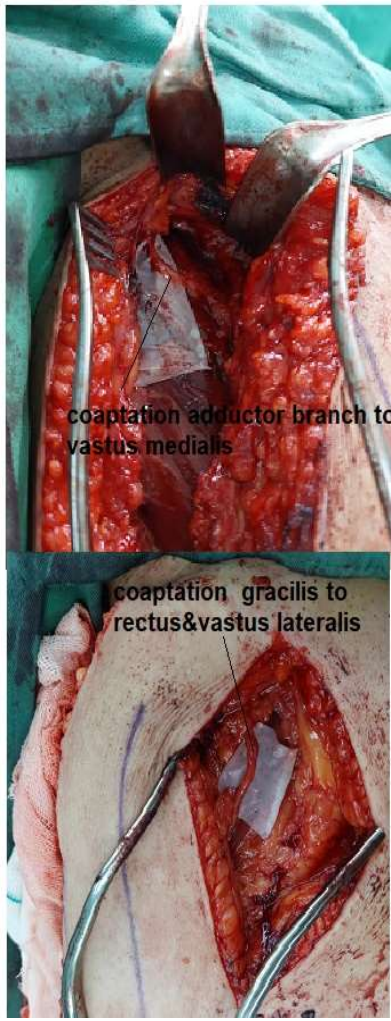


# Obturator to femoral nerve transfer



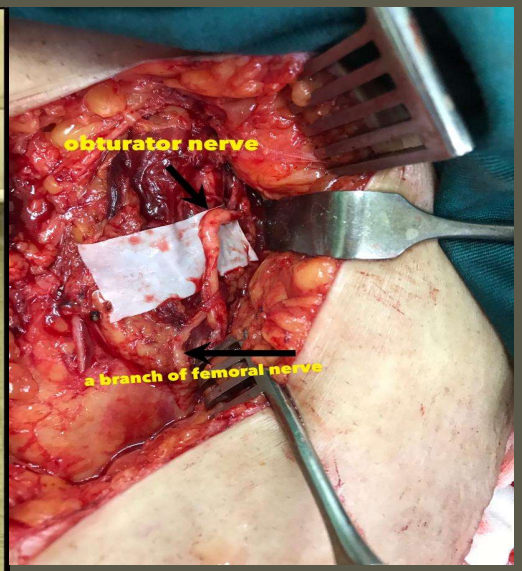




Genuine


مرکز ترمیم عصب و بازسازی اندام فلج
VIVAVIDEO


obturator nerve
a branch of femoral nerve

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https://doi.org/10.1080/00207454.2020.1865948

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CASE REPORT

# Successful restoration of knee extension after transferring of the anterior branch of the obturator nerve: a case study

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Received 16 August 2020
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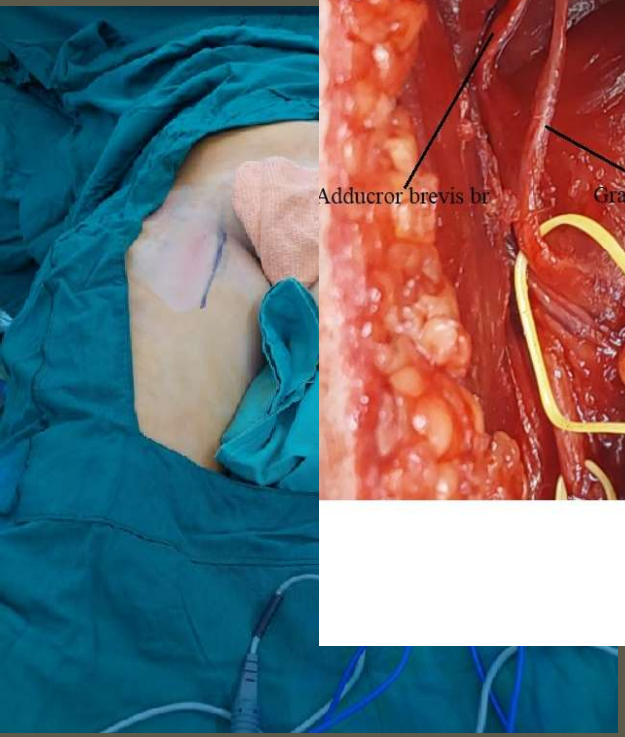
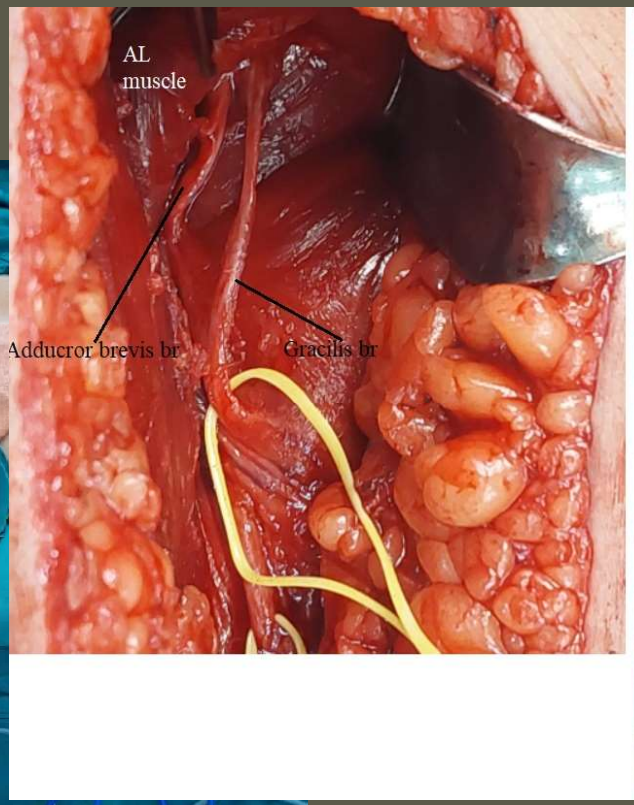
**ABSTRACT**

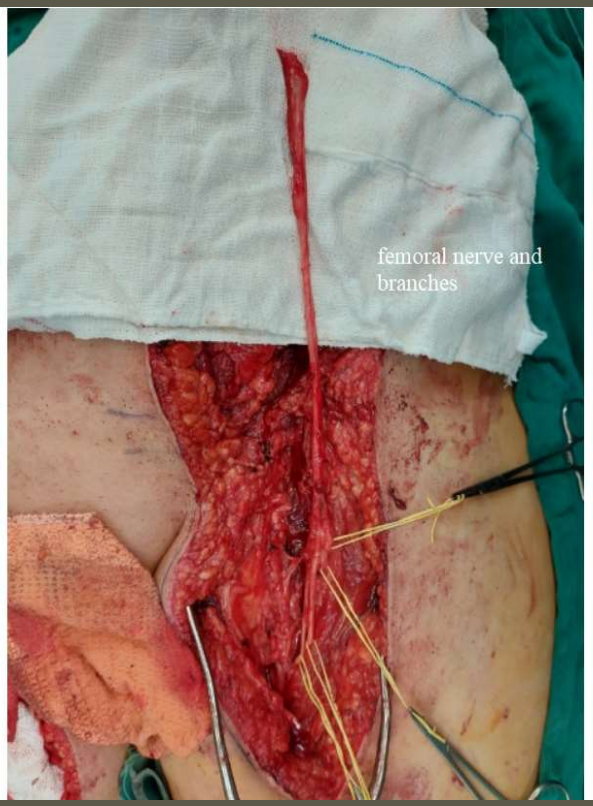
**Objective:** Femoral nerve palsy occurs after trauma, surgical procedures and tumors and leads to loss of quadriceps functions, disability and decreased quality of life. The aim of this report was to describe a successful restoration of knee extension by transferring the anterior branch of

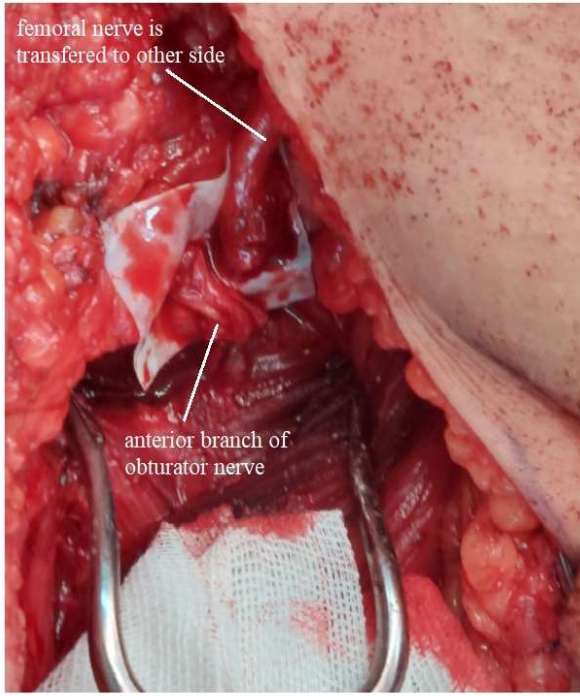
# Combine obturator and femoral injury

# SURGICAL TECHNIQUE





# lumbosacral trunk (L4,L5 roots)

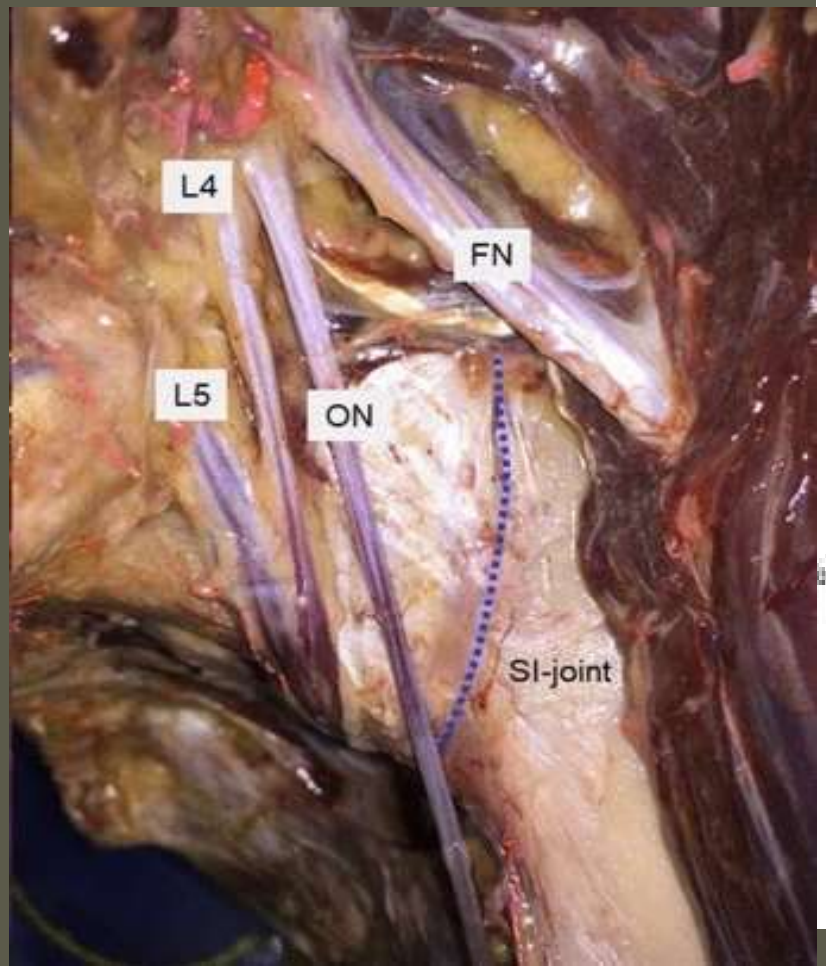
connects lumbar plexus with sacral plexus

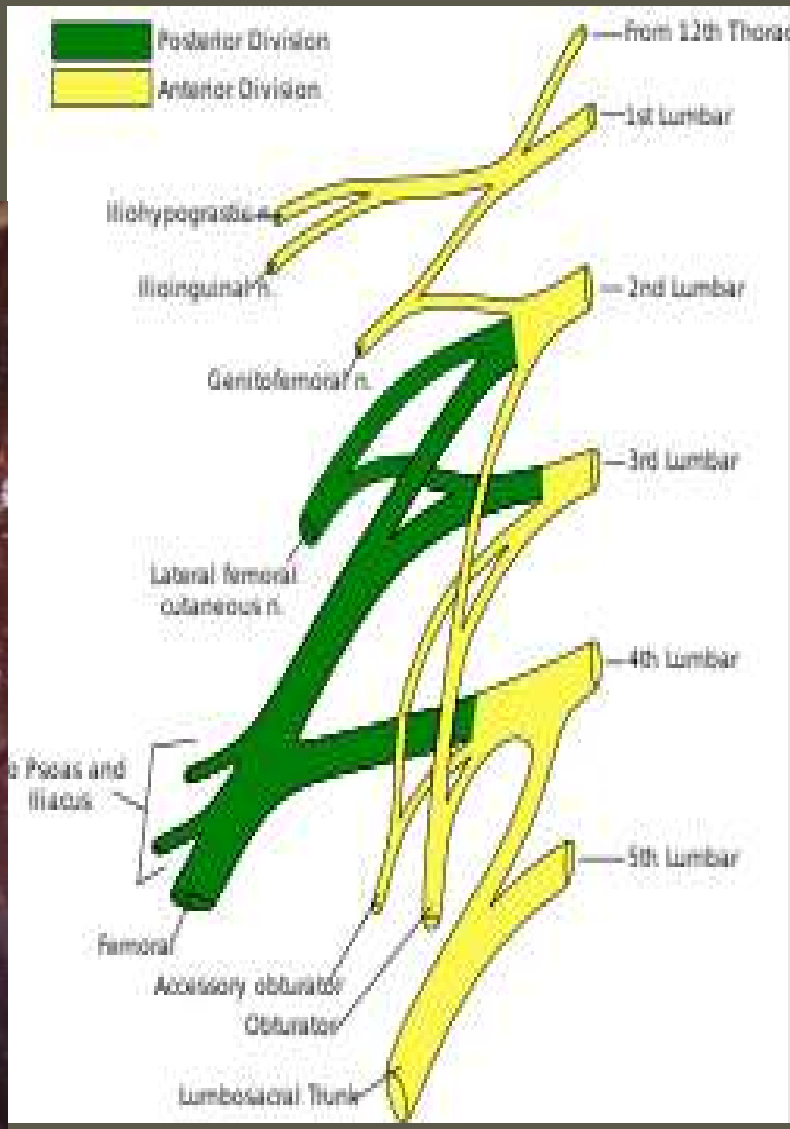
**L4,L5 root injury**

**Dorsiflexion weakness**

**Or FOOT DROP**

**Difficulty in eversion & inversion**



| Joint | Movement | Muscles | | Innervation | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | L1 | L2 | L3 | L4 | L5 | S1 | S2 | S3 |
| Ankle | Dorsiflexion | Tibialis anterior | L4 | | | | X | O | | | |
| | | EDL | L5 | | | | | X | O | | |
| | | EHL | L5 | | | | | X | O | | |
| | | Peroneus tertius | | | | | | O | O | | |
| | Plantarflexion | Gastrocnemius | | | | | | | O | O | |
| | | Soleus | | | | | | | O | O | |
| | | Flexor Digitorum Longus | S1,2 | | | | | O | X | X | |
| | | Flexor Hallucis Longus | S1,2 | | | | | O | X | X | |
| | | Peroneus Longus | L5-S1 | | | | | O | O | | |
| | | Tibialis posterior | L5 | | | | O | O | | | |
| | inversion | Tibialis anterior | | | | | X | O | | | |
| | | Tibialis posterior | | | | | O | O | | | |

Cadaveric study

Global Spine J. 2022 Jun;12(5):890-893. doi: 10.1177/2192568220968773. Epub 2020 Nov 18.

# Iatrogenic L5 Nerve Injury Following Decortication of the Sacral Ala in Posterolateral Lumbosacral Fusion Surgery

Babak Pourabbas Tahvildari [1], Maziar Oveisee [1], Mohammad Farsimadan [1], Mehran Fereidooni [2], Mohammad Zarenezhad [2]

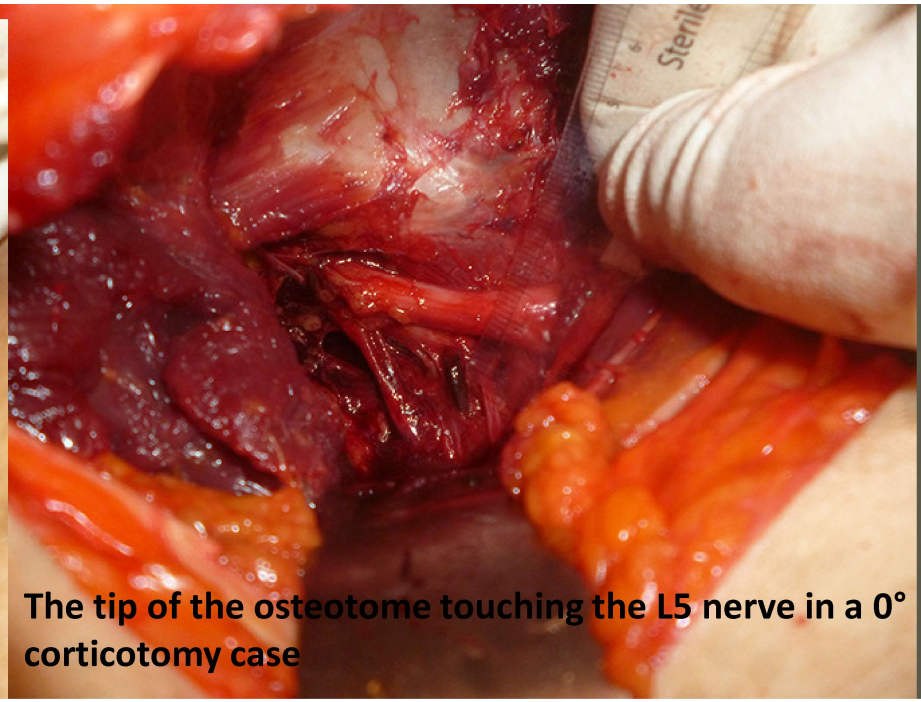
Affiliations + expand

PMID: 33203238 PMCID: PMC9344506 DOI: 10.1177/2192568220968773

Free PMC article

- **Conclusion:**
- Osteotomy of the sacral ala with <30° angle to the sagittal plane risks injury to the L5 nerve
- osteotomy angle >30° would not cause any injury to the nerve

The tip of the osteotome lateral to the L5 nerve in a 20° corticotomy case.



The tip of the osteotome touching the L5 nerve in a 0° corticotomy case

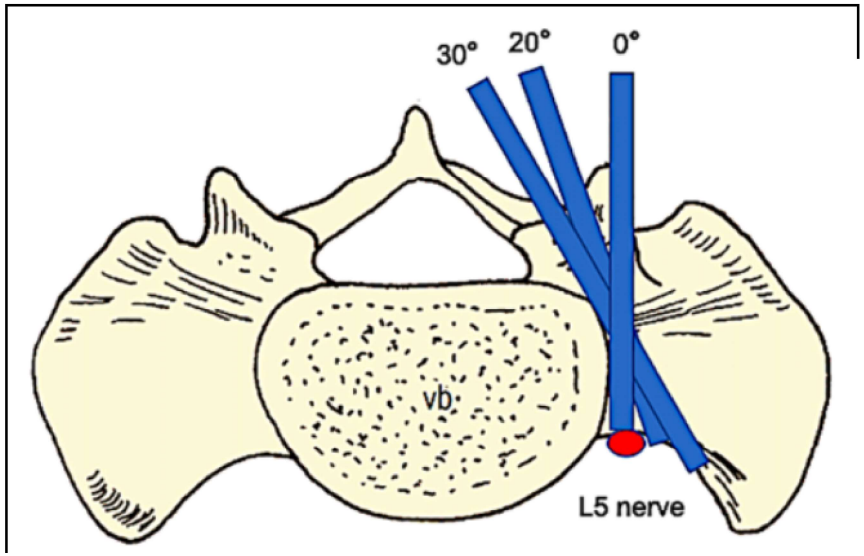



**Table 3.** The Location of the Tip of the Osteotome in Relation to the "Risk Zones."

| Osteotomy angle \ Risk zones | Danger zone | Intermediate zone | Safe zone |
|---|---|---|---|
| 0° | 100% (n = 16) | - | - |
| 20° | 83% (n = 5) | 17% (n = 1) | - |
| 30° | - | - | 100% (n = 6) |

# FOOT DROP after spinal surgery

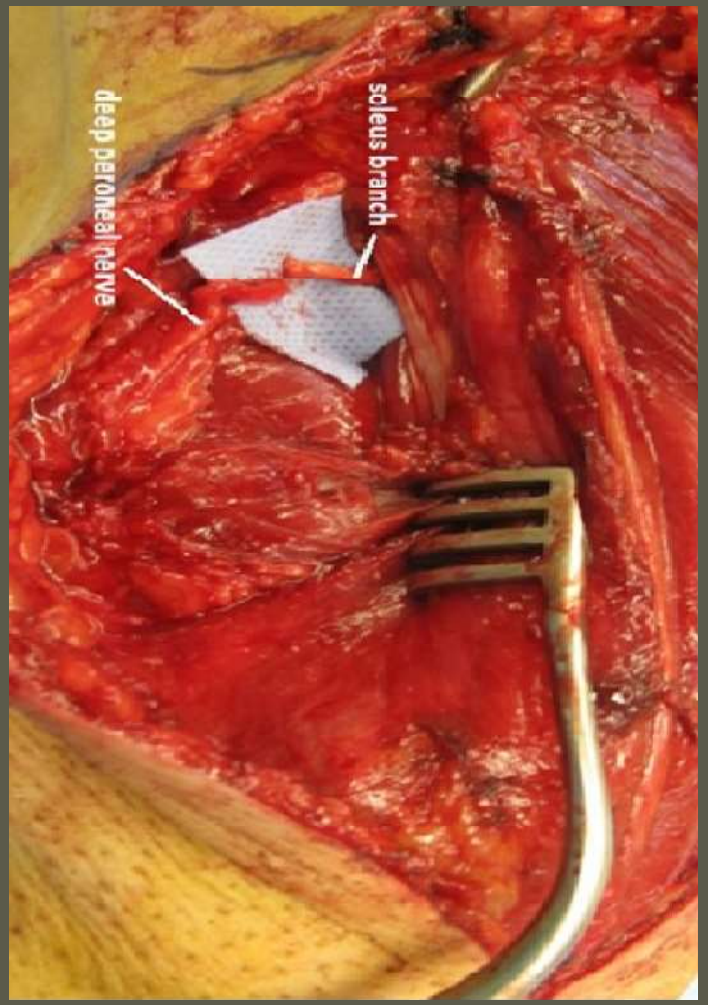
*role of peripheral nerve surgeon*

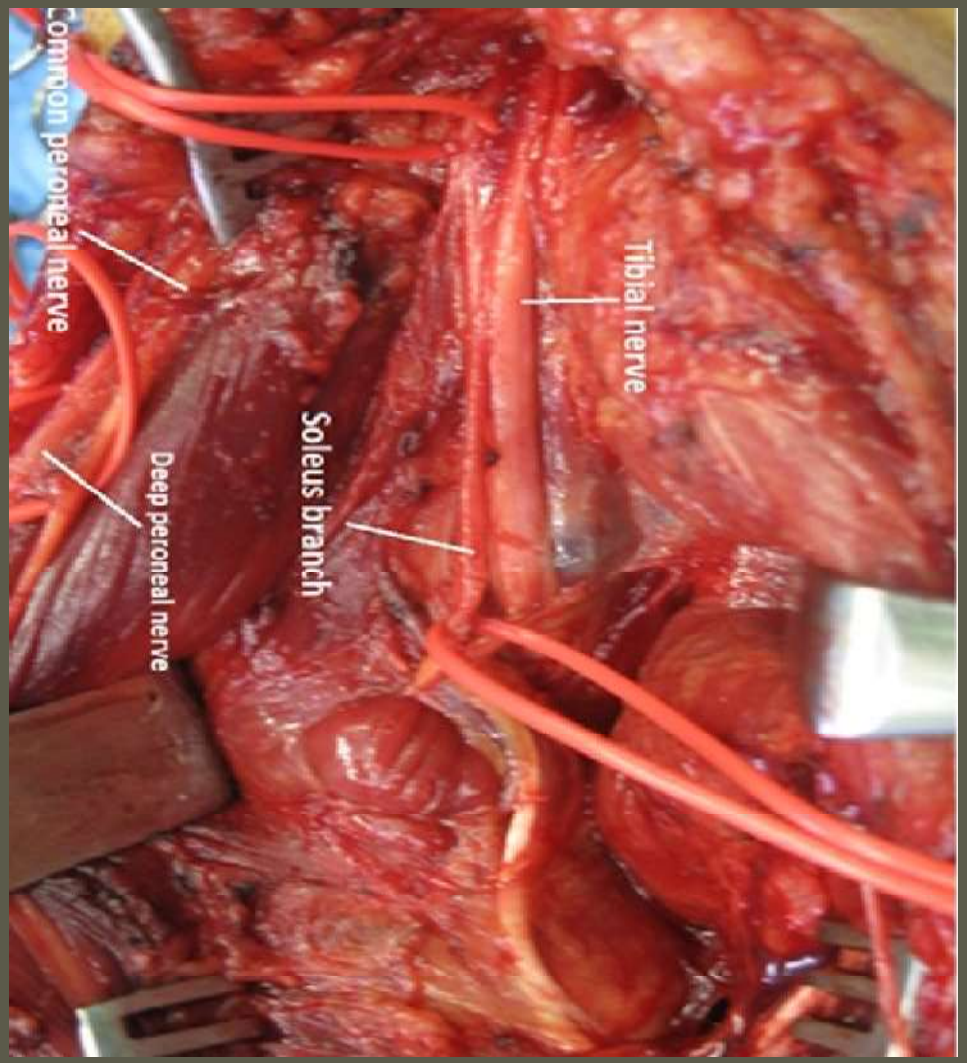
- Tendon transfer ? Why not
- Use of Posterior tibialis tendon (L5)

- Gastrocnemius muscle S1,2
- Soleus muscle S1,2

- **Motor reeducation**

Soleus branch transfer to DPN

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Clinical study

# Soleus nerve transfer to deep peroneal nerve for treatment of foot drop

Mohammadreza Emamhadi [a], Amin Naseri [b], Iraj Aghaei [c,*], Morteza Ashrafi [b], Roxana Emamhadi [d],

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Foot drop
Nerve graft
Soleus nerve transfer

ABSTRACT

Different mechanisms including knee dislocation, replacement surgery, nerve tumor, lumbar disc herniation, sharp injury, and gunshot wound lead to foot drop. Several surgical techniques have been used for treatment of foot drop, however, they have had sub-optimal outcomes. Soleus branch of tibial nerve is a good donor for nerve transfer for treatment of foot drop. In this is retrospective study, we reviewed medical records of 6 consecutive patients with sustained foot drop following injury to lumbar root or peroneal nerve, who underwent transfer of the soleus branch of tibial nerve to deep peroneal nerve during 2014–2016. The mean age of the patients was 44.8 years and duration of injury to surgery and follow-up was 8.3 and 14.6 months, respectively. At the end of the follow-up, ankle dorsiflexion force was M4 in two patients (with traumatic peroneal nerve injury with M3 toe extension) and was M2 in one patient. There were three patients with lumbar degenerative disease. Of these patients, two showed M0 and one patient experienced M1 ankle dorsiflexion. We recommend that transfer of soleus nerve to deep peroneal nerve is used as an alternative technique for treatment of foot drop.

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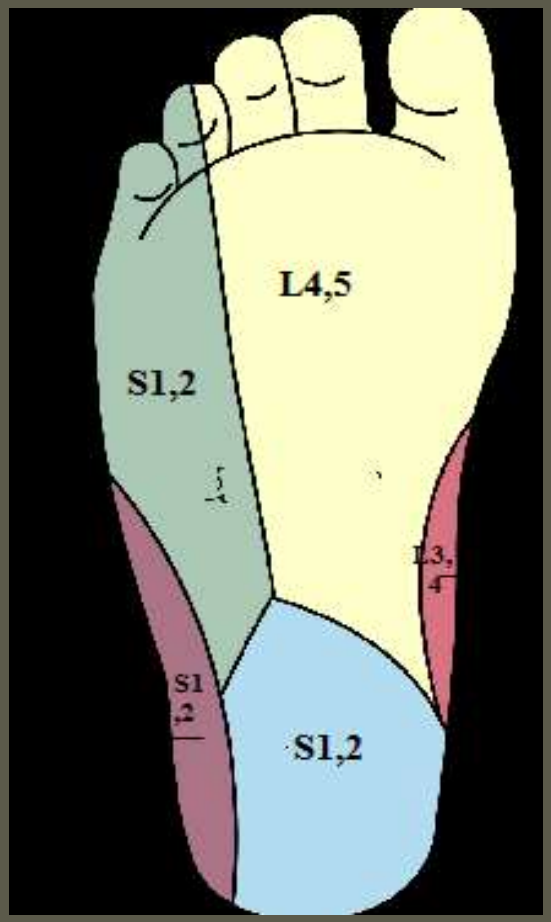
# L5,S1,S2 roots

*like SCIATIC NERVE INJURY*

*knee: flexion*
*ankle : dorsi flexion & plantar flexion*
*toes: flexion, extension ,abduction, adduction*

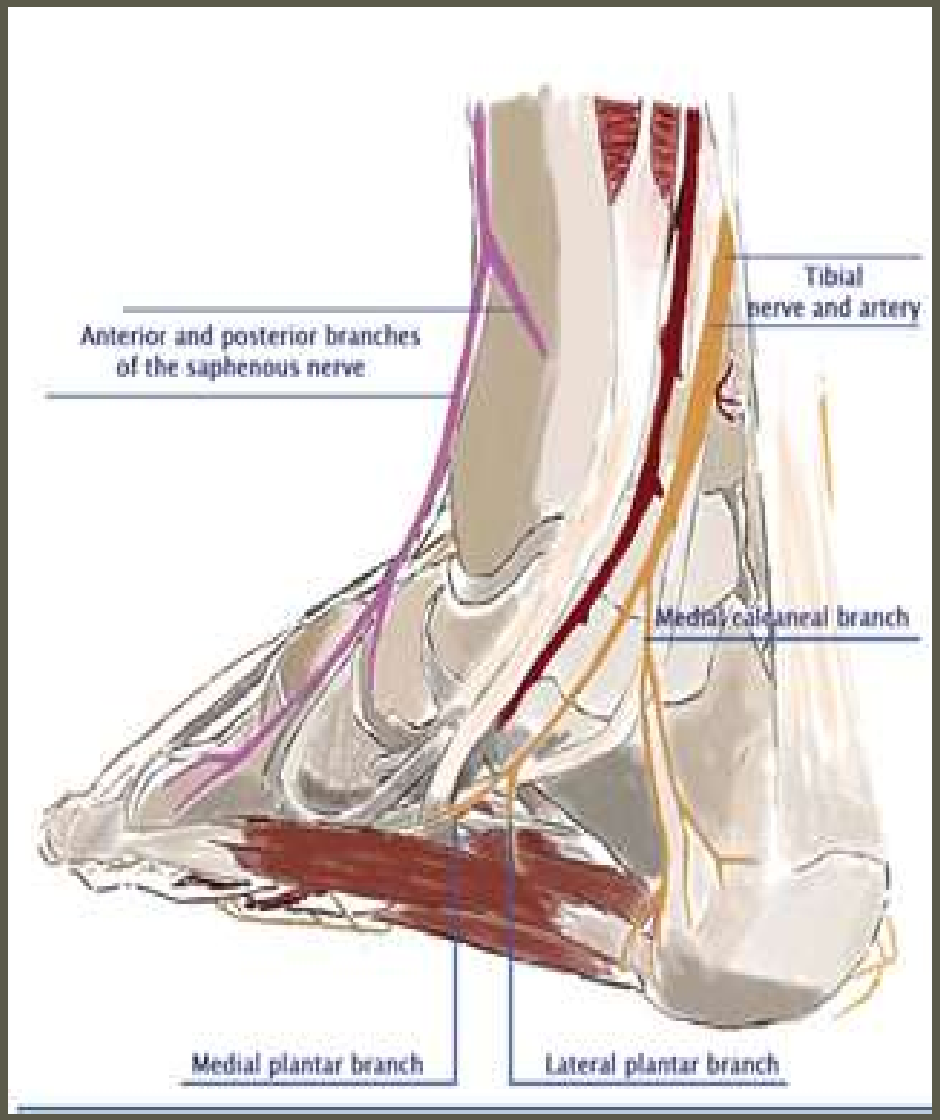


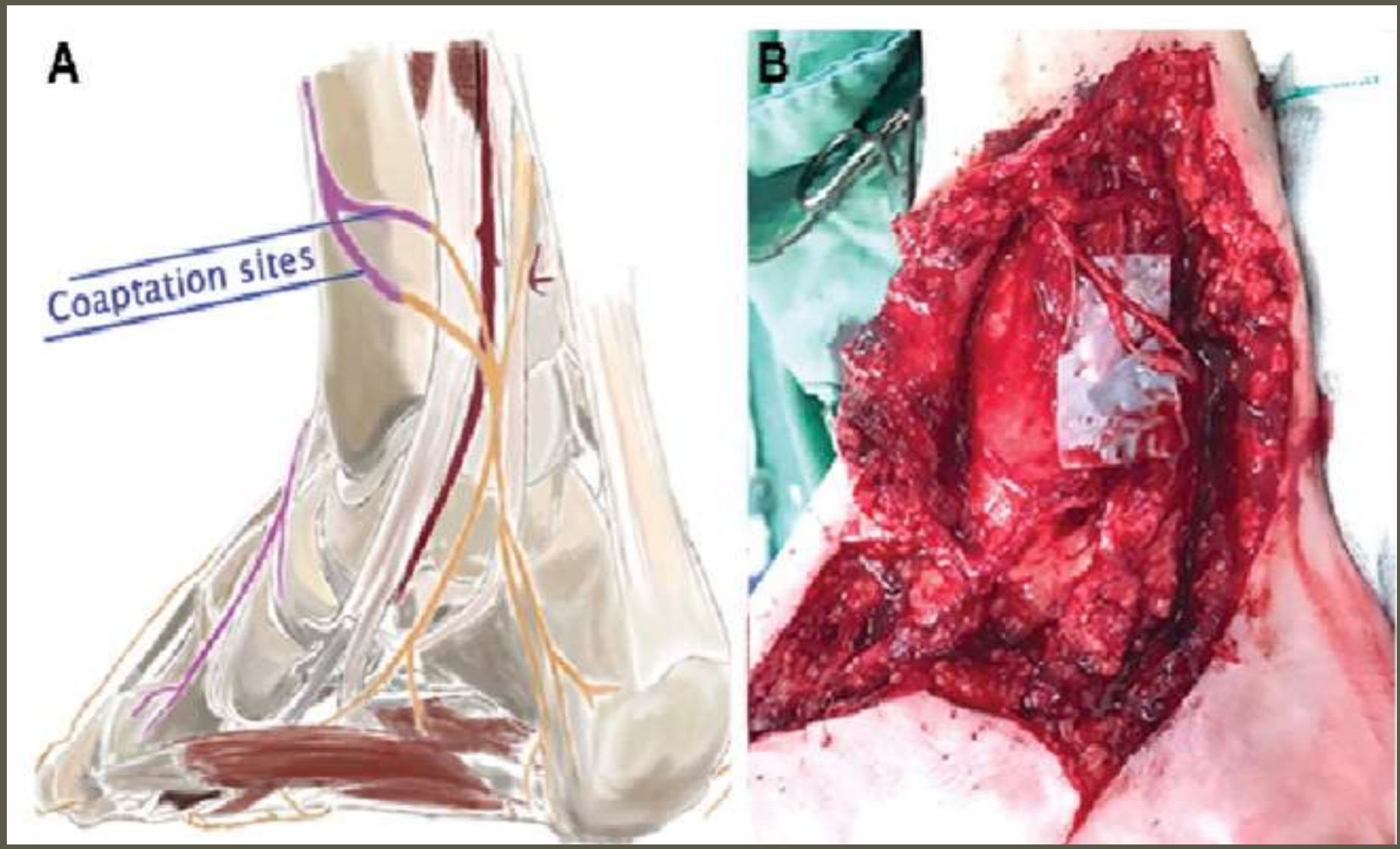

**what can nerve surgeon do?**

**1-Sole sensation**

**2- MOTOR FUNCTION**


Medial
calcaneal branch
Lateral
plantar branch
Medial


Anterior and posterior branches
of the saphenous nerve
Tibial
nerve and artery
Medial calcaneal branch
Medial plantar branch
Lateral plantar branch


A
Coaptation sites
B


**two-point discrimination (*2PD*) test**



Higet–Zachary system (Highet, 1942)

S0 when there is no sensation,
S1 when there is sensation of painful stimuli (protective),
S2 when there is some tactile sensation,
S2+ when there is additional subjective overstatement
(subjective overstatement is when the patient percieves a slight touch as painful or bothering),
S3 when there is tactile and pain sensation recovery,
S3+ when there is also two-point discrimination at a distance of more than 1 cm,
S4 when there is tactile discrimination of two points less than 1 cm apart.

# Clinical Application of Saphenous Nerve Transfer for Sensory Reconstruction of the Sole After Sciatic Nerve Injury: A Case Series

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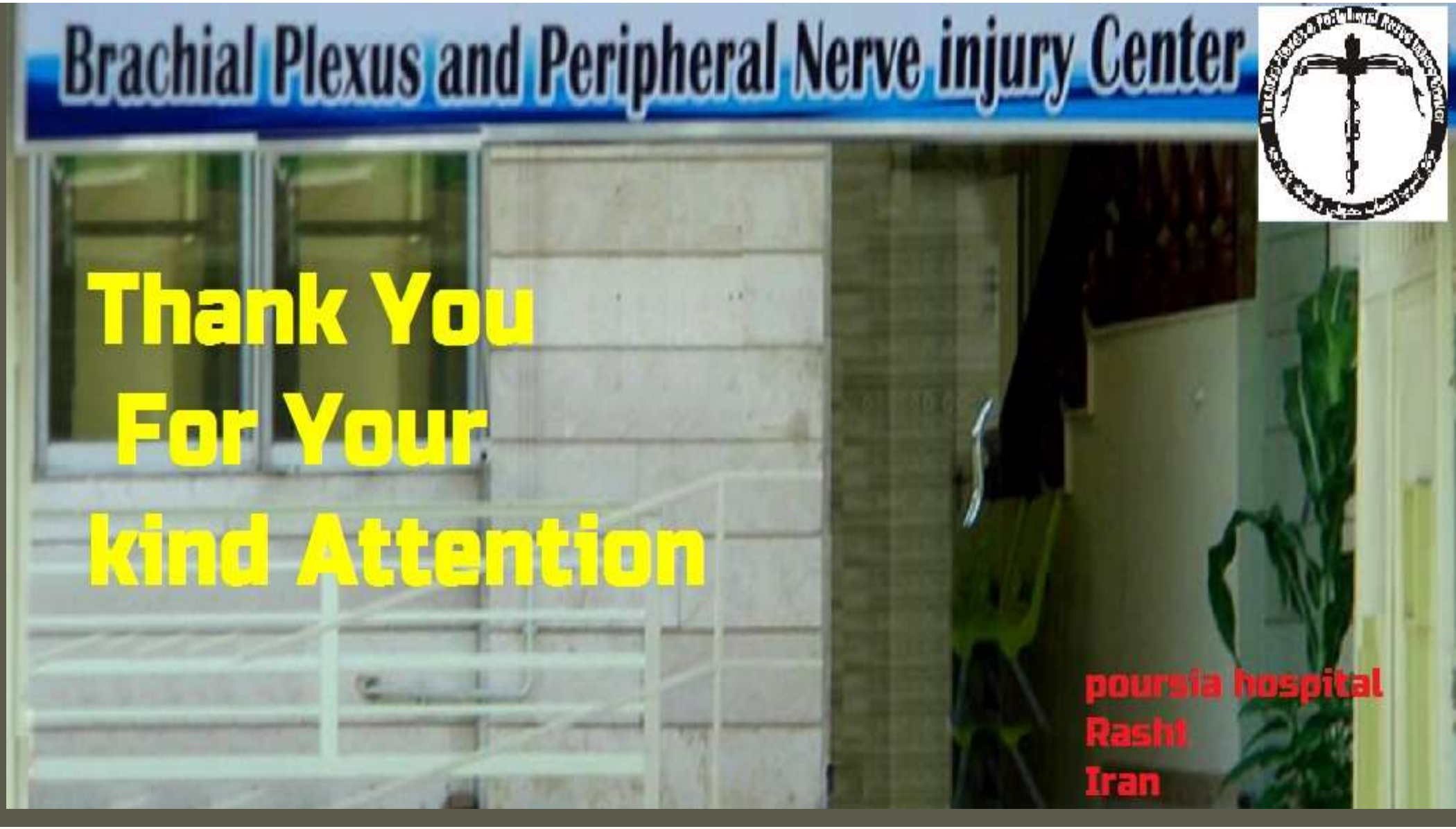
**BACKGROUND:** Sole sensation is essential for standing and walking. Moreover, lack of protective sensation of sole increases the risk of fall-related injuries. In the light of recent developments in nerve transfer, reconstruction of sole sensation can be achieved even in sciatic nerve injuries. Few researchers have addressed the problem of lack of potential donor nerve in proximal sciatic nerve injuries. The saphenous nerve has sufficient sensory fibers and is anatomically feasible to be used as a donor nerve to reconstruct sensation.

**OBJECTIVE:** This study outlines a new approach to restore the sensation of the sole using terminal branches of the saphenous nerve.

**METHODS:** In an attempt to restore sole sensation, 4 patients underwent saphenous nerve transfer to medial plantar and calcaneal branches. Highet–Zachary system scoring was used to evaluate sensory recovery in target regions (heel, metatarsal heads, and big toe).

**RESULTS:** Of the study population, heel sensation recovered up to S3 in 1 case, S2 in 2 cases, and S1 in 1 case. Partial recovery of the metatarsal heads and the big toe was achieved in 2 cases.

**CONCLUSIONS:** The findings of this study indicate that the saphenous nerve is a suitable and available donor to restore sole sensation in sciatic or posterior tibial nerve injuries.


Brachial Plexus and Peripheral Nerve injury Center
Thank You
For Your
kind Attention
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# An unusual complication of sacral nerve root injury following bone marrow harvesting: a case report

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burning and tingling sensation at the left posterior thigh and calf.

bone marrow harvesting procedure using both superior iliac spine (PSIS) as the puncture site

(EMG) neurogenic motor unit potentials on the S2-innervated intrinsic foot muscle and gastrocnemius, soleus

# SACRAL ROOTS

S2 root： glutei and musculus biceps femoris.

N. gluteus superior to gluteus medius(deltoid" of coxal joint)

, musculus gluteus minimus and m. tensor fascia lata

S3 root：flexor of big toe and only rarely other muscles on the extremity

S4 root： no muscles on the extremity

- can affect bladder, bowel, and sexual functions.
- Preservation of the S2 and more cranial nerve roots can maintain most lower-limb and bowel-bladder functions

# injury to the sacral nerve roots

closure pressure of the external urethral sphincter is induced
70 % by stimulation of the S3 ventral root,
30 per cent derives from S2 and S4 neuronal impulses.

Trans-sacral epiduroscopic laser decompression (SELD) is reported to have strong positive short-term effects in controlling lower back pain (LBP) or radicular leg pain following herniated lumbar disc (HLD

A 36-year-old man received SELD with YAG laser for controlling LBP and radicular pain due to HLD on L5-S1.
after SELD, voiding and defecation difficulties and sensory deficits on the S3-5 dermatome
An areflexic neurogenic bladder (urodynamic study)
Three months after symptom onset, the patient's voiding and defecation difficulties were nearly completely recovered

Chang: Sacral root injury during trans-sacral epiduroscopic laser decompression A case report2017

| Joint | Movement | Muscles | Innervation | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | L1 | L2 | L3 | L4 | L5 | S1 | S2 | S3 |
| Knee | Flexion | Semimembranosus | | | | | O | ⊗ | O | |
| | S1 | Semitendinosus | | | | | O | ⊗ | O | |
| | | Biceps Femoris | | | | | O | ⊗ | O | |
| | | Gastrocnemius | | | | | | ⊗ | O | |
| | Extension | Rectus Femoris | | O | ⊗ | ⊗ | | | | |
| | L3-4 | Vastus Lateralis | | O | ⊗ | ⊗ | | | | |
| | | Vastus Intermedius | | O | ⊗ | ⊗ | | | | |
| | | Vastus Medialis | | O | ⊗ | ⊗ | | | | |
| Ankle | Dorsiflexion | Tibialis anterior L4 | | | | ⊗ | O | | | |
| | | Extensor Digitorum Longus L5 | | | | | ⊗ | O | | |
| | | Extensor Hallucis Longus L5 | | | | | ⊗ | O | | |
| | | Peroneus Tertius | | | | | O | O | | |
| | Plantarflexion | Gastrocnemius | | | | | | O | O | |
| | | Soleus | | | | | | O | O | |
| | | Flexor Digitorum Longus S1,2 | | | | | O | ⊗ | ⊗ | |
| | | Flexor Hallucis Longus S1,2 | | | | | O | ⊗ | ⊗ | |
| | | Peroneus Longus L5-S1 | | | | | O | O | | |
| | | Tibialis posterior L5 | | | | O | O | | | |
| | Inversion | Tibialis Anterior | | | | ⊗ | O | | | |
| | | Tibialis Posterior | | | | O | O | | | |
| Toes | Flexion | Flexor Digitorum Longus | | | | | O | ⊗ | ⊗ | |
| | | Flexor Hallucis Longus | | | | | O | ⊗ | ⊗ | |
| | | Flexor Hallucis Brevis | | | | | | O | O | |
| | | Flexor Digitorum Brevis | | | | | | O | O | |
| | | Flexor Digitorum Accessorius | | | | | | | O | O |
| | | Flexor Digiti Minimi Brevis | | | | | | | O | O |
| | | Abductor Hallucis | | | | | | O | O | |
| | | Abductor Digiti Minimi | | | | | | | O | O |
| | | Lumbricals | | | | | | O | O | O |
| | Extension | Extensor Digitorum Longus | | | | | X | O | | |
| | | Extensor Digitorum Brevis | | | | | O | O | | |
| | | Extensor Hallucis Longus | | | | | X | O | | |
| | Abduction | Abductor Hallucis | | | | | | O | O | |

⊗ – Main Nerves Innervating Muscle

O – Accessory Nerves Innervating Muscle

| | |
|---|---|
| L4 | Quadriceps<br>Hip adductors<br>Tibialis anterior |
| L5 | Toes, Extensor & Flexor<br>Ankle, Dorsiflex, Inversion & Eversion<br>Hip, Abductor |
| S1 | Gastrocnemius<br>Hamstrings<br>Gluteus maximus<br>Toe flexors |

**Knee**

| Joint | Movement | Muscles | Innervation | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | L1 | L2 | L3 | L4 | L5 | S1 | S2 | S3 |
| | Flexion<br>S1 | Semimembranosus | | | | | O | X | O | |
| | | Semitendinosus | | | | | O | X | O | |
| | | Biceps Femoris | | | | | O | X | O | |
| | | Gastrocnemius | | | | | | X | O | |
| | Extension<br>L3-4 | Rectus Femoris | | O | X | X | | | | |
| | | Vastus Lateralis | | O | X | X | | | | |
| | | Vastus Intermedius | | O | X | X | | | | |
| | | Vastus Medialis | | O | X | X | | | | |

# Lumbar Plexus: T12 to L5

iliohypogastric nerve : T12 and L1

Sensory input: lateral gluteal area

Motor innervation: internal oblique muscle; transverse abdominal muscles.

ilioinguinal nerve : L1 spinal nerve

Sensory : thigh; males, anterior scrotal nerve root of the penis and the superior part of the scrotum

females, anterior labial nerves , mons pubis and the labia majora.

Motor : internal oblique muscle; transverse abdominal muscles.

genitofemoral nerves L1 and L2 spinal nerves

genital and the femoral branch

Sensory input (genital branch): Skin of the scrotum and mons pubis and labia majora in women

Sensory input (femoral branch): innervation to the anterior and superior area of the thigh

Motor innervation (genital branch): Cremaster muscle in men