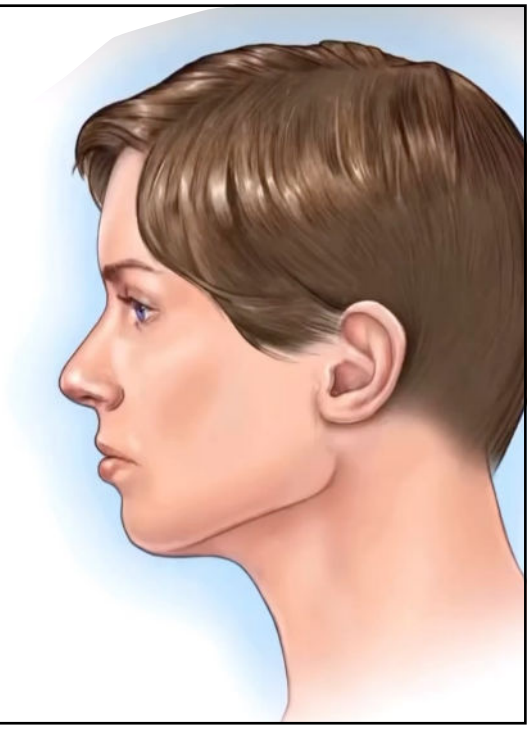
OSLO 2024

Clinical Considerations of the Cervical Spine

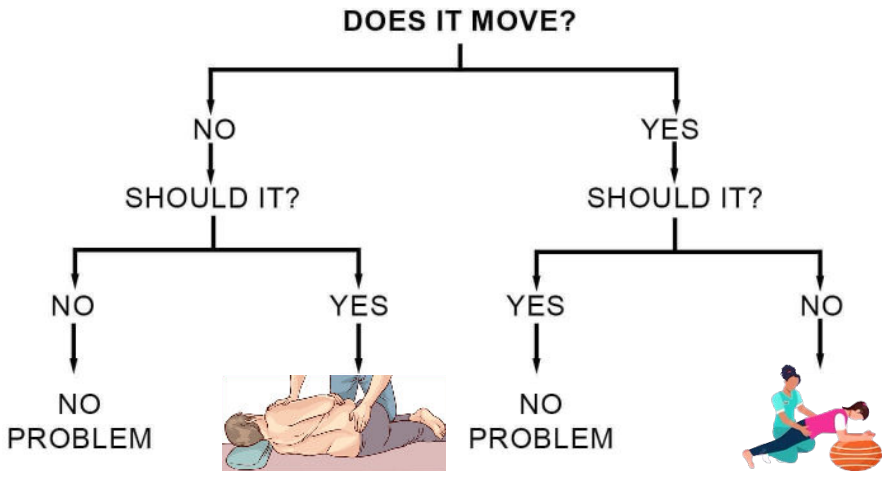


Christian Fossum, DO
Associate Professor
School of Health Sciences

Kristiania

1

Simpler Times Flowchart



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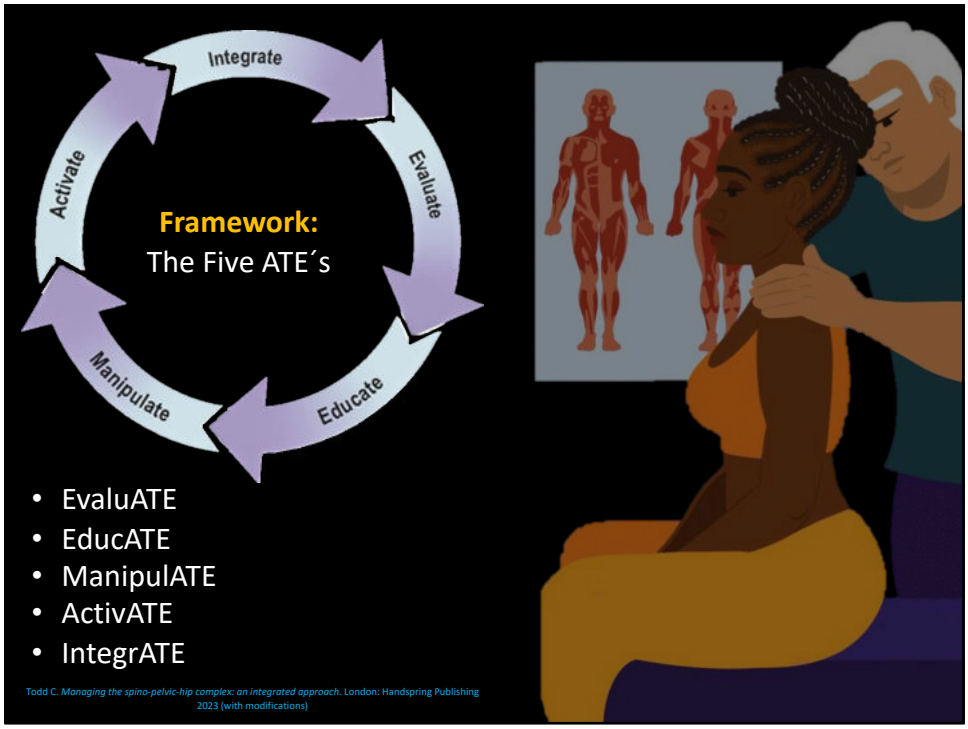
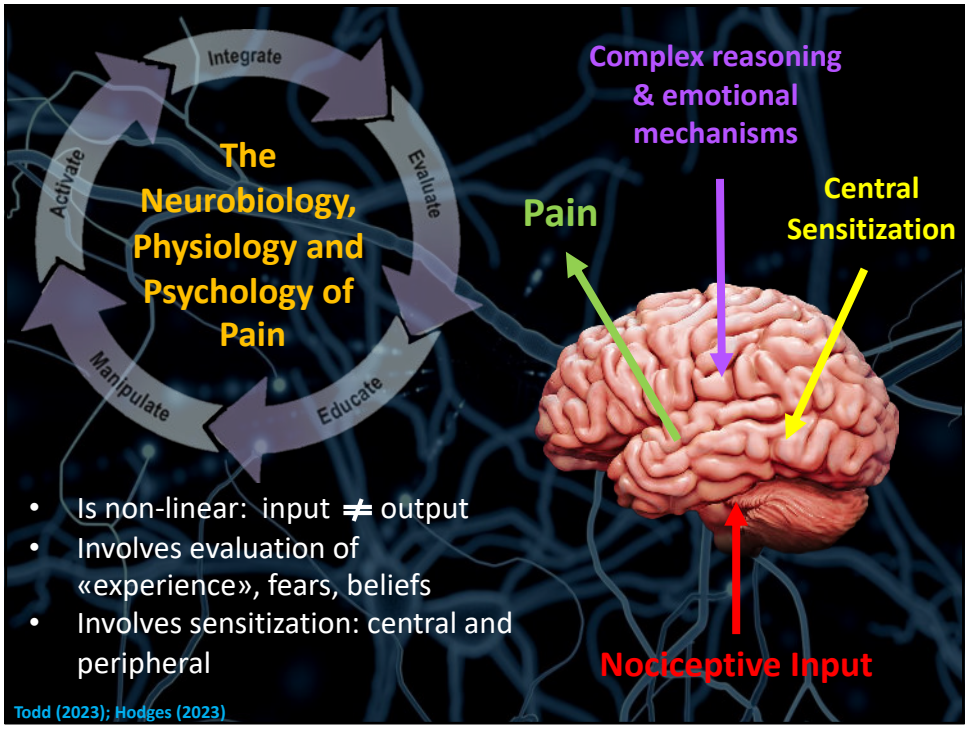

Integrate
Evaluate
Educate
Manipulate
Activate
Framework:
The Five ATE´s
• EvaluATE
• EducATE
• ManipulATE
• ActivATE
• IntegrATE
Todd C. Managing the spino-pelvic-hip complex: an integrated approach. London: Handspring Publishing 2023 (with modifications)

3

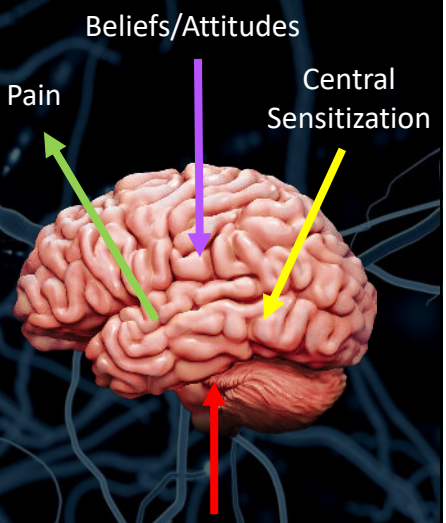

Integrate
Evaluate
Educate
Manipulate
Activate
The Neurobiology, Physiology and Psychology of Pain
Complex reasoning & emotional mechanisms
Pain
Central Sensitization
Nociceptive Input
• Is non-linear: input ≠ output
• Involves evaluation of «experience», fears, beliefs
• Involves sensitization: central and peripheral
Todd (2023); Hodges (2023)

4

Pain neurobiology: Not all pain is the same

Pain maintained by:

- Nociceptive mechanisms
- Nociplastic mechanisms
- Neuropathic mechanisms



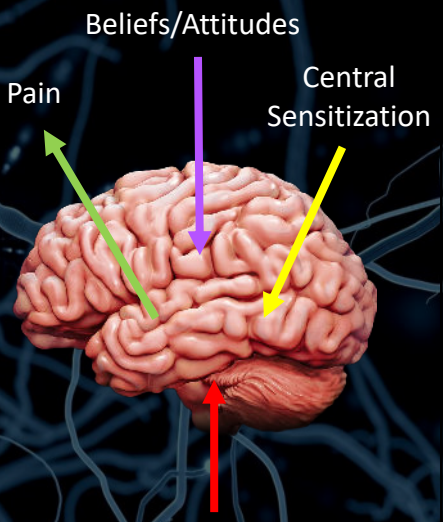
Hodges (2023)

5

Pain neurobiology: Not all pain is the same

Pain maintained by:

- Nociceptive mechanisms
  - Pain that arises from actual or threatened damage to non-neural tissue and is due to activation of nociceptors
- Nociplastic mechanisms
  - Pain arising from altered nociception despite no clear evidence of actual or threatened tissue damage causing the activation of peripheral nociceptors or evidence for disease or lesion of the somatosensory system causing pain
- Neuropathic mechanisms
  - Pain caused by a lesion or disease of the somatosensory nervous system



Hodges (2023)

6

Pain neurobiology: Not all pain is the same

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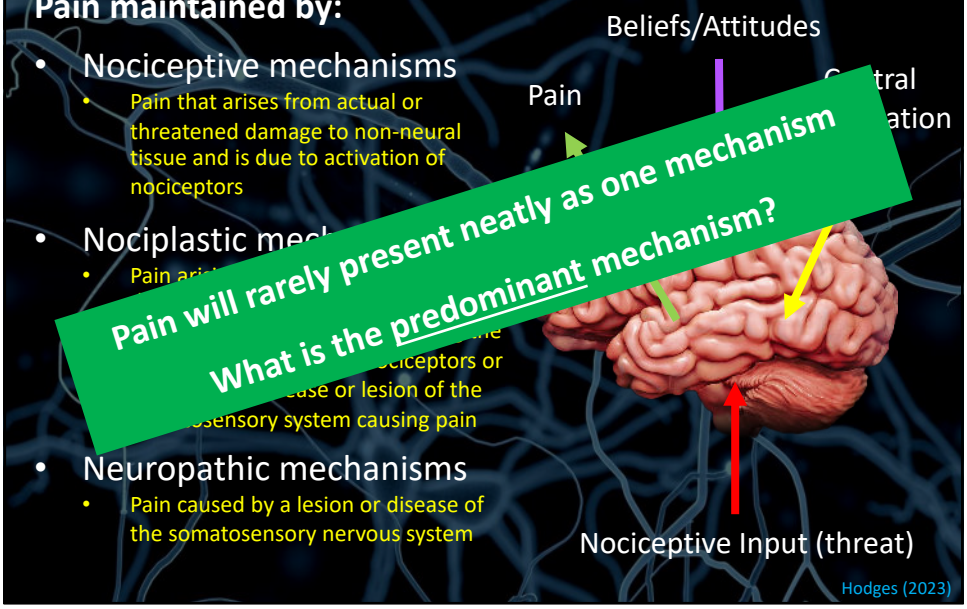
  - Pain that arises from actual or threatened damage to non-neural tissue and is due to activation of nociceptors
- Nociplastic mec
  - Pain ari
  - ciceptors or
  - ase or lesion of the
  - sensory system causing pain
- Neuropathic mechanisms
  - Pain caused by a lesion or disease of the somatosensory nervous system

Pain will rarely present neatly as one mechanism

What is the predominant mechanism?



Hodges (2023)

7

Pain neurobiology: Not all pain is the same

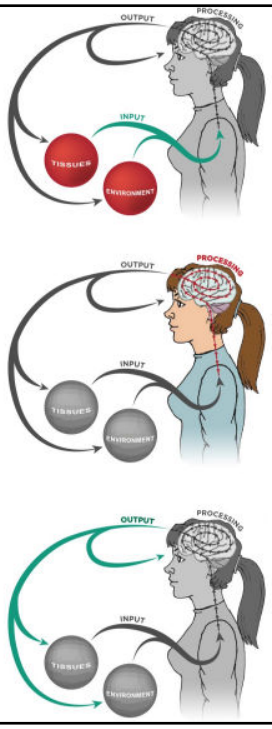
Pain maintained by:

- Nociceptive mechanisms
  - Reduce nociceptive input: Modify tissue loading – manual therapy and motor control
- Nociplastic mechanisms
  - Pain arising from altered nociception
  - Reduce amplification: psychological, education, pharmacological
  - somatosensory system causing pain
- Neuropathic mechanisms
  - Modify nerve loading + reduce amplification

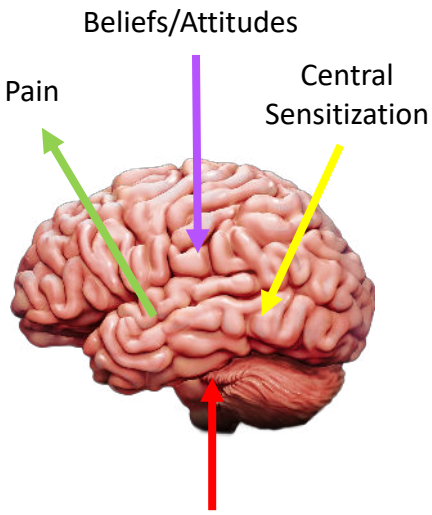
Hodges (2023)

8

- **Input mechanisms:** Input mechanisms refer to the various forms of information sent into the spinal cord and brain for processing. This includes information from the tissues (nociception), environmental influences and the peripheral nervous system, outside the dorsal horn.
- **Processing mechanisms:** The processing mechanisms refer to the structures and processes inside the central nervous system (CNS) and brain processing the information sent by the various input systems. The processing mechanisms include processing sensory, cognitive and emotional aspects of the experience, ultimately putting a value on the information and coming to some form of conclusion.
- **Output mechanisms:** Biologically, there is a response to the input and the brain's interpretation of the experience. The output mechanisms include various biological systems and are strongly driven by survival instincts in lieu of a pain experience.



Modified from: Louw (2021)



9

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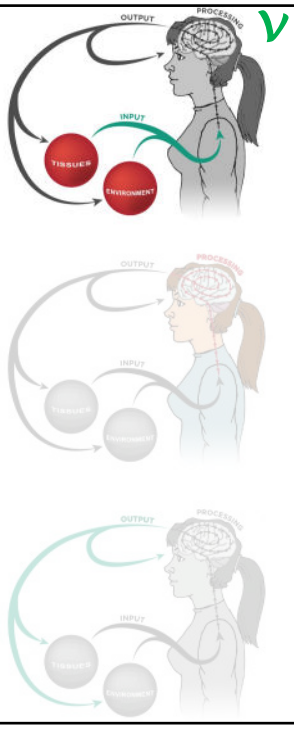

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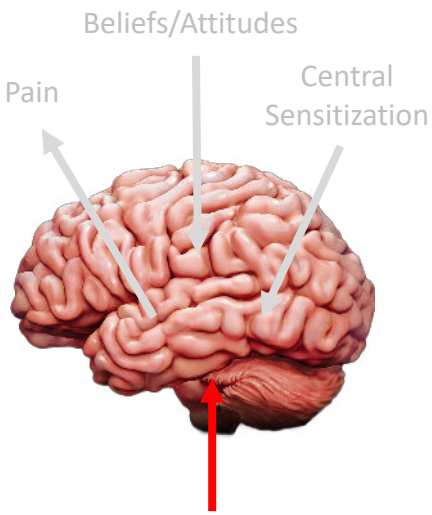

10

11

Goals of the Clinical Examination

Exclude Serious Pathology

- Vertebrovascular Injury
- Ligamentous Instability
- Fracture
- Infection
- Space Occupying Lesions

Peripheral Nervous System (nerve root)
- Radicular Pain
- Radiculopathy

Central Nervous System (spinal cord)
- Cervical Myelopathy

Understand Possible Pain Generators

12

Serious causes of neck pain are rare

- Two population studies using radiography of the cervical spine, each involving >1,000 patients, reported not detecting any serious pathology that was not otherwise suspected from the patient´s history
- These data imply a prevalence of less than 0.4%
- Even in patients attending emergency departments with suspected fractures, fractures was only evident in about 4%

Heller CA, Stanley P, Lewis-Jones B, Heller RF. Value of x ray examinations of the cervical spine. *Br Med J* 1983;287(6401):1276–8.

Johnson MJ, Lucas GL. Value of cervical spine radiographs as a screening tool. *Clin Orthop* 1997;340: 102–8.

Roberge RJ, Wears RC, Kelly M, et al. Selective application of cervical spine radiography in alert victims of blunt trauma: A prospective study. *J Trauma* 1988;28 (6):784–8

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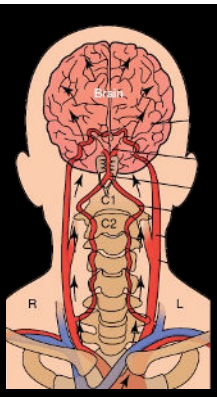
Risk Profiling the Patient

- Recent history of trauma
- Neck pain, Headache, Facial Pain
- Atypical presentation/progression
- Female > Male (3 : 1)
- Age 32 – 45
- Major risk factors
  - Hypertension
  - History of migraine
  - Smoking
  - Oral prevention



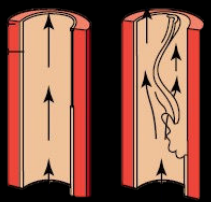
VertebroVascular System

mDNA: Signs & Symptoms

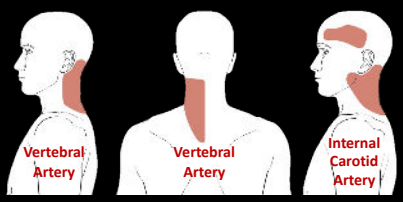
m = Mental
D = Dizziness
D = Drop Attacks
D = Dysphagia
D = Dysarthria
D = Diplopia
N = Nausea
N = Nystagmus
N = Numbness
A = Ataxia

- Cranial Nerves
- Peripheral Nerves
- Balance/Coordination
- Imaging

Pain Patterns with Cervical Arterial Dysfunction


Normal Artery

Dissected Artery

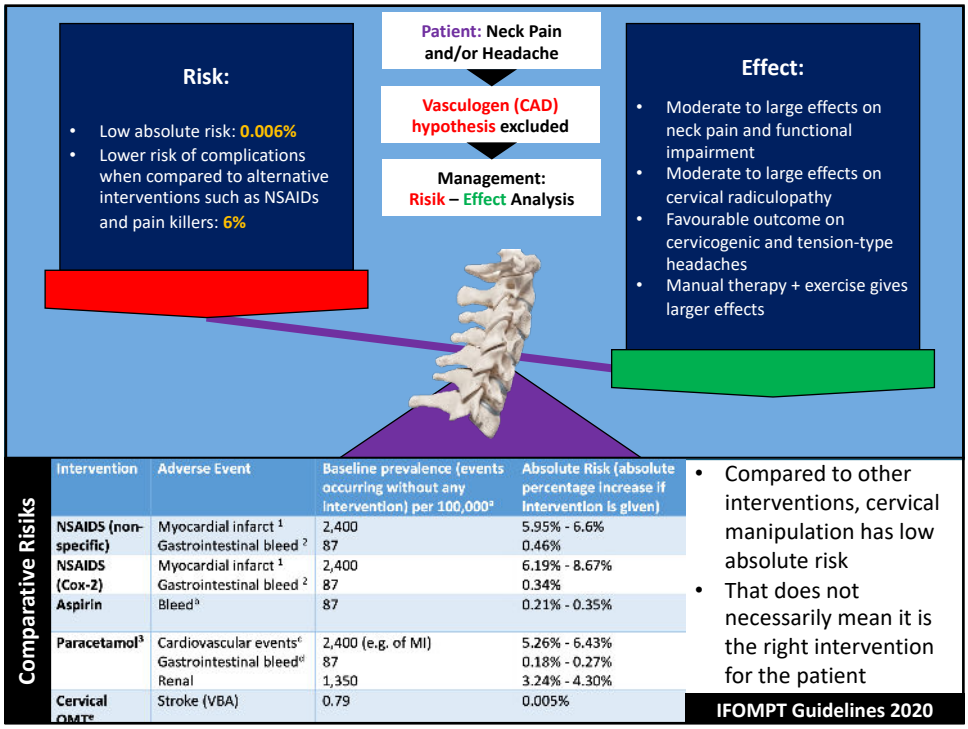


0 Days → Progression → 9-14 Days


Thrombus ↓ Occlusion


Embolus ↓ To Brain

14



Comparative Risiks

Intervention	Adverse Event	Baseline prevalence (events occurring without any intervention) per 100,000[a]	Absolute Risk (absolute percentage increase if intervention is given)
NSAIDS (non-specific)	Myocardial infarct [1]	2,400	5.95% - 6.6%
	Gastrointestinal bleed [2]	87	0.46%
NSAIDS (Cox-2)	Myocardial infarct [1]	2,400	6.19% - 8.67%
	Gastrointestinal bleed [2]	87	0.34%
Aspirin	Bleed[b]	87	0.21% - 0.35%
Paracetamol[3]	Cardiovascular events[c]	2,400 (e.g. of MI)	5.26% - 6.43%
	Gastrointestinal bleed[d]	87	0.18% - 0.27%
	Renal	1,350	3.24% - 4.30%
Cervical OMT[e]	Stroke (VBA)	0.79	0.005%

- Compared to other interventions, cervical manipulation has low absolute risk
- That does not necessarily mean it is the right intervention for the patient

IFOMPT Guidelines 2020

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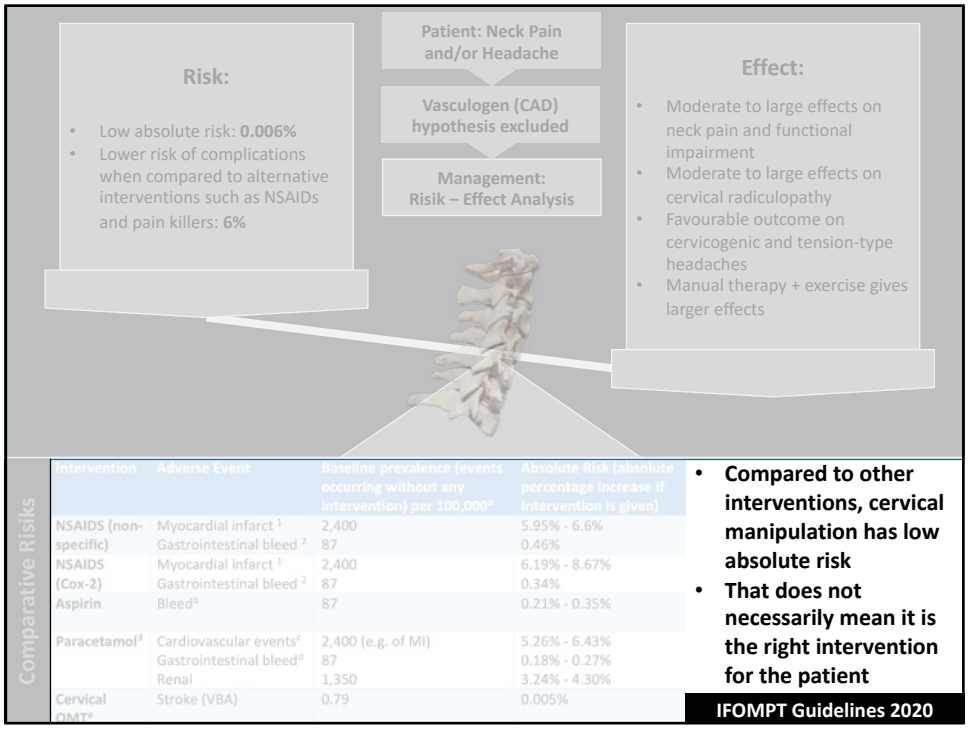

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IFOMPT Guidelines 2020

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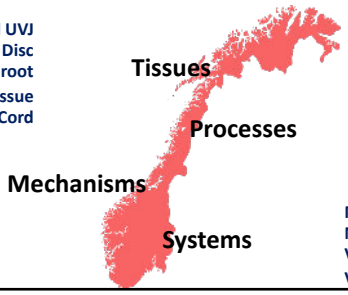
Central Nervous System (spinal cord)
- Cervical Myelopathy

Understand Possible Pain Generators

Joints: ZAJ and UVJ
Intervertebral Disc
Nerve root
Connective tissue
Nerves and Spinal Cord

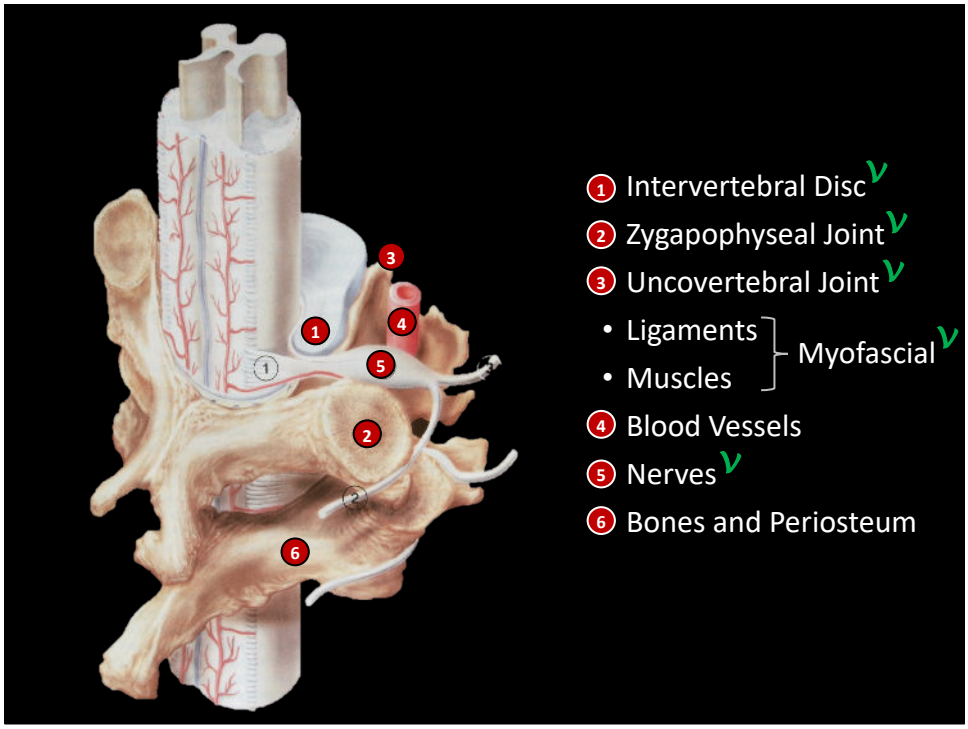
Nociceptive
Neuropathic
Nocifensive



Inflammation
Ischemia
Congestion

Musculoskeletal
Neurologic
Vascular
Visceral

17



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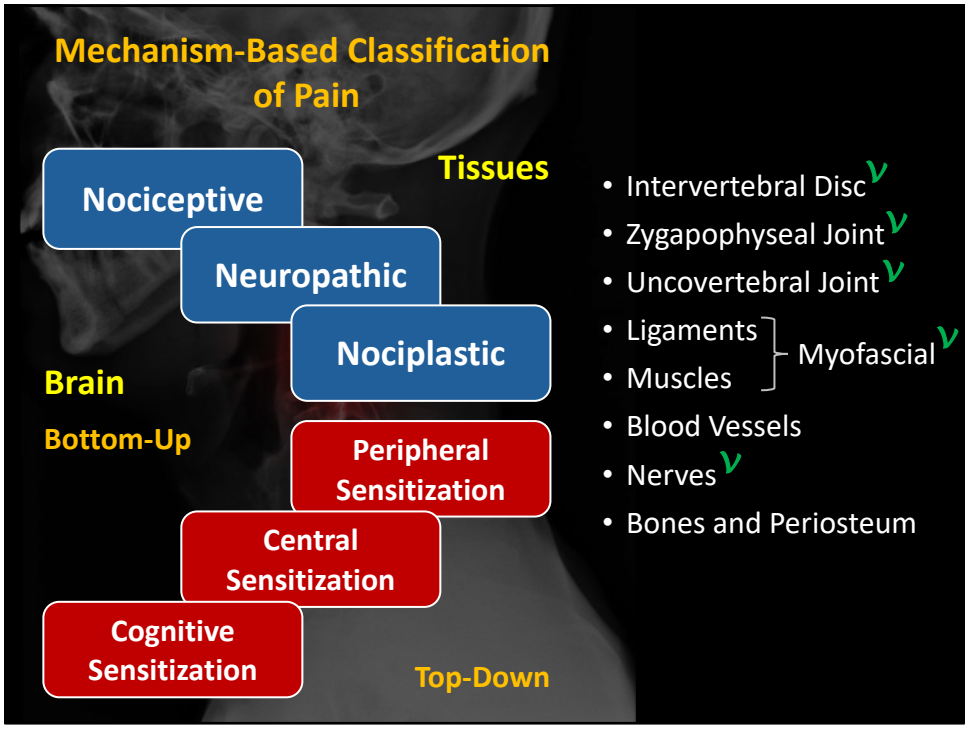
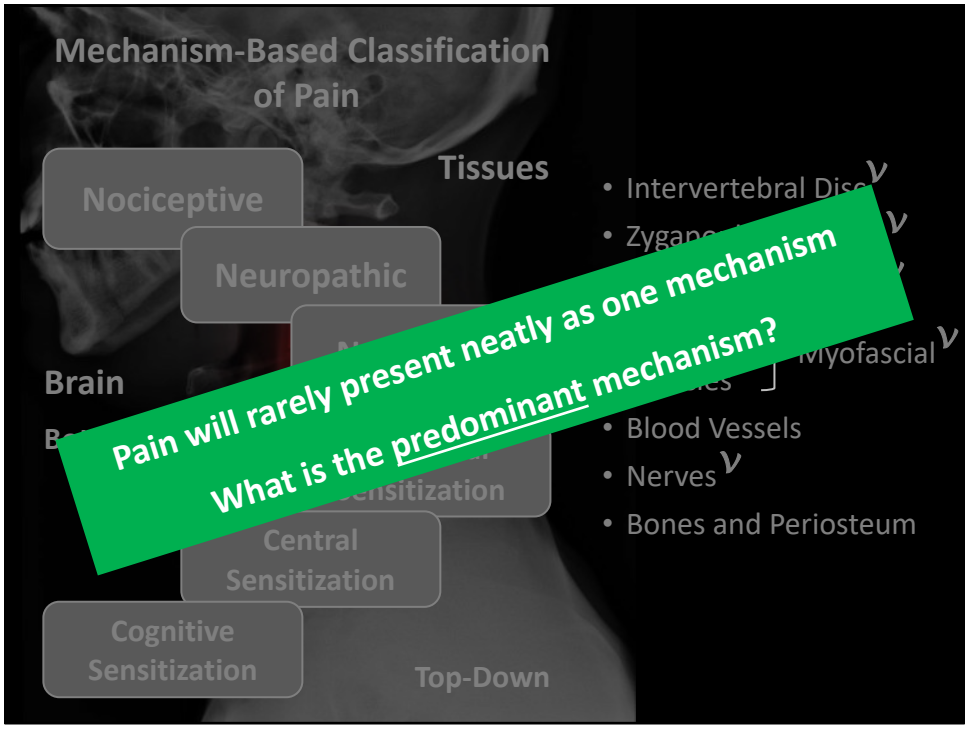

Mechanism-Based Classification of Pain
Nociceptive
Neuropathic
Nociplastic
Peripheral Sensitization
Central Sensitization
Cognitive Sensitization
Tissues
Brain
Bottom-Up
Top-Down
• Intervertebral Disc
• Zygapophyseal Joint
• Uncovertebral Joint
• Ligaments
• Muscles
Myofascial
• Blood Vessels
• Nerves
• Bones and Periosteum

19


Mechanism-Based Classification of Pain
Nociceptive
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Central Sensitization
Cognitive Sensitization
Tissues
Brain
Top-Down
• Blood Vessels
• Nerves
• Bones and Periosteum
Pain will rarely present neatly as one mechanism
What is the predominant mechanism?

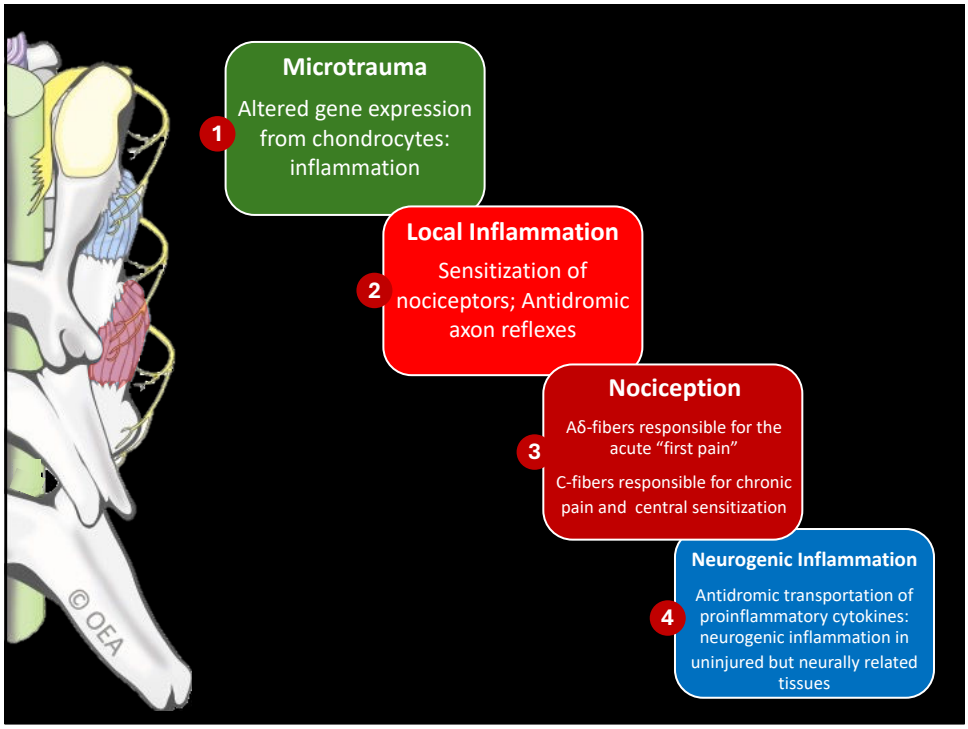
20

Challenges with Cervical Pain

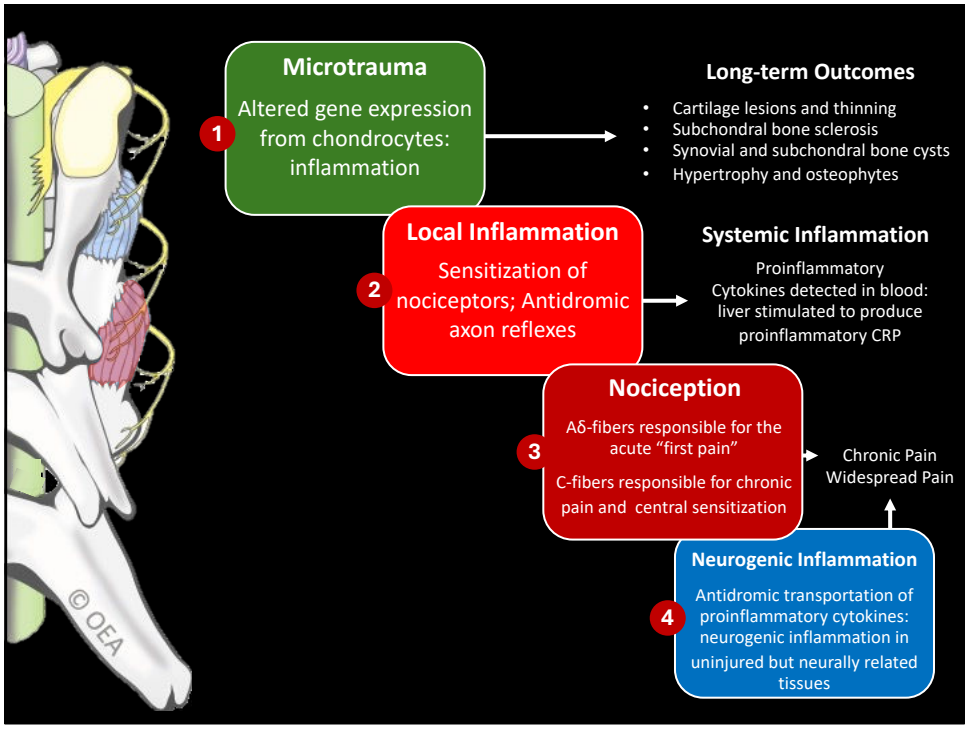
- Many structures shares innervation or segments of innervation
- Somatic referred pain: sensitization involves non-noxious structures
- Neurogenic inflammation
- For many structures there is good evidence for their role in pain but there is a lack of valid and reliable tests to include or exclude them

21

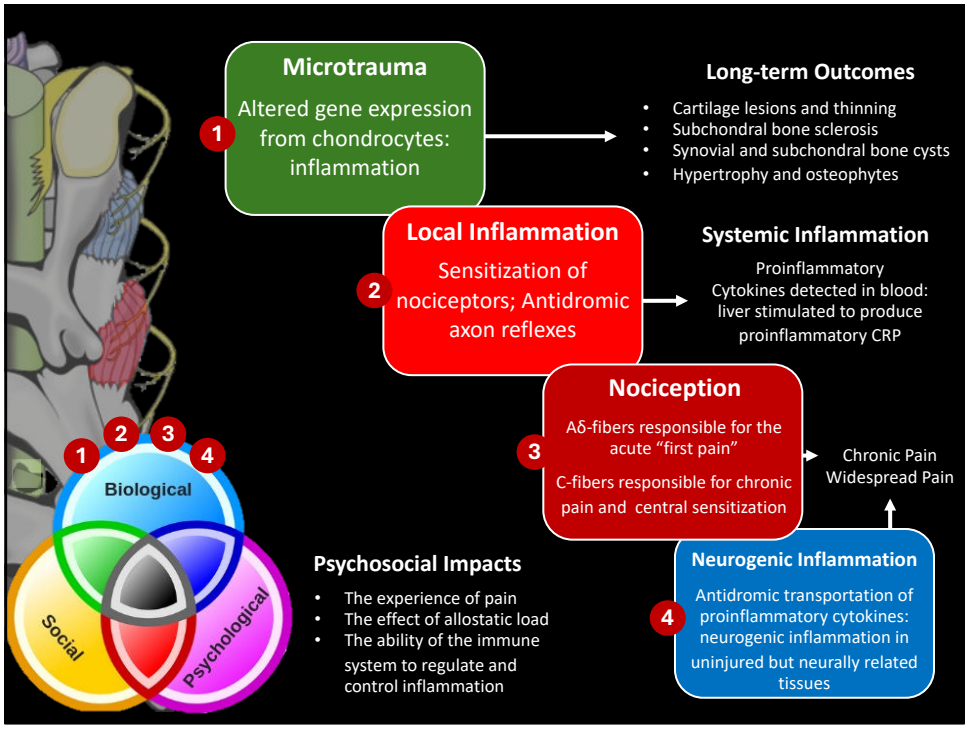
22


Microtrauma
1
Altered gene expression from chondrocytes: inflammation
Local Inflammation
2
Sensitization of nociceptors; Antidromic axon reflexes
Nociception
3
Aδ-fibers responsible for the acute "first pain"
C-fibers responsible for chronic pain and central sensitization
Neurogenic Inflammation
4
Antidromic transportation of proinflammatory cytokines: neurogenic inflammation in uninjured but neurally related tissues
© OEA

23


Microtrauma
1
Altered gene expression from chondrocytes: inflammation
Long-term Outcomes
Cartilage lesions and thinning
Subchondral bone sclerosis
Synovial and subchondral bone cysts
Hypertrophy and osteophytes
Local Inflammation
2
Sensitization of nociceptors; Antidromic axon reflexes
Systemic Inflammation
Proinflammatory Cytokines detected in blood: liver stimulated to produce proinflammatory CRP
Nociception
3
Aδ-fibers responsible for the acute "first pain"
C-fibers responsible for chronic pain and central sensitization
Chronic Pain
Widespread Pain
Neurogenic Inflammation
4
Antidromic transportation of proinflammatory cytokines: neurogenic inflammation in uninjured but neurally related tissues
© OEA

24



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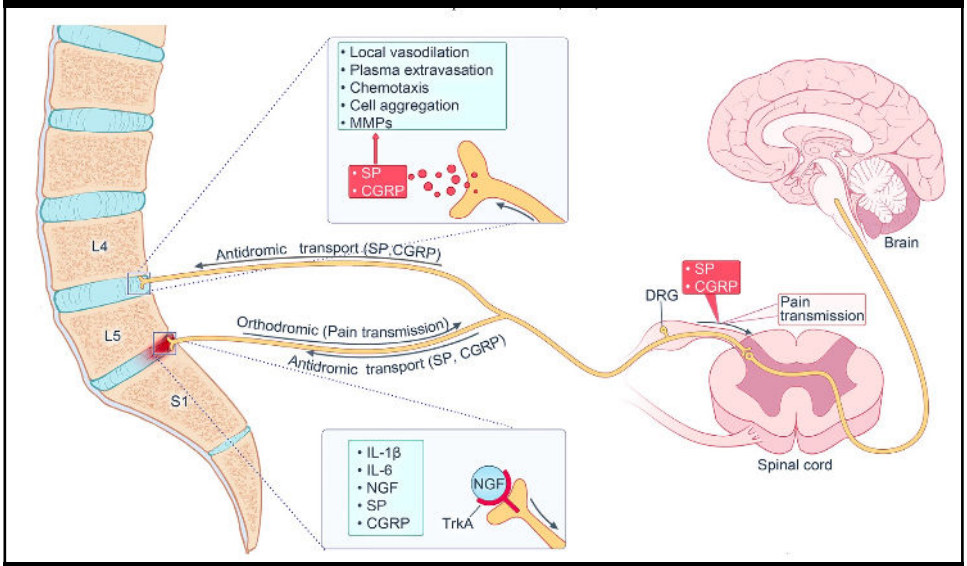
Neurogenic Inflammation of Adjacent Disc Caused by Degenerative Disc at L5 – S1



Li et al. Intervertebral disc njury triggers neurogenic inflammation of adjacent healthy discs. *The Spine Journal* 000 (2024) 1–11

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What is the role of Degenerative Changes and OA in the Cervical Spine:

Sheep in Wolf´s clothing or Wolf in Sheep´s clothing?

27

"Identifying or nominating the precise lesion in a cervical structure may be difficult, but a symptomatic segment can be identified with considerable accuracy in a clinical examination with neck pain"

Jull G et al. *Management of neck disorders: A research informed approach.* Edinburgh: Elsevier 2019: Page 7

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Innervation Cervical Spine

Why?

- Common things are common: what do we know about them today?
- Increases the possibility of better understanding the role of tissues in pain

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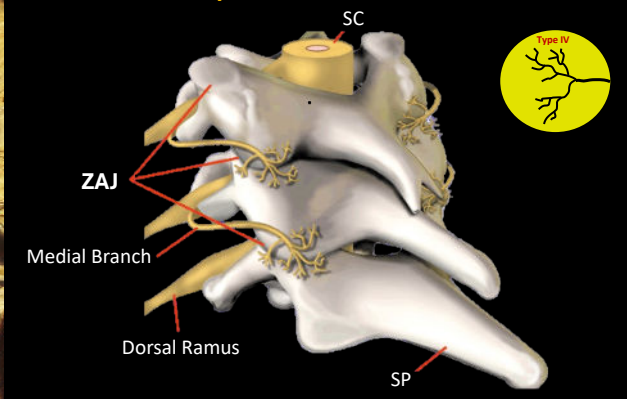
Cervical Spine: ZAJ Innervation



Cervical Segments	Plexus like pattern	Double innervation, multiple level	Multiple direct facet joint branches	Multiple medial branch innervation, single level
C1/C2				
C2/C3				
C3/C4				
C4/C5				
C5/C6				
C6/C7				

Thorpe Lewis CG et al. Visualization of facet joint recesses of the cadaveric spine: a micro-CT and sheet plastination study. *BMJ Open Sports & Exercise Medicine* 2018; 8:4; Büsken F et al. The innervation of cervical facet joints: an anatomical and histological approach. *Clinical Anatomy* (2022)

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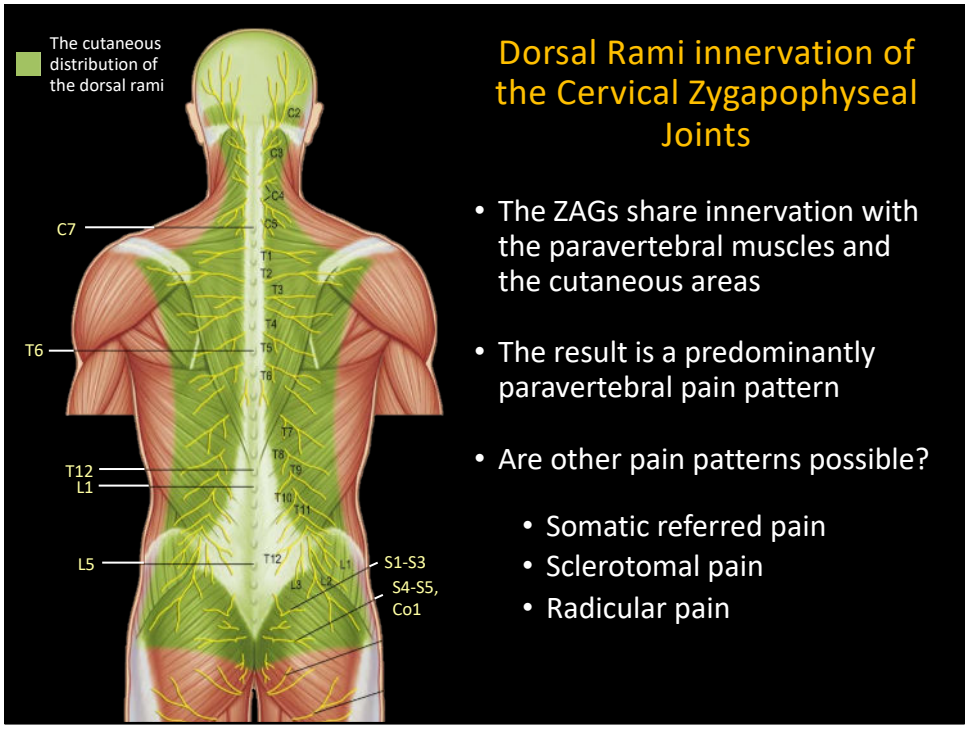

Dorsal Rami innervation of the Cervical Zygapophyseal Joints

- The ZAGs share innervation with the paravertebral muscles and the cutaneous areas
- The result is a predominantly paravertebral pain pattern
- Are other pain patterns possible?
  - Somatic referred pain
  - Sclerotomal pain
  - Radicular pain

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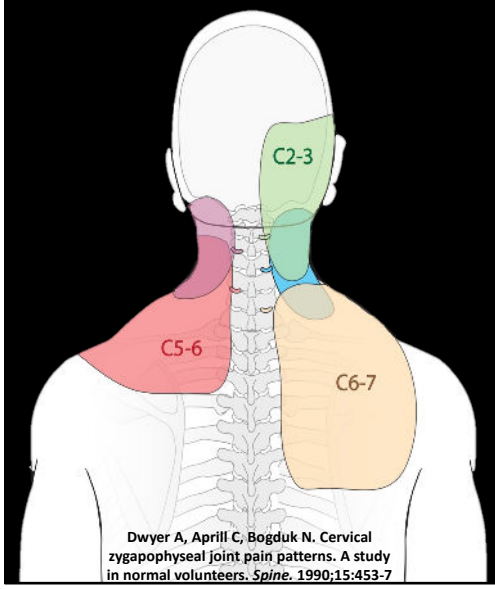
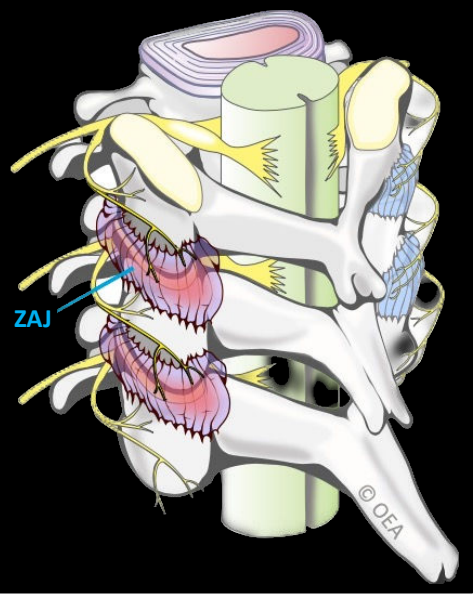
Typical Cervical Spine: ZAJ Pain Patterns



Dwyer A, Aprill C, Bogduk N. Cervical zygapophyseal joint pain patterns. A study in normal volunteers. *Spine.* 1990;15:453-7



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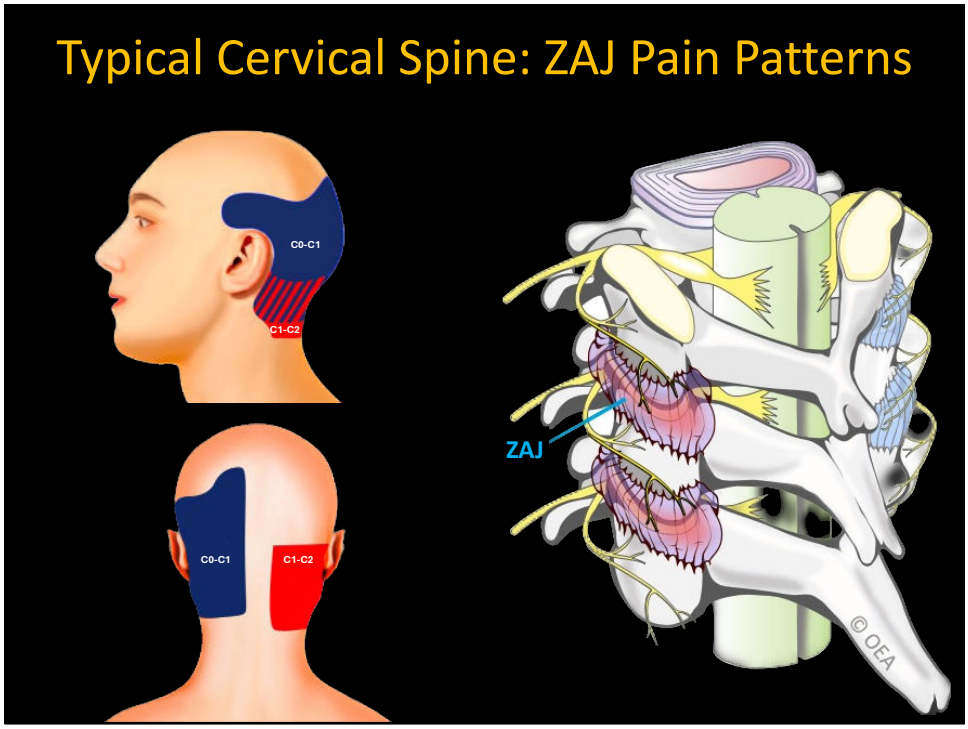
Typical Cervical Spine: ZAJ Pain Patterns
C0-C1
C1-C2
C0-C1
C1-C2
ZAJ
© OEA

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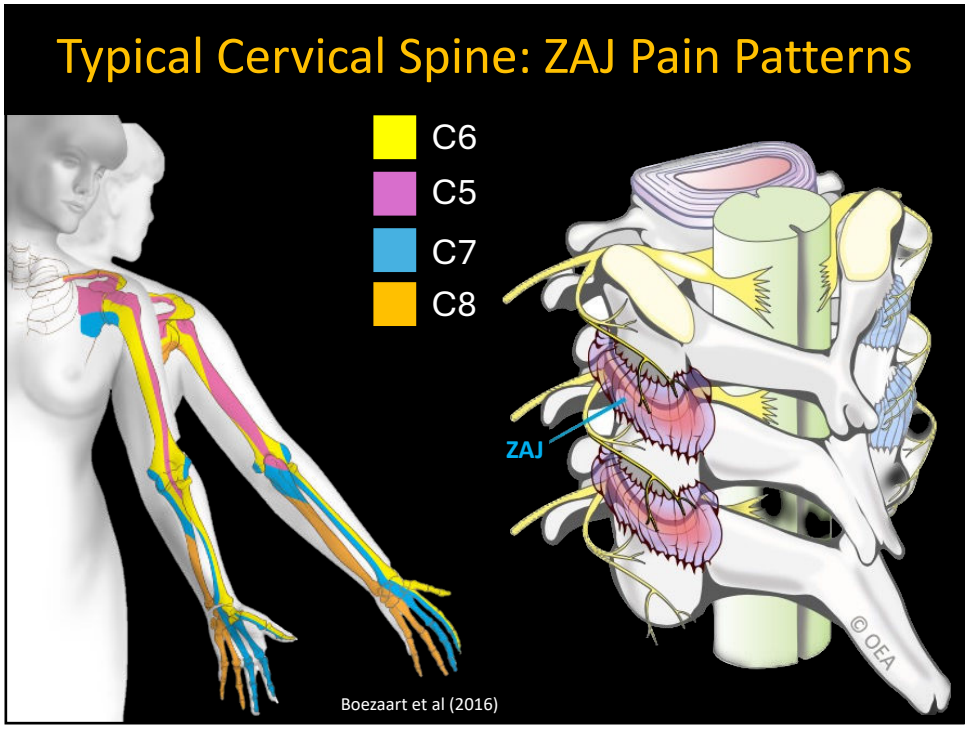
Typical Cervical Spine: ZAJ Pain Patterns
C6
C5
C7
C8
ZAJ
© OEA
Boezaart et al (2016)

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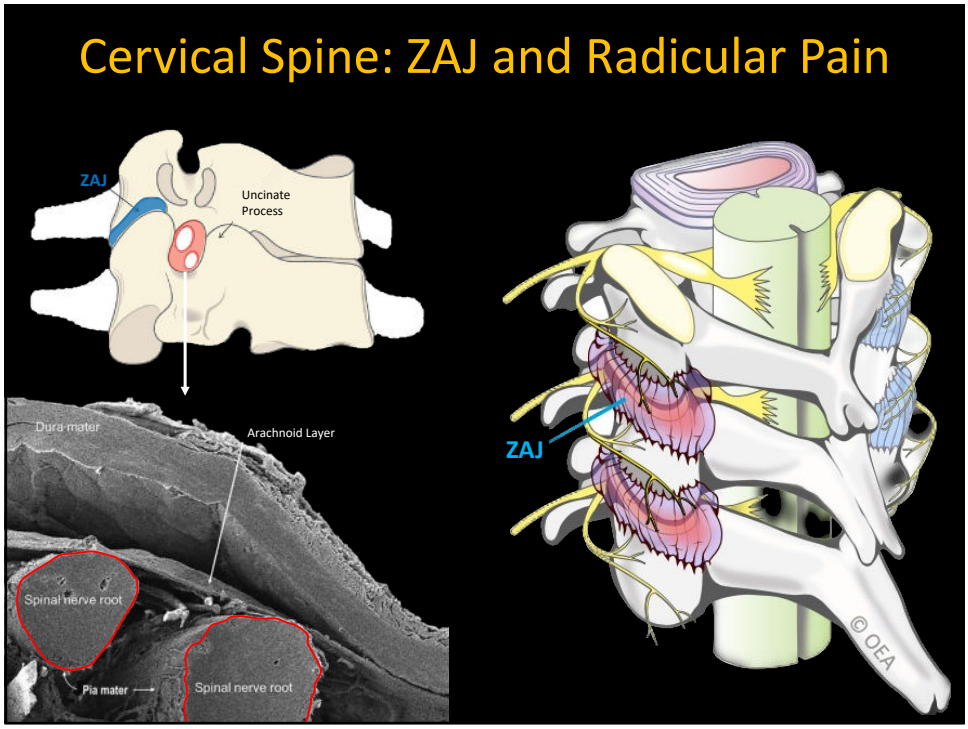
Cervical Spine: ZAJ and Radicular Pain
ZAJ
Uncinate Process
Dura mater
Arachnoid Layer
Spinal nerve root
Pia mater
Spinal nerve root
ZAJ
© OEA

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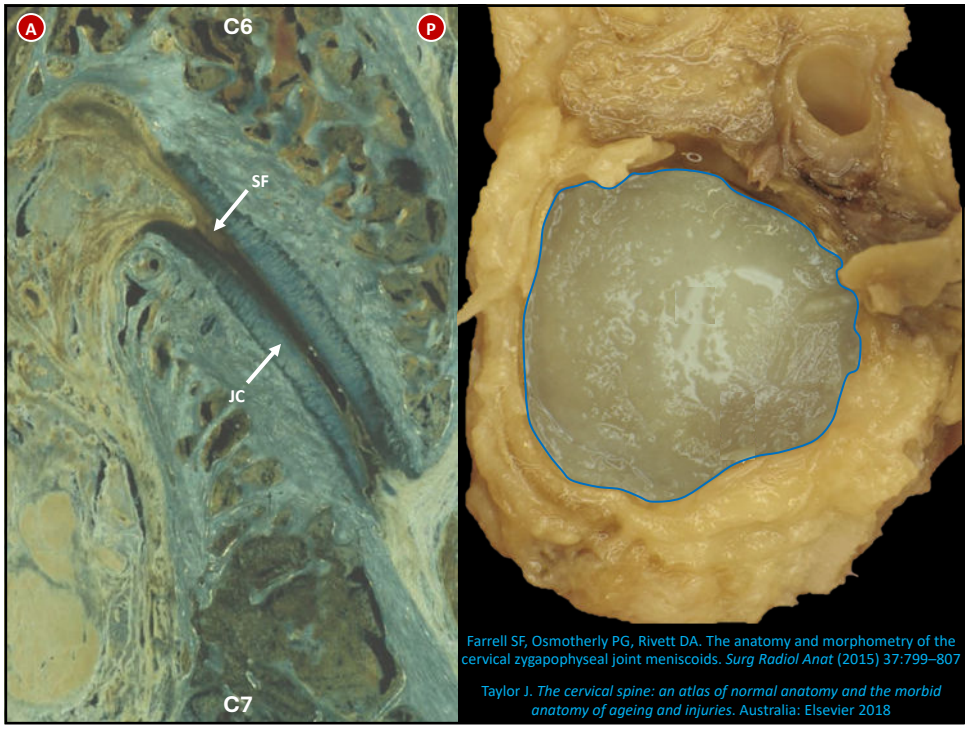
A
C6
P
SF
JC
C7
Farrell SF, Osmotherly PG, Rivett DA. The anatomy and morphometry of the cervical zygapophyseal joint meniscoids. *Surg Radiol Anat* (2015) 37:799–807
Taylor J. *The cervical spine: an atlas of normal anatomy and the morbid anatomy of ageing and injuries.* Australia: Elsevier 2018

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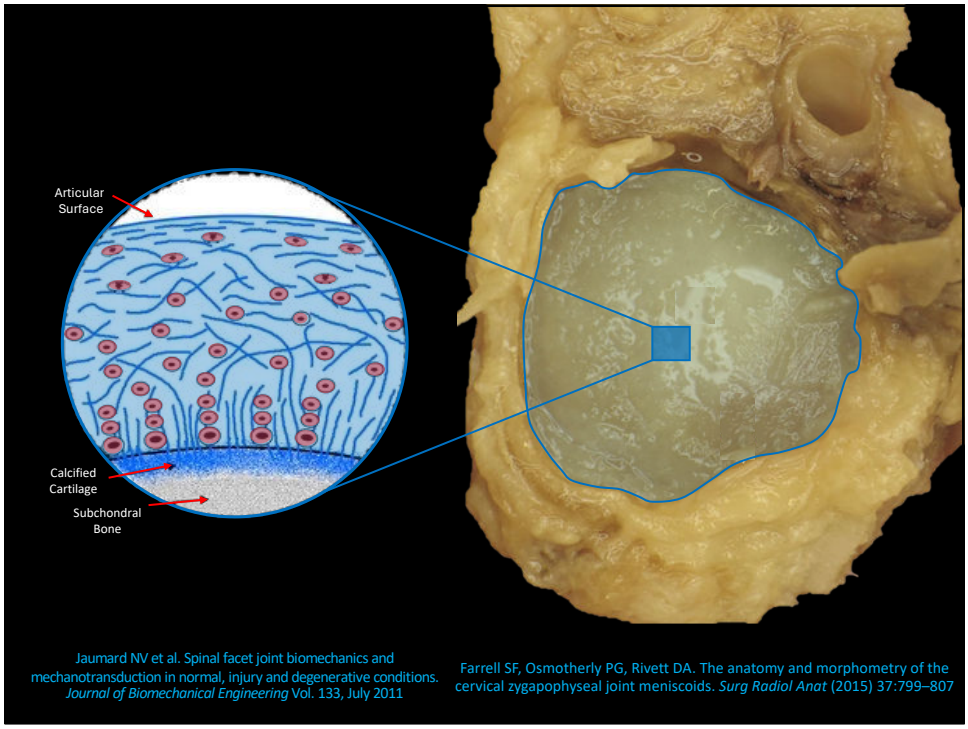
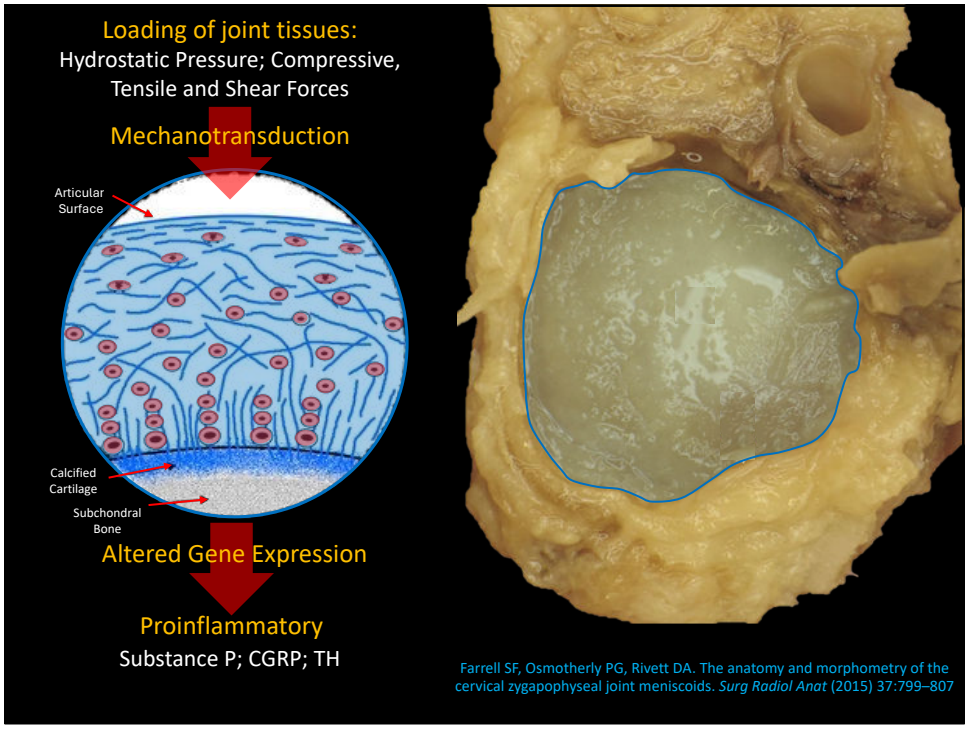

Articular Surface
Calcified Cartilage
Subchondral Bone
Jaumard NV et al. Spinal facet joint biomechanics and mechanotransduction in normal, injury and degenerative conditions. *Journal of Biomechanical Engineering* Vol. 133, July 2011
Farrell SF, Osmotherly PG, Rivett DA. The anatomy and morphometry of the cervical zygapophyseal joint meniscoids. *Surg Radiol Anat* (2015) 37:799–807

37


Loading of joint tissues:
Hydrostatic Pressure; Compressive, Tensile and Shear Forces
Mechanotransduction
Articular Surface
Calcified Cartilage
Subchondral Bone
Altered Gene Expression
Proinflammatory
Substance P; CGRP; TH
Farrell SF, Osmotherly PG, Rivett DA. The anatomy and morphometry of the cervical zygapophyseal joint meniscoids. *Surg Radiol Anat* (2015) 37:799–807

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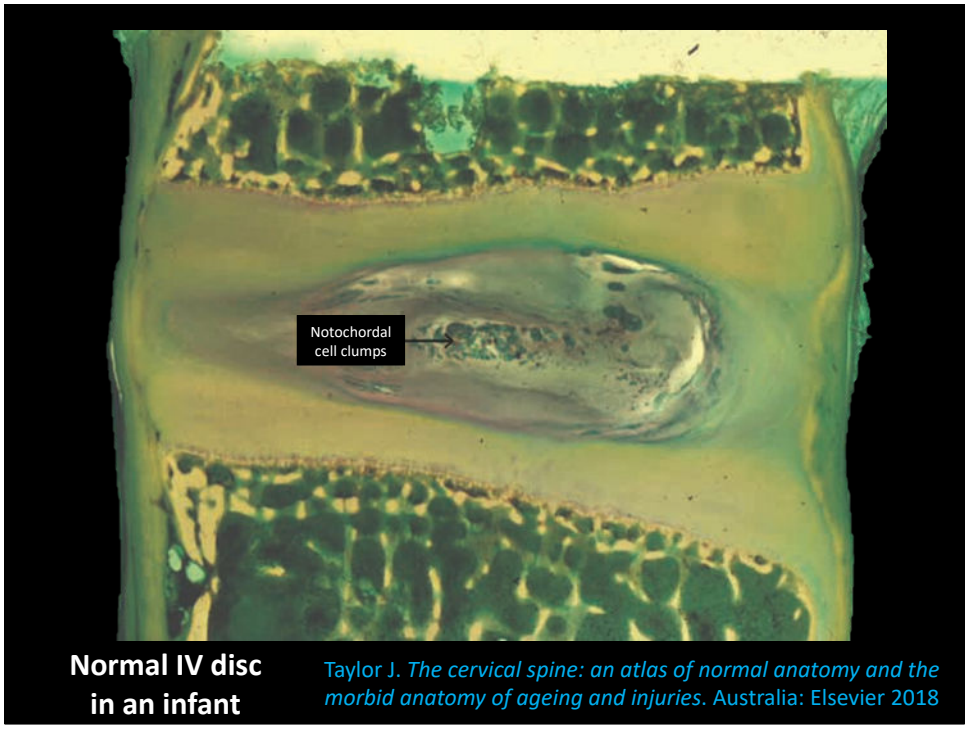
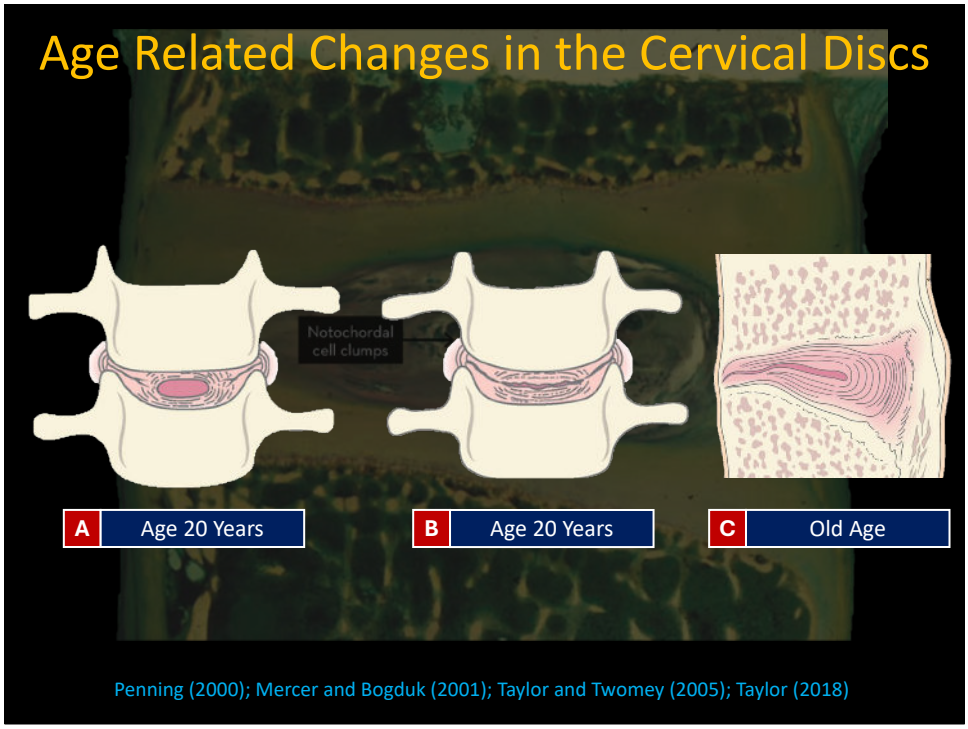


Normal IV disc in an infant

Taylor J. *The cervical spine: an atlas of normal anatomy and the morbid anatomy of ageing and injuries*. Australia: Elsevier 2018

39



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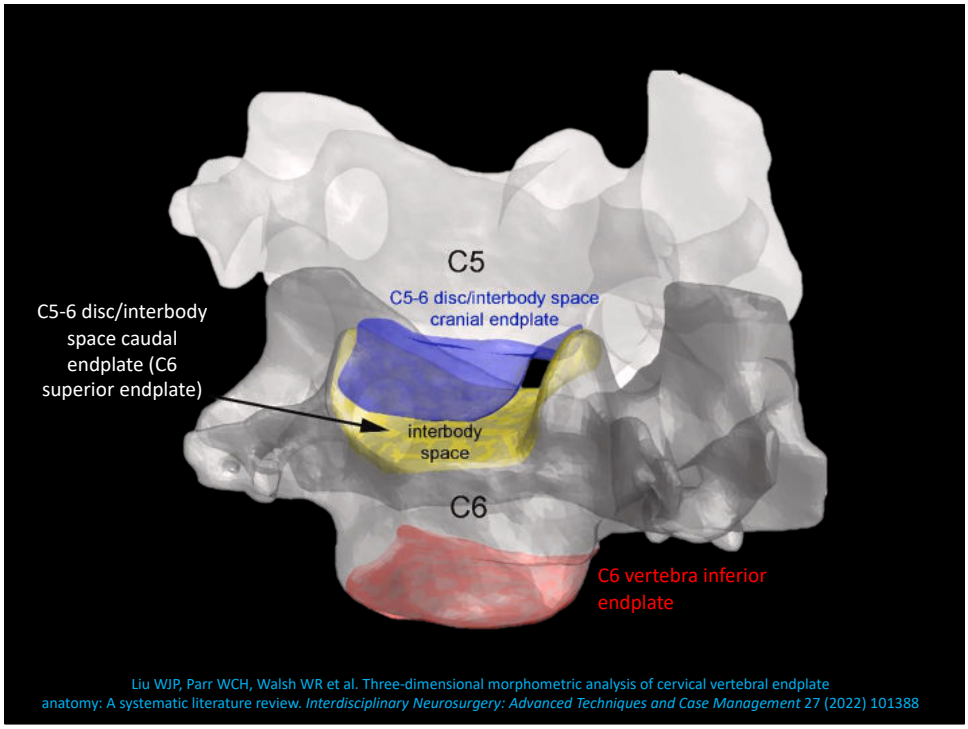
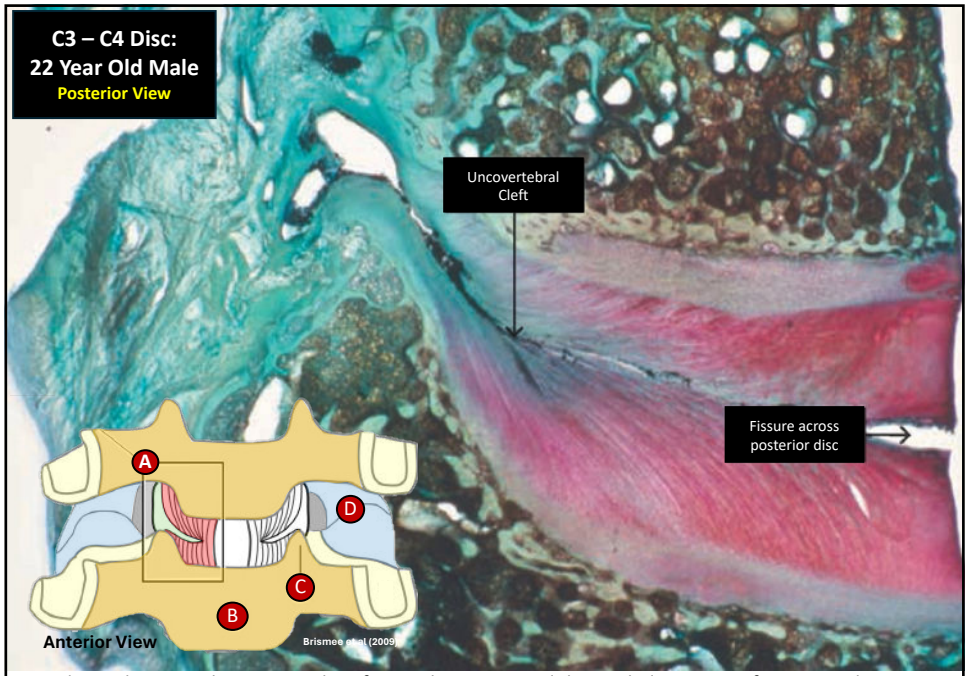


Liu WJP, Parr WCH, Walsh WR et al. Three-dimensional morphometric analysis of cervical vertebral endplate anatomy: A systematic literature review. *Interdisciplinary Neurosurgery: Advanced Techniques and Case Management* 27 (2022) 101388

41



Taylor J. *The cervical spine: an atlas of normal anatomy and the morbid anatomy of ageing and injuries*. Australia: Elsevier 2018

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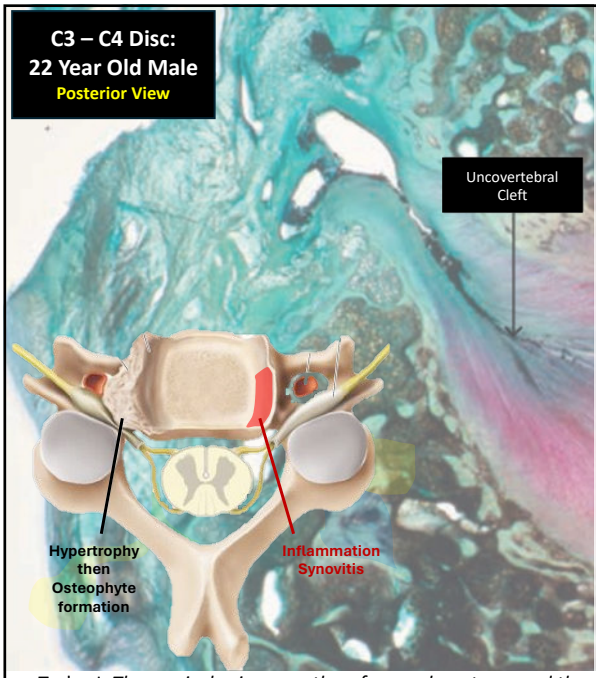

- **The UVJ are small but true synovial joints**
- **Does have a dense somato-sympathetic innervation**
- **Substance P, CGRP and Neuropeptide Y**
- **Source of nociception**
- **Subject to degenerative changes** (from early 20s)

SYMPTOMS

- Pain
- May cause popping and grinding noises when moving the neck
- Symptoms often worse in the morning or after inactivity

Taylor J. *The cervical spine: an atlas of normal anatomy and the morbid anatomy of ageing and injuries*. Australia: Elsevier 2018

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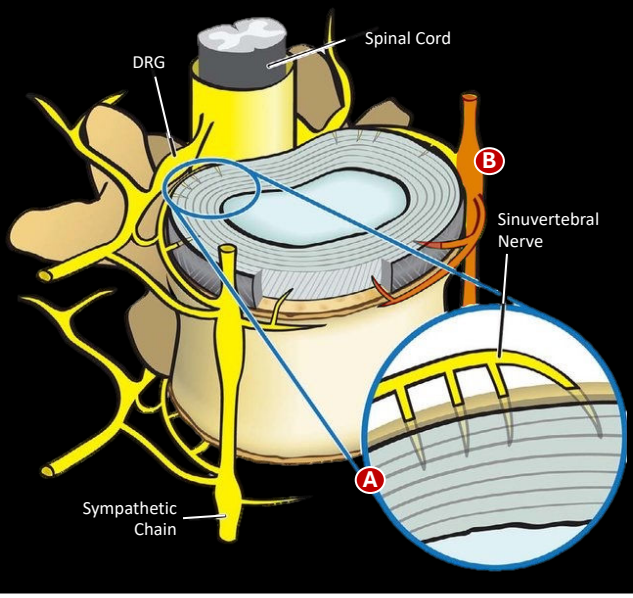
Innervation of Intervertebral Discs



- Somatosympathetic innervation
  - Sinuvertebral nerve (SVN)
  - Gray Rami Communicantes
- Can create complex and confusing pain
  - Nociceptive
  - Sensory via sympathethics
  - Neurogenic inflammation
  - Neuropathic with injury to C-fibers

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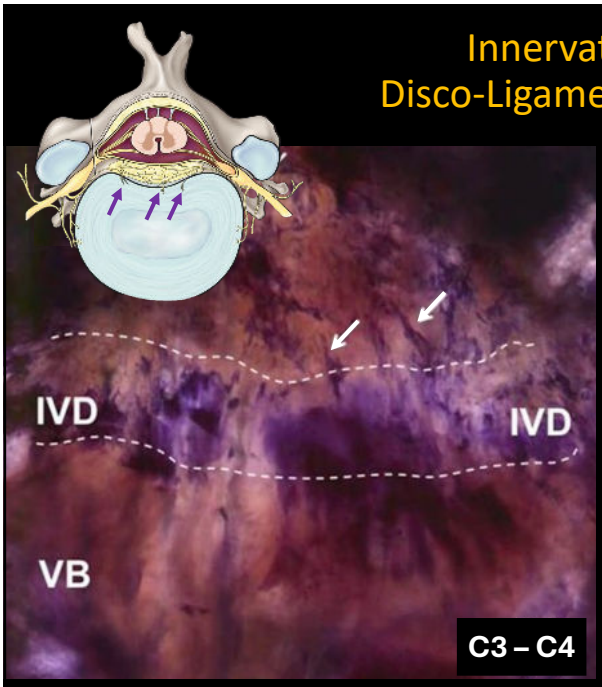
Innervation of the Disco-Ligamentous Complex

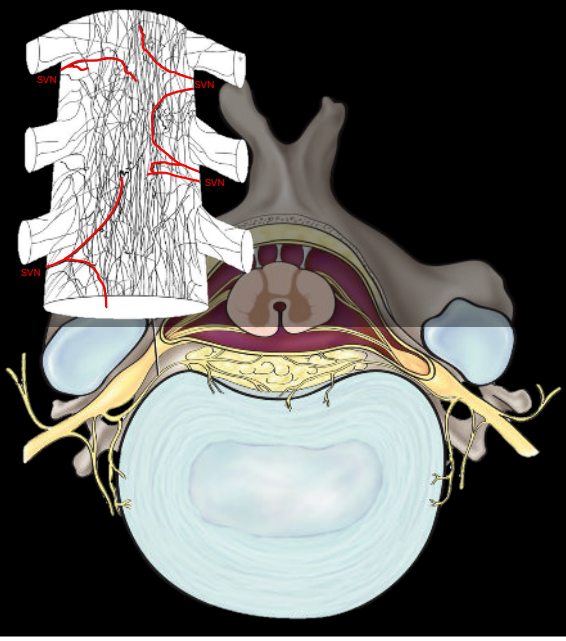


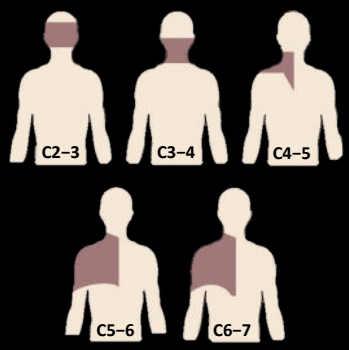
- Important neuronal structures:
  - Spinal nerve with its branches to the dura
  - The Sinuvertebral nerves with their connections to the sympathetic trunk
  - The basivertebral nerves
  - The perivascular plexus
- Staining positive for CGRP
  - A potent vasodilator and involved in the neurogenic inflammatory response
- Denser in areas of vessels, possibly involved in neoangiogeneses with tissue injury

Stegmann T et al. **On the importance of the innervation of the human cervical longitudinal ligaments at vertebral level.** ***Surgical and Radiologic Anatomy*** **(2020) 42:127–136**

45

Discogenic Pain





Grubb SA, Kelly CK, Bogduk N. Cervical discography: Clinical implications from 12 years of experience. *Spine* 25:1382-1389, 2000

Slipman CW, Plastaras C, Patel R, et al. Provocative cervical discography symptom mapping. *Spine J.* 2005;5:381–388

Standaert CJ, Herring SA, Sinclair JD. The patient history and physical examination: cervical, thoracic, and lumbar. In: Herkowitz HN, Garfin SR, Eismont FJ, et al (Eds). *Rothman-Simeone the spine.* 6th ed. Philadelphia: Elsevier; 2011

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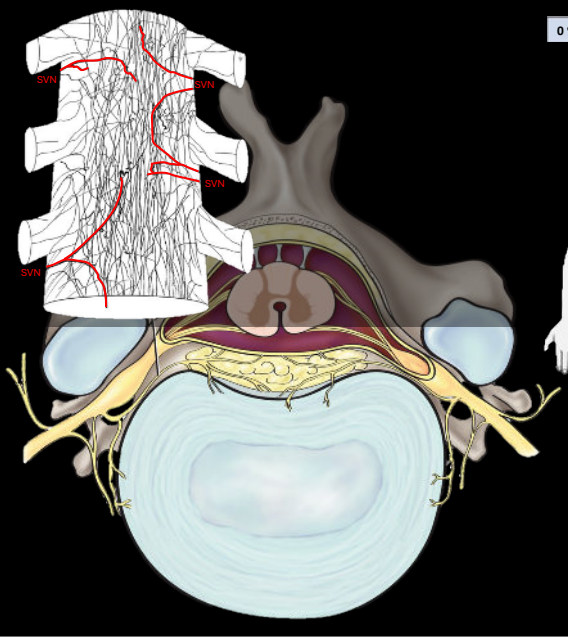
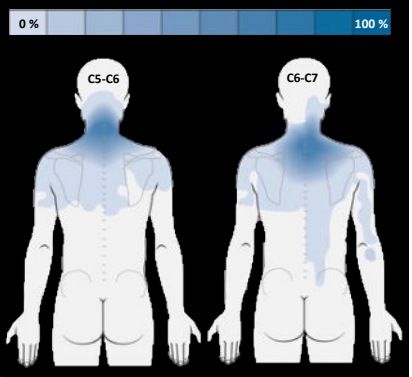
Discogenic Pain





Slipman CW, Plastaras C, Patel R, et al. Provocative cervical discography symptom mapping. *Spine J.* 2005;5:381–388

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Challenges with Cervical Discogenic Pain

What is known

- Basic science evidence supports the concept of cervical disc pain
- Experimental studies in normal volunteers provoke disc pain
- Laboratory studies have have provided models of the complex mechanisms involved in nociception from the disc

The unknown

- The pathologies rendering the disc painful is still unknown
- Spondylosis and disc degeneration is not an explanation
- There is no convenient method of diagnosing the painful disc

Peng B, Bogduk N. Cervical discs as a source of neck pain: an analysis of the evidence. *Pain Medicine* 20(3), 2019, 446 - 455

48

Cervical Radiculopathy

Radicular Pain versus Radiculopathy?

Reliable Suspicion of Cervical Radiculopathy Based On[1]:

Arm pain; Neck Pain; Scapular or periscapular pain

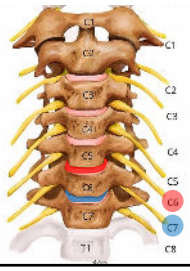
Paresthesia; Numbness and Sensory Changes

Muscle weakness; Loss of deep tendon reflexes

SIGNS	SYMPTOMS
Neck– and/or Scapular and/or arm pain	Positiv Spurling; Arm–Squeeze Test
Paresthesia; Numbness	Hyporeflexia
Motor deficits	Shoulder–ABD Relief Sign

[1]Grade B recommendation. *North American Spine Society* (NASS) 2010

- Genetics
- Ageing
- Injury
- Nutrition



Radiculopathy ➔ C5–C6 > C6–C7

- Average age 40 – 59 yr (47 – 48 yr)
- Men: 107.3 pr 100.000
- Women 63.5 per 100.000
- Natural history ➔ Good Prognosis

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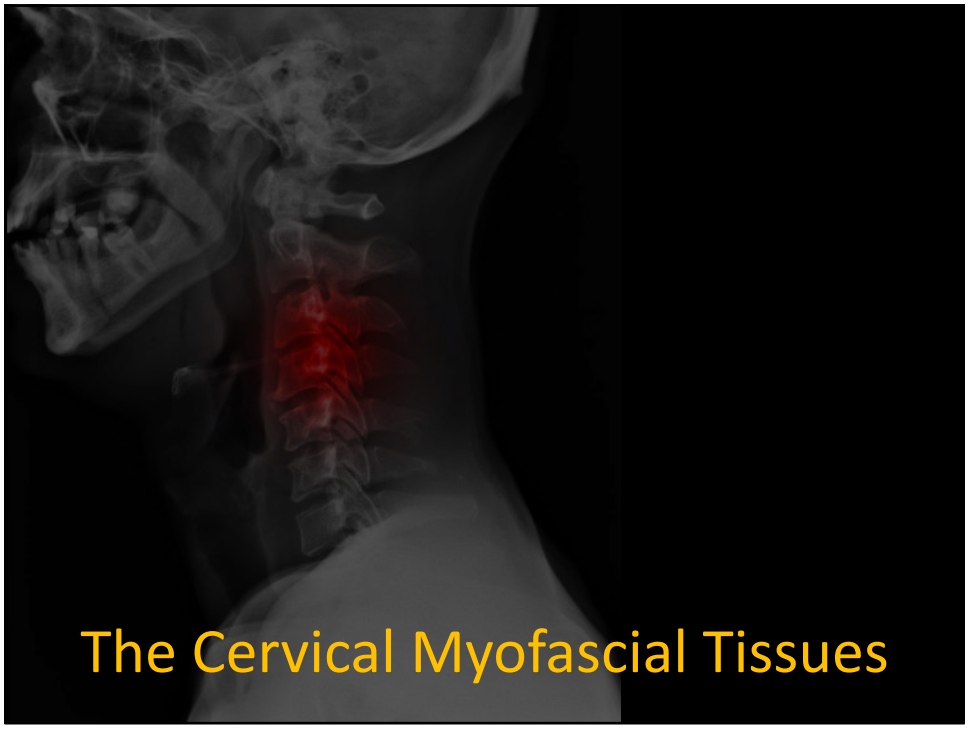

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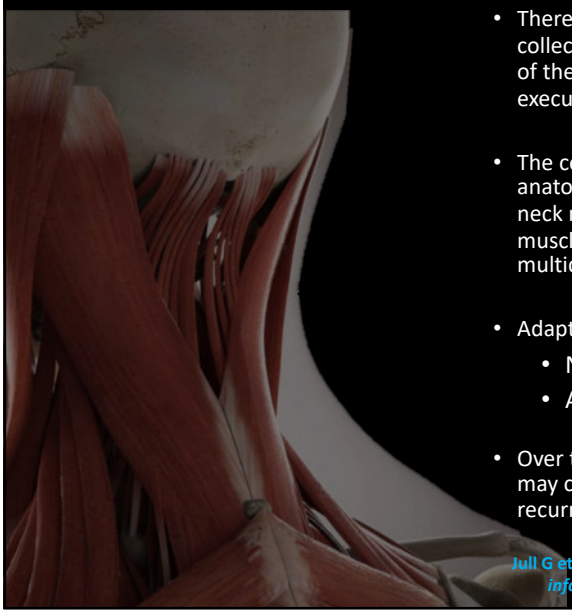
Neuromuscular adaptations in people with neck pain



- There are 44 muscles in the neck which collectively facilitate the control and support of the cervical spine while simultaneously executing voluntarily movements
- The central nervous system copes with this anatomic complexity and redundancy of the neck muscles by developing consistent muscle synergies to generate multidirectional patterns of force
- Adaptive changes may occur in relation to
  - Nociception and pain
  - Anticipation of pain
- Over time ➔ Maladaptive response which may contribute to persistence and recurrence of symptoms

Jull G et al. *Management of neck disorders: A research informed approach*. Edinburgh: Elsevier 2019

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Neuromuscular adaptations in people with neck pain

Motor Output

- Decreased strength
- Decreased endurance
- Decreased force steadiness
- Decreased range of motion
- Decreased speed of movement
- Reduced smoothness of movement

Muscle Behavior

- Increased muscle coactivation
- Reduced specificity of neck muscle activity
- Decreased activation of deep muscle activity
- Delayed muscle responses
- Reduced muscle relaxation
- Increased muscle fatigability

Changes in Muscle Properties

- Muscle fatty tissue infiltrate and atrophy
- Reduced muscle microcirculation
- Muscle fibre transformation
- Biochemical alterations

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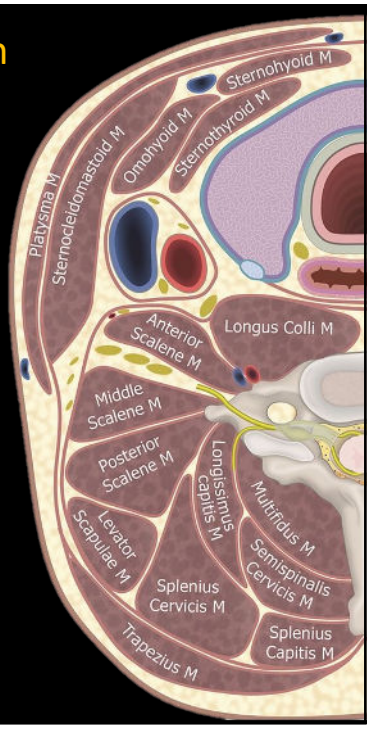
52

Myofascial Pain and Dysfunction

- Causes and mechanisms of myofascial pain is still unknown and debated (Mense, 2015, 2021)

Characteristic of Muscle Pain (Mense, 2015, 2021)	
	• **Difficult to Localize** • **Cramps, aching, pulling pain** • **Referred pain**
	• Strong affective components • Nausea • Autonomic reactions: sweat (sudomotor)

- Provocative tests commonly used in practice
  - Palpation of muscles and their changes for symptom provocation (tenderness and tissue texture changes)
  - Isometric muscle testing to reproduce pain
- Palpatory changes often described as
  - Myofascial trigger points (MTrP): local pathophysiologic changes in muscles as the bases for localized and referred pain
  - Tender Points: specific tissue changes and local pain as indicators of specific muscle and joint dysfunctions
- Energy crisis model and tissue sensitization



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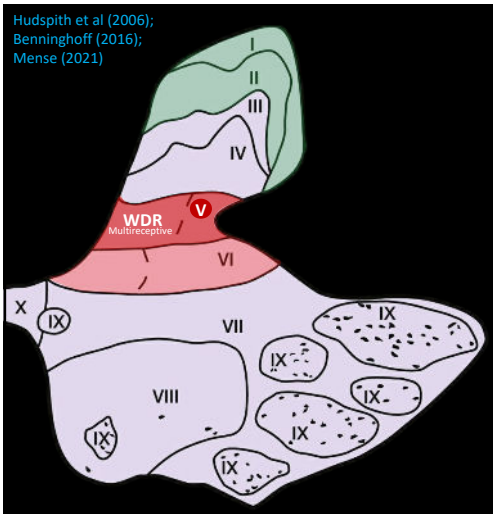
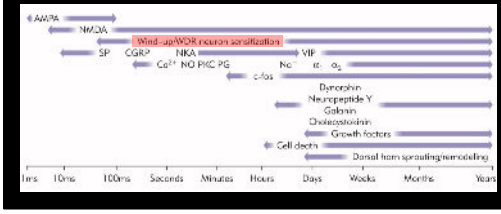
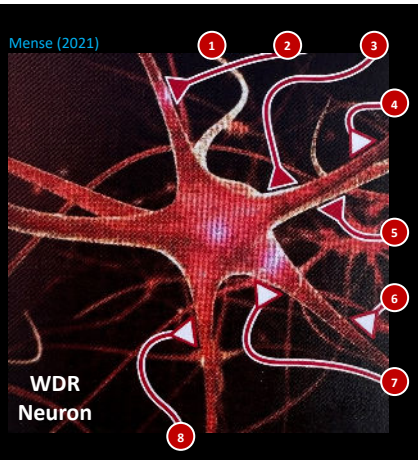
Hudspith et al (2006); Benninghoff (2016); Mense (2021)





Mense (2021)



Effective Synapse Ineffective Synapse

1. Axon
2. Multifidus Muscle
3. Thoracolumbar Fascia
4. Other Deep Somatic Tissue
5. Cutaneous
6. Other Deep Somatic Tissue
7. Gastrocnemius – Soleus Muscle
8. Other Deep Somatic Tissue

Convergence on WDR neurons: when effective synapses is senzitized its AP can activate ineffective synapses

54

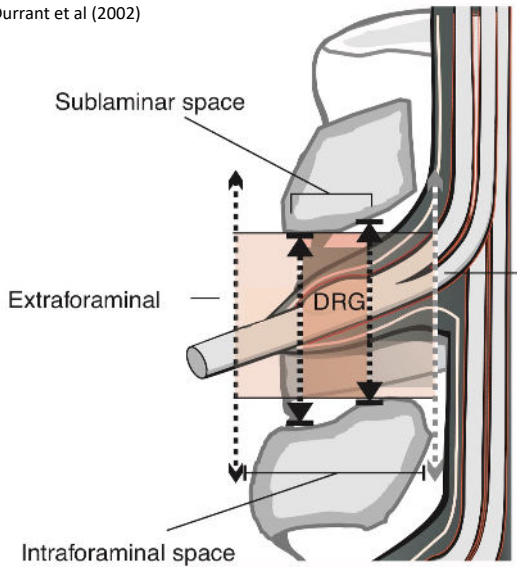
The Intervertebral Foramina

Why?

- To highlight processes that may compromise the IVF
- To highlight the effects of compression, inflammation and fibrosis

55

Durrant et al (2002)



The dorsal root ganglia (DRG) is exposed to greater risk of compression when it is located more medial in the intervertebral foramina

Conditions Influencing the Intervertebral Foramina

- Protrusion and Prolapse Intervertebral Disc
- Oedema in Nerve Roots
- Venous Congestion
- Osteophytes from Uncovertebral Joints
- Osteophytes from Zygapophyseal Joints
- Swelling in the Capsule of the Cervical ZA Joints
- Hypertrophy of Scalene Muscles

Clinical Manifestations

- **Neck pain:** Common
- **Radicular pain:** + / -
- **Radiculopathy:** + / -

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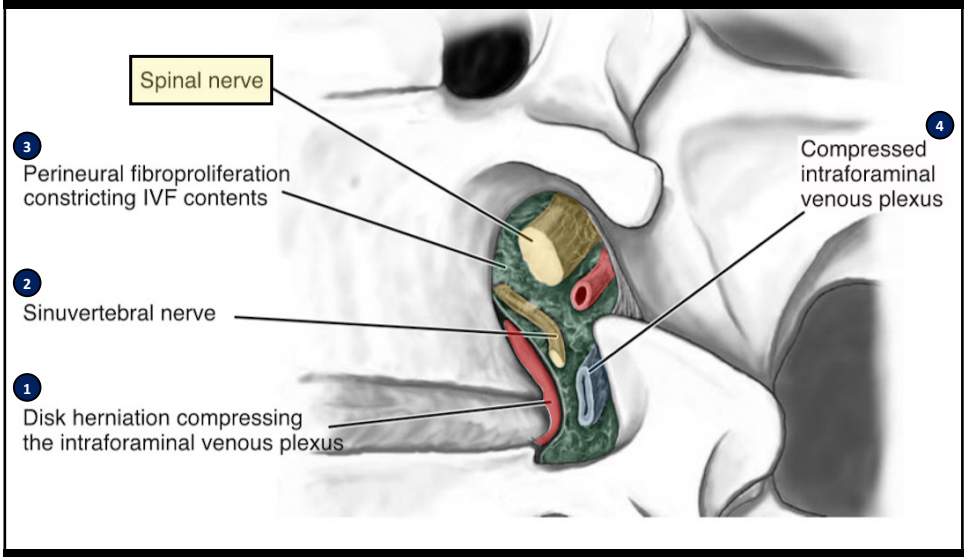
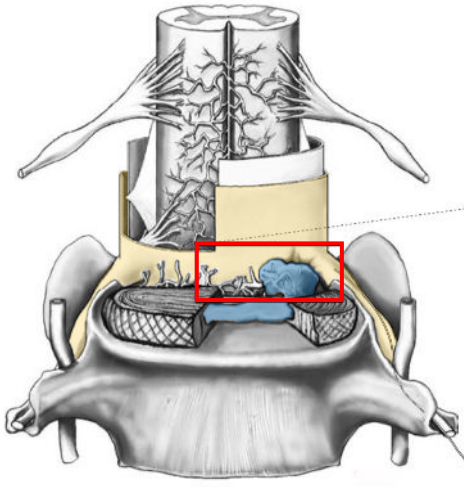
Changes in the Intervertebral Foramina



Durrant DH, True JM. *Myelopathy, radiculopathy, and peripheral entrapment syndromes*. London: CRC Press 2002

57

Venous Congestion



- Venous plexus congestion may occur with thecal sac effacement
- Chronic compression produces engorgement and dilation of local venous tributaries, which can lead to the development of
  - Inflammation, and
  - fibrous infiltration secondary to venous stasis

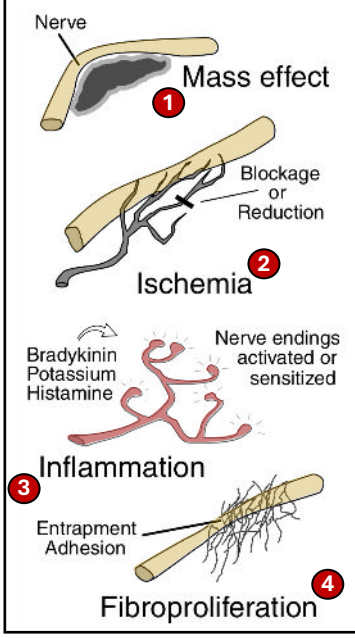
Internal vertebral venous plexus congestion

Reduced venous drainage through IVF

Durrant DH, True JM. *Myelopathy, radiculopathy, and peripheral entrapment syndromes*. London: CRC Press 2002

58

Common pathomechanism of radicular irritation



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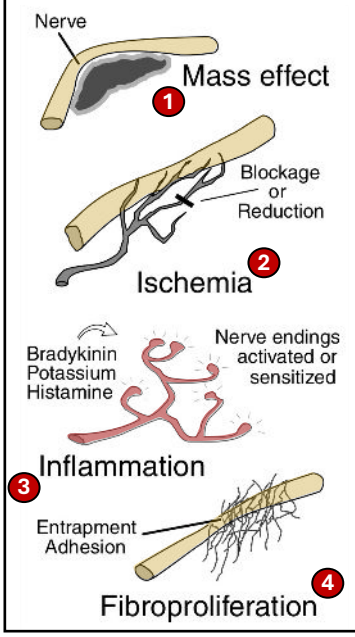
Common pathomechanism of radicular irritation



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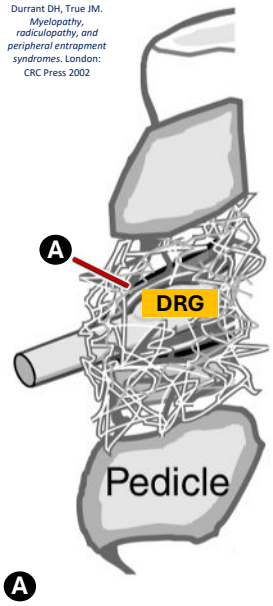
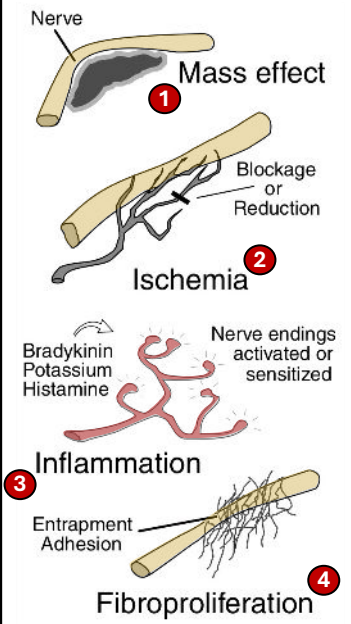


A

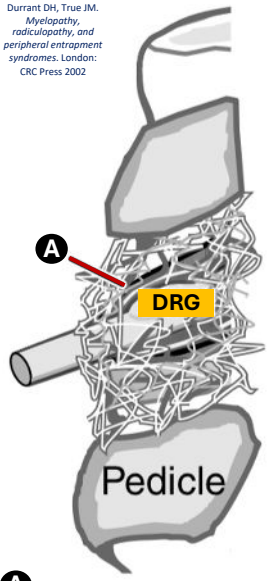
Fibrotic adhesion of nerve root preventing normal nerve root glide

60

Common pathomechanism of radicular irritation



Durrant DH, True JM. *Myelopathy, radiculopathy, and peripheral entrapment syndromes.* London: CRC Press 2002



A

Fibrotic adhesion of nerve root preventing normal nerve root glide

Clinical Symptoms

- Axial Neck Pain
  - Sinuvertbral nerve irritation
- Radicular Pain
  - Stretching and ischemia of nerve
- Paresthesia
  - Due to ischemia of the nerve
- ULTT positive + / -

- Neurological findings
  - Rare
  - Venous obstruction with hypoxia may lead to neuronal atrophy and nerve root damage
  - + / -

- Many debatable treatment options

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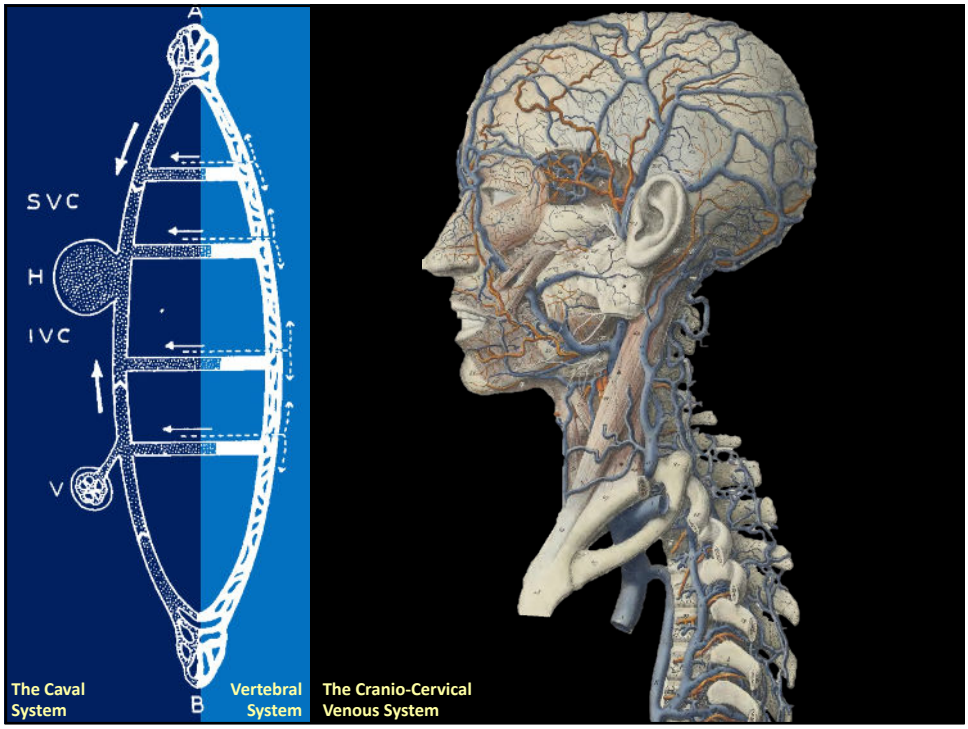
The Venous System

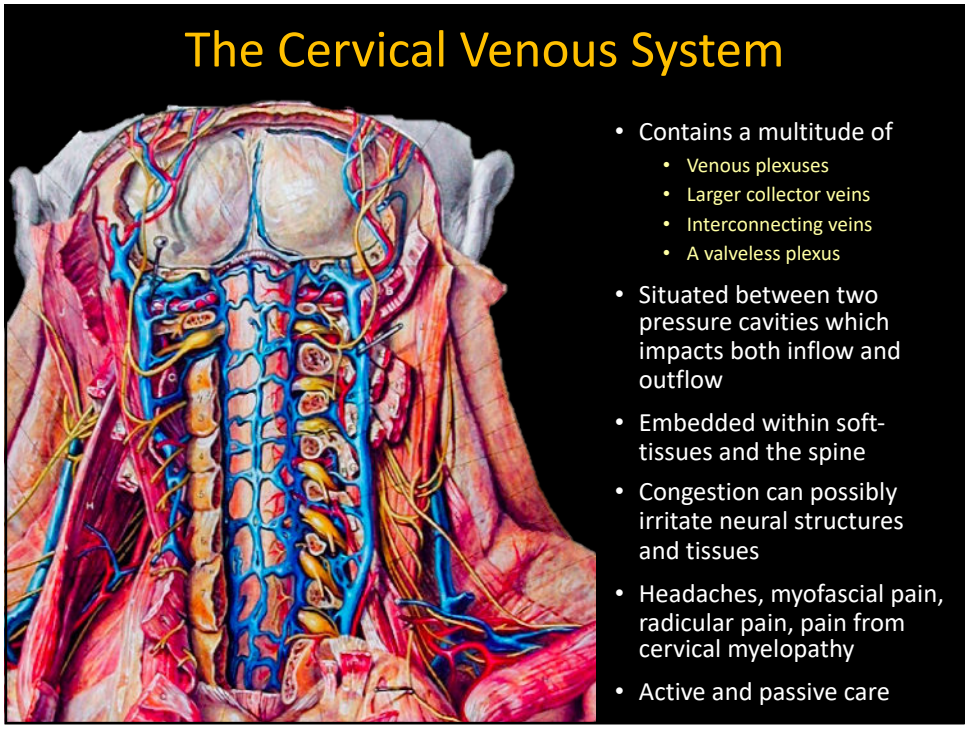
Why?

- To highlight its possible role in musculoskeletal pain from the cervical region
- To highlight its possible role in headache syndromes

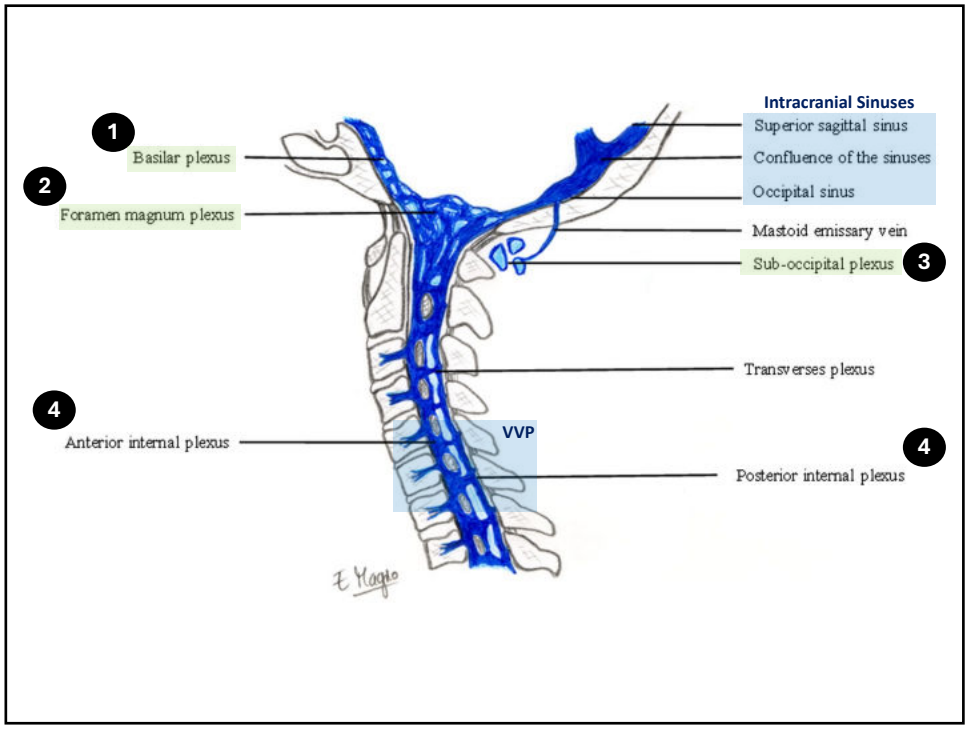
62


A
SVC
H
IVC
V
B
The Caval System
Vertebral System
The Cranio-Cervical Venous System

63


The Cervical Venous System
• Contains a multitude of
• Venous plexuses
• Larger collector veins
• Interconnecting veins
• A valveless plexus
• Situated between two pressure cavities which impacts both inflow and outflow
• Embedded within soft-tissues and the spine
• Congestion can possibly irritate neural structures and tissues
• Headaches, myofascial pain, radicular pain, pain from cervical myelopathy
• Active and passive care

64



65

The Cervical Venous System

From dissection by Prof. W. Neuhuber; Fredrich-Alexander University, Erlangen

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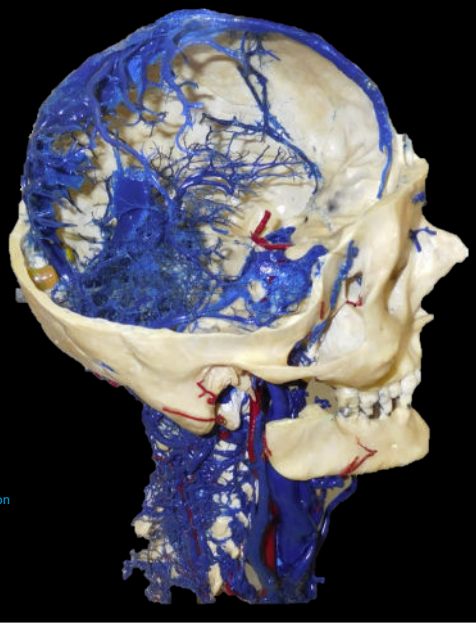
The Cervical Venous System



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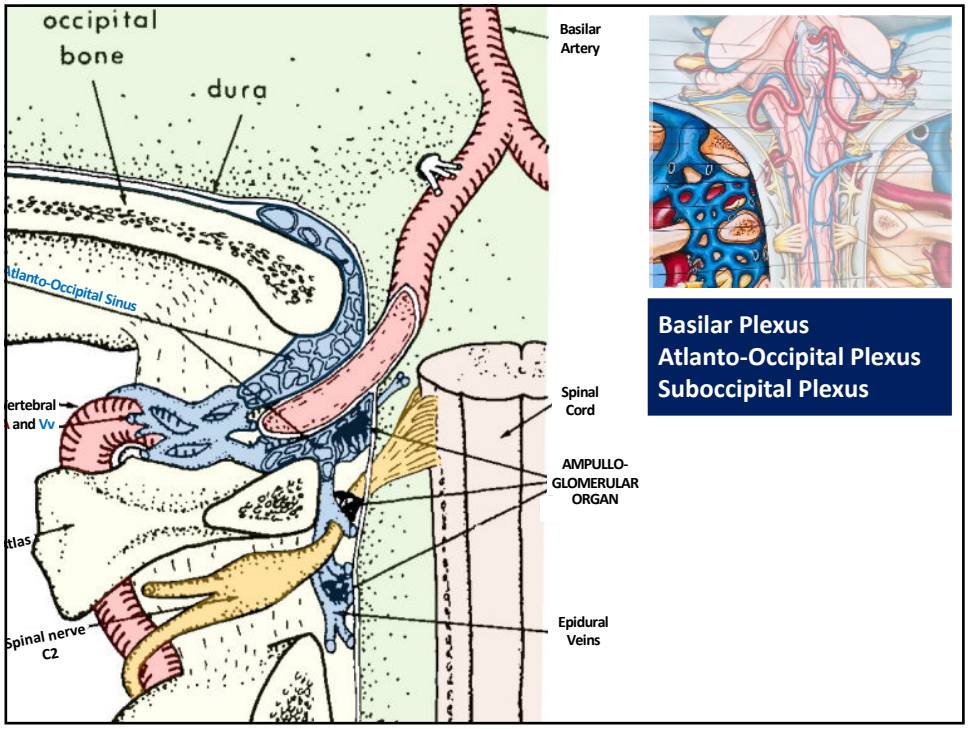

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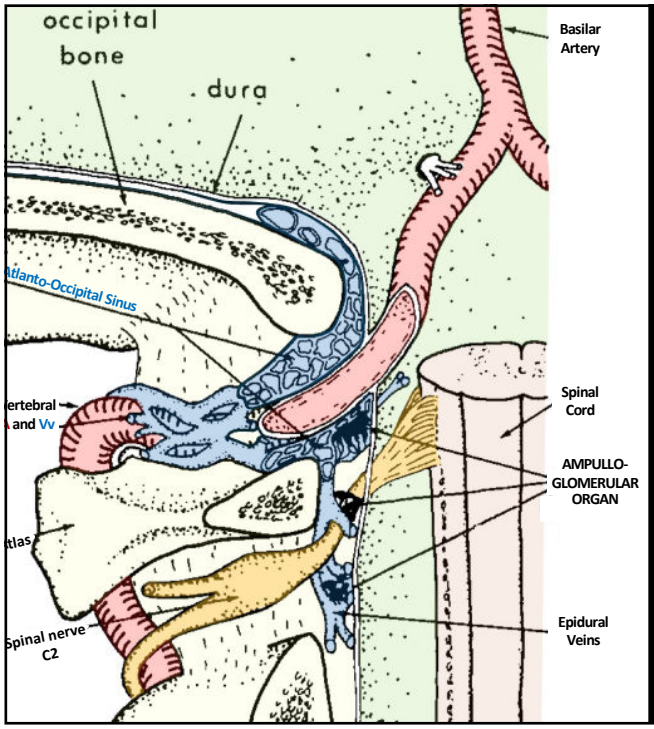


Ampullo-Glomerular Organ

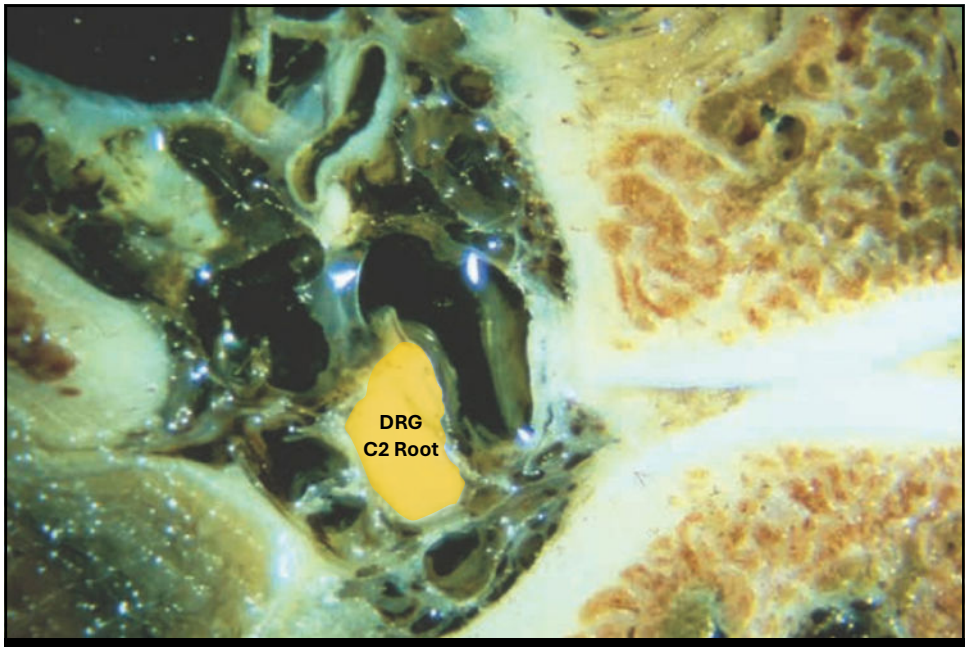
- Arteriovenous shunts in the atlantooccipital sinus
- Epidural sinuses within the skull are denied any significant area for expansion for hydrostatic reasons
- This sinus could respond to subtle changes in intravenous pressure by passive expansion
- Neurovascular reflexes: baroreceptors that converts mechanical deformation into nerve impulses
- Passive congestion

Parke et al (1978)

69

Taylor J. *The cervical spine: An atlas of normal anatomy and the morbid anatomy og ageing and injuries*. Edinburgh: Elsevier 2017

70



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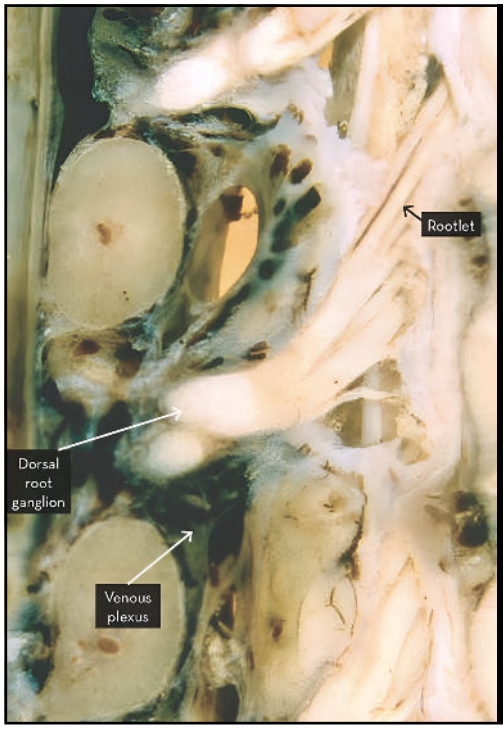

- Findings of interest is the frequency of venous engorgement in the suboccipital space post-whiplash
- Especially behind the lateral C1 – C2 joint around the C2 nerve roots
- Suboccipital venous plexus irritation of C2 nerve root has been implicated in chronic headaches, including occipital and cervicogenic headaches (Jansen et al, 1989; Pikus and Philips, 1995, Alpini et al 2014; Taylor 2017)

The suboccipital venous plexus is unique, in that small arteries feed into the veins creating a hogher venous pressure than normal around the second cervical dorsal root ganglion and the origin of the greater occipital nerve

Taylor J. *The cervical spine: An atlas of normal anatomy and the morbid anatomy og ageing and injuries*. Edinburgh: Elsevier 2017

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