Manual therapy as a key component for multidisciplinary concussion care

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- Athletic therapy (Concordia University, 2003)
- Osteopathy (Centre Ostéopathique du Québec, 2012)
- Master’s degree (Concordia, 2019)

- Provincial Rugby Programs (Quebec, 15 years)
- National Circus School (Montreal, 5 years)
- Vancouver Olympic Games (2010) Canada Games (2009, 2015)
- Affiliation with the National Sport Institute of Canada

Mechanism of Injury

- “A concussion is a traumatic brain injury induced by biomechanical forces from a direct blow to the head, face, or body with an impulsive force transmitted to the brain. A concussion is the result of a complex pathophysiological process mainly resulting in a functional disturbance rather than a structural one. »
- Consensus Statement on Concussion in Sport (Berlin, 2016)

Mechanism of injury

Neck: cervical spine, muscles, fascia, thyroide	Thorax: Fascia, thoracic spine, diaphragm	Cranium, brain, la falx cerebri, tentorium cerebelli, cranial nerves
CNS, ANS : local lesion vs the network	Cerebral vasculature	Visual, vestibular and proprioceptive systems

Physiology

- Neuro-metabolic cascade: within the neuron: ionic imbalance, mitochondrial dysregulation, ↓ ATP
  - Gay M et al., *Sports Med Arthro Rev* (2016)

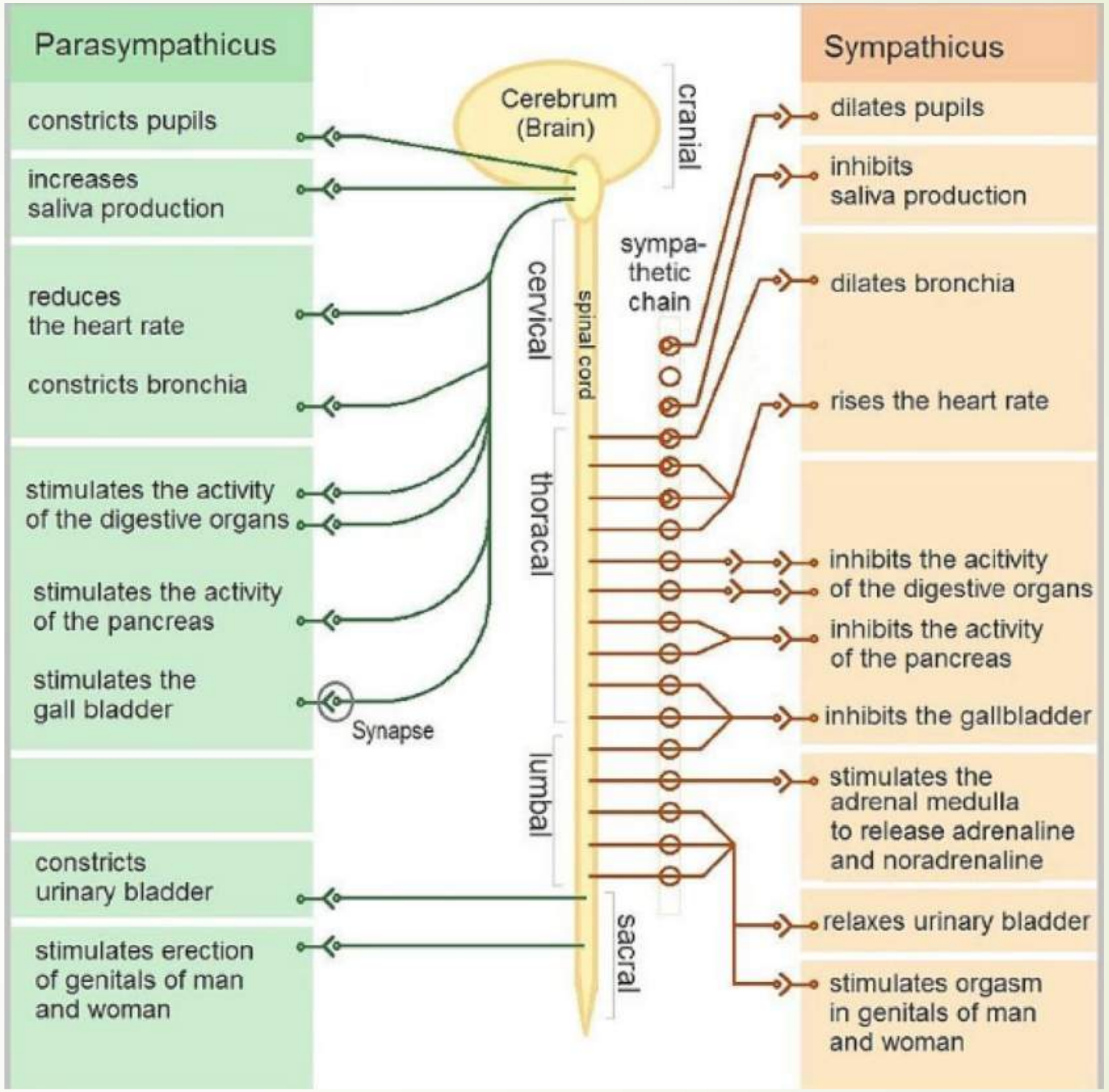
- Disruption in cerebral blood flow autoregulation
  - Wang Y et al., *J of Neurotrauma* (2016)

- Disruption of the autonomous nervous system
  - Esterov et al., *Brain Sci.* (2017)

Disruption of ANS

- Vascular and cardiac regulation
- Blood pressure regulation
- Gastrointestinal response
- Contraction of the bladder
- Focusing of the eyes
- Thermoregulation.
- These systemic complications have been studied through changes in heart rate variability, pupillary dynamics, eye pressure and arterial pulse wave in those with mTBI mainly in acute concussion.

• Esterov et al., *Brain Sci.* (2017)



Current research behind physical rehabilitation

- Quatman-Yates et al. Physical rehabilitation interventions for post-mTBI symptoms lasting greater than 2 weeks: systematic review. *Phys Ther.* 2016;96:1753–1763
- Systematic review of the possible physical rehabilitation interventions used to address persistent symptoms of a concussion. 3437 possible titles and abstracts, 8 were retained for evaluation.
- Inclusion criteria included: a physical rehabilitation intervention, published in English in a peer-reviewed format, with human participants. The interventions 3 types: physiological, vestibulo-ocular, and cervicogenic.
- Results: vestibular rehabilitation, manual therapy, and progressive exercise interventions

Aerobic exercise

- Leddy et al. (2010) evaluated the effectiveness of a physiological intervention with sub-symptom threshold exercise training to address the prolonged symptoms of a concussion.
- Case series had 12 participants (6 athletes/6 non-athletes), mean age 27.9 y (SD 15.3, range 16– 53), with symptoms of at least 6 weeks, but no longer than 52 weeks.
- Their outcome measures were: concussion symptom scale, exercise duration, blood pressure, heart rate, perceived exertion, and oxygen consumption.
- They achieved statistically significant **improvements in symptoms and exercise time, higher peak heart rate and blood pressure during exercises. Athletes recovered faster than non-athletes**. No adverse events were reported.

2019

- 103 participants from 13-18 years old.
- Récupération 13 days intervention group vs 17 days placebo group.
- Did not include participants with prolonged recovery.
- They controlled the population in a short-term recovery and teenage population.

More ▽

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Early Subthreshold Aerobic Exercise for Sport-Related Concussion

A Randomized Clinical Trial

John J. Leddy, MD[1]; Mohammad N. Haider, MD[1,2]; Michael J. Ellis, MD[3,4,5]; et al

› Author Affiliations

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Editorial Comment

Full Text

Key Points

Question What is the effectiveness of subsymptom threshold aerobic exercise vs a placebo-like stretching program prescribed to adolescents in the short term after sport-related concussion?

Findings In this randomized clinical trial of 103 adolescents, those assigned to aerobic exercise recovered faster (13 days) than those assigned to placebo-like stretching (17 days), a significant difference.

Meaning Early subthreshold aerobic exercise appears to be an effective treatment for adolescents after sport-related concussion.

Cervical and vestibular rehabilitation

- Schneider et al. Cervicovestibular rehabilitation in sport-related concussion: a randomized controlled trial. *Br J Sports Med* (2014) 48:1294-1298
- Aim: to determine whether a combination of vestibular rehabilitation and cervical spine manual therapy decreased the time until medical clearance compared with the local standard of care using RCT.
- All: standard care cervical range of motion, stretching and postural education.
- The intervention group also received cervical manual therapy and/or vestibular rehabilitation.
- Physiological, vestibular and cervicogenic intervention: 31 athletes (15 TG, 16 CG), median age 15 (12–30).

- Outcome measures: number of days until medical clearance to return to sports, pain, Balance Confidence Scale, Dizziness Handicap Index, Sport Concussion Assessment Tool 2 (SCAT2), dynamic visual acuity test, head thrust test, modified motion sensitivity test, functional gait assessment, cervical flexor endurance, and joint position error test.
- 73% percent of the treatment group, compared to 7.1% of control group, was medically cleared for return to play within 8 weeks
- Low sample size, the intervention group both vestibulo-ocular and cervicogenic interventions
- 26.7% of the participants were not medically cleared after 8 weeks of intervention

- 4854 articles found
- 43 articles retained
- 1) association between cervical sprain and symptoms of mTBI.
- 2) the mechanism of injuryand c-spine involvement
- 3) Treatments applied

Review Article

Cervical Spine Involvement in Mild Traumatic Brain Injury: A Review

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Background. There is a lack of scientific evidence in the literature on the involvement of the cervical spine in mTBI; however, its involvement is clinically accepted. *Objective.* This paper reviews evidence for the involvement of the cervical spine in mTBI symptoms, the mechanisms of injury, and the efficacy of therapy for cervical spine with concussion-related symptoms. *Methods.* A keyword search was conducted on PubMed, ICL, SportDiscus, PEDro, CINAHL, and Cochrane Library databases for articles published since 1990. The reference lists of articles meeting the criteria (original data articles, literature reviews, and clinical guidelines) were also searched in the same databases. *Results.* 4,854 records were screened and 43 articles were retained. Those articles were used to describe different subjects such as mTBI's signs and symptoms, mechanisms of injury, and treatments of the cervical spine. *Conclusions.* The hypothesis of cervical spine involvement in post-mTBI symptoms and in PCS (postconcussion syndrome) is supported by increasing evidence and is widely accepted clinically. For the management and treatment of mTBIs, few articles were available in the literature, and relevant studies showed interesting results about manual therapy and exercises as efficient tools for health care practitioners.

- *"PCS related symptoms are nonspecific. Professionals must consider other pathologies as alternative explanations to persistent symptoms."*
- *"…a prospective Norwegian study of 348 participants identifies through a questionnaire that headaches persisting for more than 3 months after trauma and diagnosed as PCS are often related to a musculoskeletal pathology. In other words, the head or brain injury does not cause the persistent symptoms."*
- *" The Majority of articles in the literature currently focus on the diagnosis of mTBI, but few are dedicated to its management and treatments."*
- *"Treatments such as vertebral manual therapy, cervical tractions, manipulations, and exercises can relieve neck pain."*
- *"There is still nonempirical support that stronger neck muscles could reduce the risks of mTBI on the field. Neck strength does not decrease head acceleration, but anticipatory cervical muscle activation potentially could."*

- Study before and after on 51 participants with PCS over 6 months
- Psychologist, vestibular, visual, aerobic exercice
- No cervical spine improvements

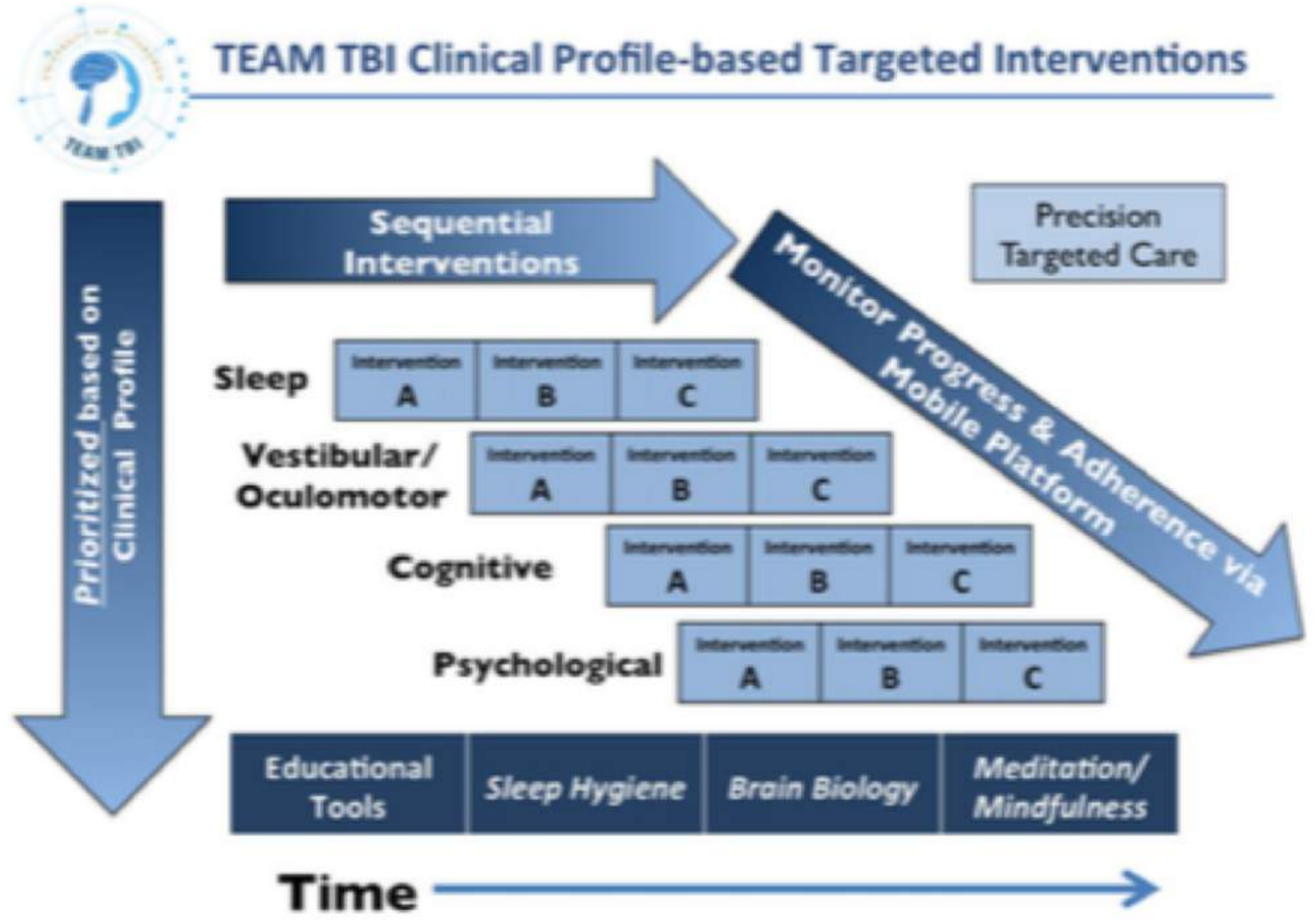


FIGURE 2. Conceptual model for targeted, precision interventions matched to prioritized mTBI clinical profiles for each patient.

Schneider 2019

- A need for multifaceted approach
- To date there is a limited number of quality studies evaluating the efficacy of treatment strategies for the persistent symptoms of a concussion
- Research challenges in the area of concussion rehabilitation:
  - Different treatments may be more appropriate at different times in the rehabilitation.
  - A different number of treatments may be needed for each subtype of ongoing alterations in function.
  - Lack of a validated measure of recovery.
- Despite the lack of evidence, Schneider suggests treatment interventions should include: cervical spine treatment, vestibular rehabilitation, sleep management, low level aerobic exercise, headache management, psychological interventions, cognitive rehabilitation, and vision therapy.

Osteopathy

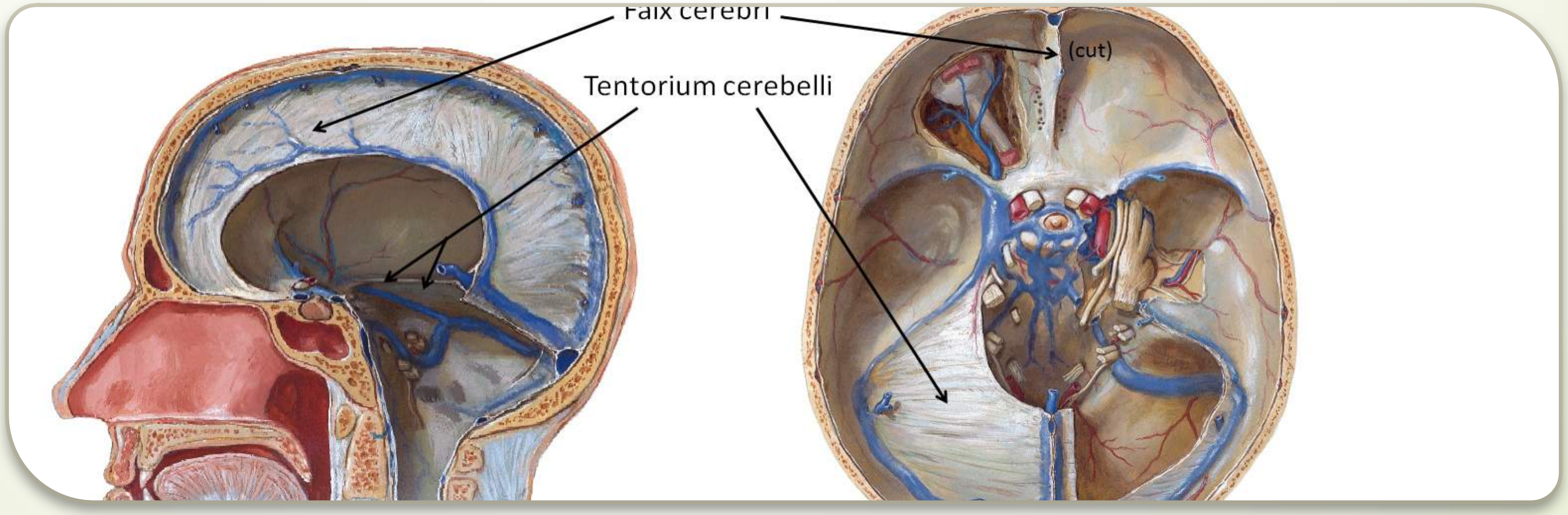
- **Osteopathy is a strictly manual therapy that aims at restoring mobility to the body’s structure to stimulate the body’s capacity for self-healing**
  - Benchmarks for training in osteopathy. World Health Organization

Tensegrity

- The cranium, when observed as a vault, is a model of tensegrity, derived from the word tension and integrity. Tensegrity describes structures that are inherently stable as a result of balance between compression and tension.

- Scarr G. *International Journal of Osteopathic Medicine* (2008)

- The sutures, held apart by the duramater, the falx cerebri and the tentorium cerebelli serve as the tension element. The bones of the vault are linked by the falx cerebri linking the ethmoid, frontal, parietal, and occipital bones and the tentorium cerebelli linking the sphenoid, temporal and occipital bones.
- With Newton's 3rd law of motion: action and reaction are equal and opposite, if a load is applied to the structure, there will be a uniform change in the whole shape and the tension and compression will be distributed evenly.



- Cranial bones exhibit viscoelasticity that improves their malleability and ability to protect the internal structures.
- When subjected to external trauma due to impact forces, cranial bones exhibit high bending forces.
- The cranial sutures hold the bones of the skull together while allowing for mechanical stress and deformation.
- In adults, sutures serve as shock absorbers to dissipate stress transmitted to the skull.
- Recent advances in micro-computed tomography has shown that sutures remain partly open even beyond the 7th decade, with varying degrees of connectivity across the suture gaps.

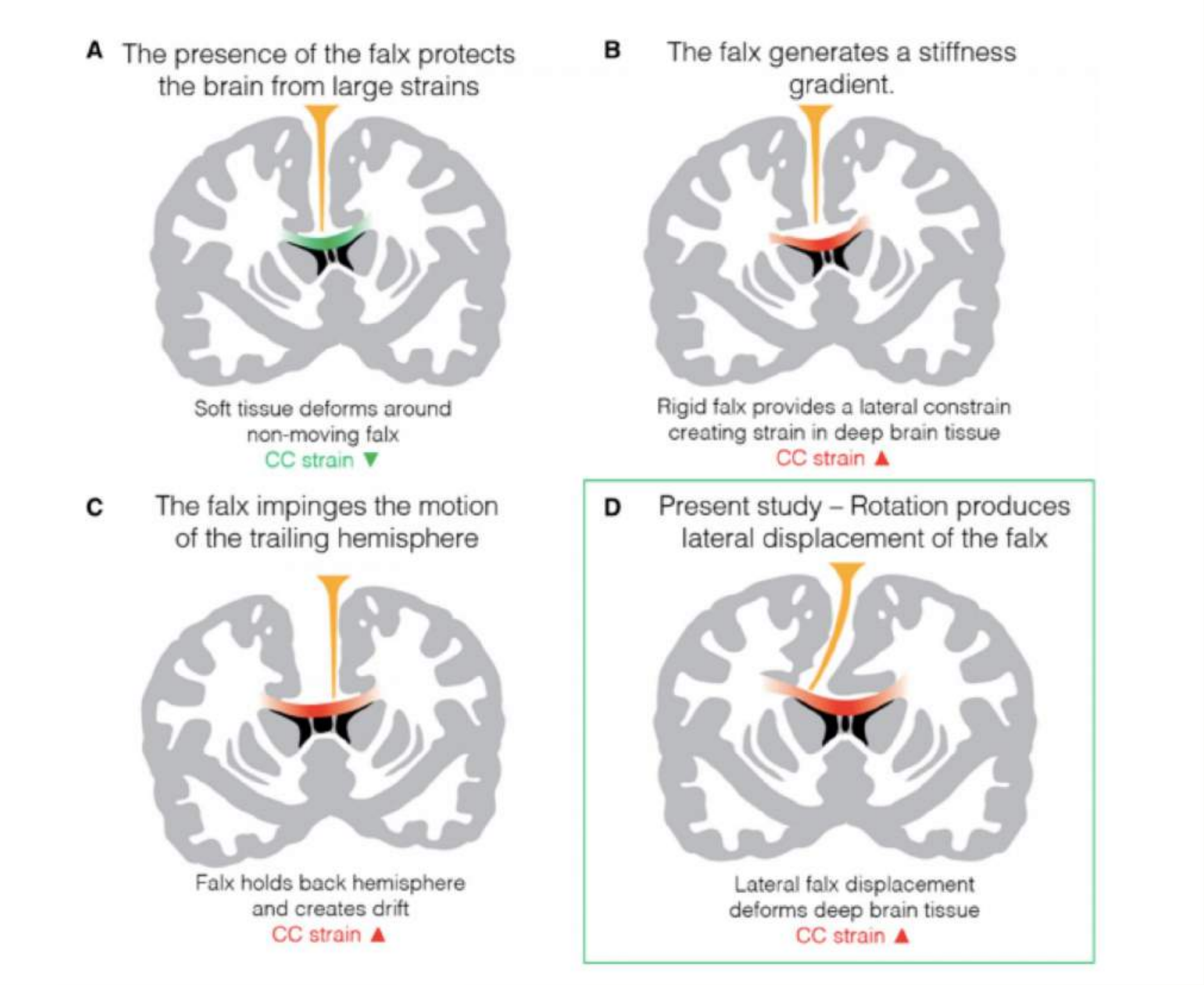
- Maloul et al.. *Journal of Biomechanics* (2013)

- Both Yu et al. in 2004 and Maloul et al in 2013 demonstrated the biomechanical suture force absorption abilities in the cranium.
- They deduced that sutures have the greatest absorption ability when subjected to parallel forces, but not as much with perpendicular forces and even less in shear forces received at a 45-degree angle.
- They also described that sutures with high degrees of inter-digitation, such as the sagittal suture, are more effective to withstand load

- Maloul et al. *Journal of Biomechanics* (2013)
- Yu et al. *Semin Pediatr Neurol* (2004)

- Hernandez et al. demonstrated, using a sensor cap on football players that at the moment of impact, the falx cerebri is stretched and kept under tension, and the greatest fluctuation in movement is seen in the corpus callosum at the center of the brain.
- When we consider that cerebrospinal fluid is reabsorbed within the meninges, that the falx cerebri encloses the sinus straight, links several cranial bones, and becomes tense, and there are increased fluctuations at the center of the brain, this can lead to reflection on potential physiological repercussions of the physical mechanism.

- Hernandez et al. *Biomechanics and Modeling in Mechanobiology* (2019)



Accessibility to Osteopathic Manipulative therapy in the United States

- American Osteopathic Association
  - Osteopathic Manipulative Treatment
  - www.doctorsthatdo.org
- Biodynamics
  - http://jamesjealous.com/physician-directory/u-s-physician-directory/
- Upledger
  - Cranio-sacral therapy courses for massage therapists

Osteopathy research

- Cranial manual therapy for migraines; 3-armed random control trial
  - 105 participants, 3 groups(intervention/sham/control); ↓ days of migrain, intensity and functional disability; ↓ in drug use.
    - Cerritelli et al. *Complementary Therapies in Medicine* (2015)
- Cranial manual therapy for headaches; single-blind random control trial with placebo group
  - 44 participants with headaches, 4 treatments over 4 weeks. Treatment group = ↓ headaches frequency and medication intake.
    - Rolle G et al., *J Am Osteopath Assoc*. (2014)

Osteopathy research

- Cranial manual therapy for persistent dizziness (3 months).
  - 16 participants; ↑ in all outcome mesures: Neurocom, dizziness handicap inventory and self-assessment inventory.
    - Fraix et al. *Journal Amer* Osteo Ass (2013)
- Cranial manual therapy on visual function RCT
  - 19 participants in intervention (n=15), sham (n=14). Outcome measures: acuity, NPC, stereoacuity, and pupillary size.
    - Sandhouse et al., *Journal Amer Osteo Ass* (2010)

Osteopathy research

- Influence of cranial manual therapy on cardiac modulation; single blind cross-over study
  - 66 participants; 3 groups(intervention/sham/control), with electrocardiogram ↑parasympathetic, ↓ sympathetic function.
    - Ruffini et al. *Front. Neurosci* (2015)

Purpose of my research

- Could the impact received in the mechanism of injury lead to mobility restrictions?
- To investigate the prevalence of cranial bone, and upper cervical mobility restrictions in a post-concussion syndrome population.
- To investigate whether there is a correlation between mobility restrictions and the clinical concussion tests used by health care professionals.

Guidelines for reliability research

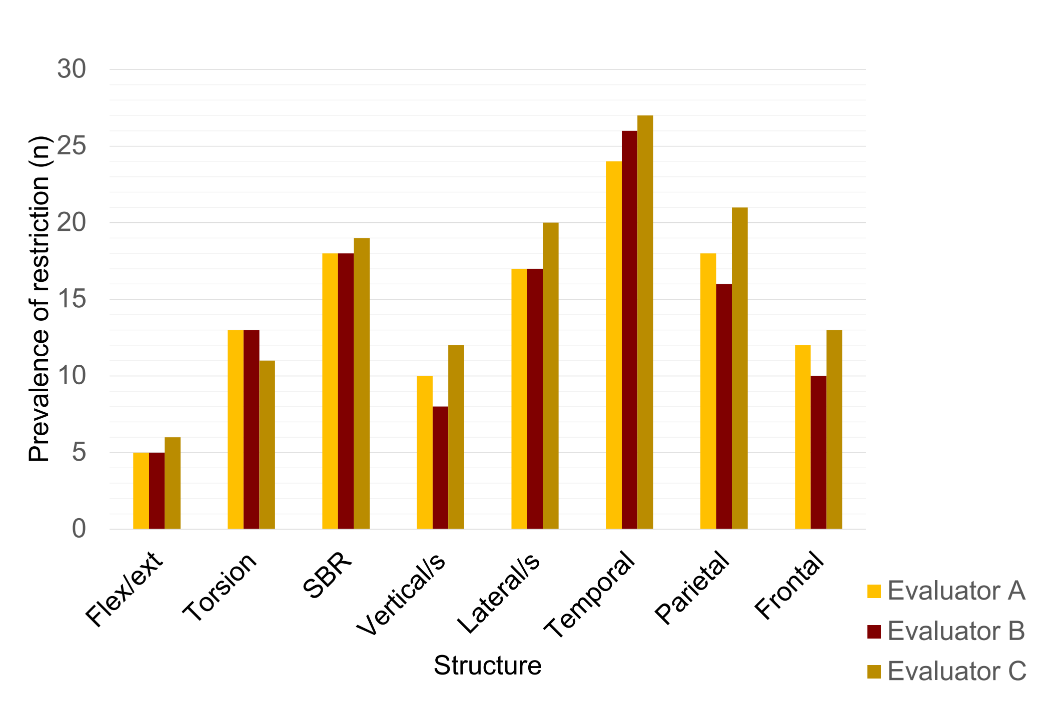
- QAREL is an 11-item checklist that cover 7 key domains:
  - the spectrum of participants
  - the experience of the evaluators
  - evaluator blinding
  - effects of order of assessments
  - the suitability of the time-interval between repeated measurements
  - appropriate test application and interpretation
  - appropriate statistical analysis
- In the field of expertise development, it takes approximately 10,000 hours of intense deliberate practice to become an expert within a chosen domain
  - Guillaud A et al., *PLoS ONE* (2016)

Reliability study

- Prior to data collection, the osteopaths participated in
  - a consensus training which included establishing the criteria for identifying a cranial bone mobility restriction
  - training using the 7-step palpation method
  - a pre-testing practice; and
  - a calibration period
    - Guillaud A et al., *PLoS ONE* (2016)
    - Aubin A et al., *Int Jour of osteo med.* (2014)

THE INTER-RATER RELIABILITY OF THE CRANIAL BONES MOBILITY TESTS AS ASSESSED THROUGH MANUAL THERAPY

FIGURE 1. Number of restrictions



Structure (n)	Pairwise % agreement	Fleiss kappa coefficient
Flex/ext(21)	90.5	0.749
Torsion(21)	84.1	0.673
SBR(21)	93.8	0.714
Vertical strain(21)	81.1	0.618
Lateral strain(21)	87.3	0.481
Temporal (42)	84.1	0.666
Parietal (42)	89.0	0.774
Frontal (21)	90.5	0.807

UNPUBLISHED DATA

HYPOTHESIS

- We hypothesized that individuals with post-concussion syndrome **(PCS) would present more cranial bone, and upper cervical spine mobility restrictions** than the control group (Ctl).
- We hypothesized that the **mobility restrictions would be correlated with the clinical test** results of the Post-Concussion Symptom Scale (PCSS), the King-Devick (KD) test, the Tandem Gait Test (TGT), a Sensory Organization Test (SOT), and the Vestibulo-Ocular-Motor Screening test (VOMS).
- The **primary outcomes** were the **group comparisons** and the **associations** between the mobility restrictions of the cranial bones, atlas and axis and the clinical concussion test results.

Methods

- Post-Concussion Syndrome group (PCS) n=21
- Concussion History group (CHx) n=11
- Control group (Ctl) n =12

- Recruited from Quebec's different sports organizations, colleges, universities, and health care professional associations from November 2017-June 2019.

- Research assistant not blinded
- Certified Osteopath double blind
- Certified Athletic Therapist single blind

Inclusion Criteria		
1: Control Group (Ctl)	2: Concussion History Group (CHx)	3: Post-Concussion Syndrome (PCS)
- Healthy physically active adults between ages of 18-35 years old.	- Healthy physically active adults between ages of 18-35 years old. - Having recovered from at least 1 previous concussion - Participation in collision or non-collision sports	- Healthy physically active adults between ages of 18-35 years old. - Having sustained a concussion 1 month ago or greater. - Having 3 concussion symptoms or more still present
Exclusion Criteria		
1: Control Group (Ctl)	2: Concussion History Group (CHx)	3: Post-Concussion Syndrome (PCS)
- previous concussion, or sub-concussive impact (hit to the head) - any participation in a collision sport where hits to the head are frequent - motor vehicle accident - previous skull fracture - chronic neck pain - severe learning disabilities - psychiatric disorder - neurological conditions - who are currently under prescribed medication that may cause dizziness, influence motor control or mimic concussion symptoms.	- motor vehicle accident - previous skull fracture - chronic neck pain - severe learning disabilities - psychiatric disorders - neurological conditions - who are currently under prescribed medication that may cause dizziness, influence motor control or mimic concussion symptoms.	- motor vehicle accident in last 5 years (unless this current concussion is from MVA) - previous skull fracture - chronic neck pain - severe learning disabilities - psychiatric disorders - neurological conditions - who are currently under prescribed medication that may cause dizziness, influence motor control or mimic concussion symptoms - having received cranial and/or upper cervical manual therapy for this concussion

Procedure

1) Participants recruited by research assistant (not blinded to group attribution)
2) Participants filled out consent, demographic and medical history form.
3) Step 1: Participants assessed by a blinded osteopath: Occiput (C0), atlas (C1) and axis (C2) passive mobility test, and spheno-basilar strain (SBS) patterns, temporal, parietal, frontal bone mobility test.
4) Step 2: Participants assessed by blinded athletic therapist: PCSS, cervical range of motion, cranial nerves, King-Devick, Tandem Gait Test, Neurocom, VOMS.
5) Step 3: Repeat step 1.

Clinical test measures

- Post-concussion symptom scale (PCSS)
- Cranial nerves (CN) and cervical range of motion (ROM)
- King Devick (KD)
- Tandem Gait Test (TGT)
- Neurocom (Sensory Organization Test - SOT)
- Vestibulo-Ocular-Motor Screening (VOMS)

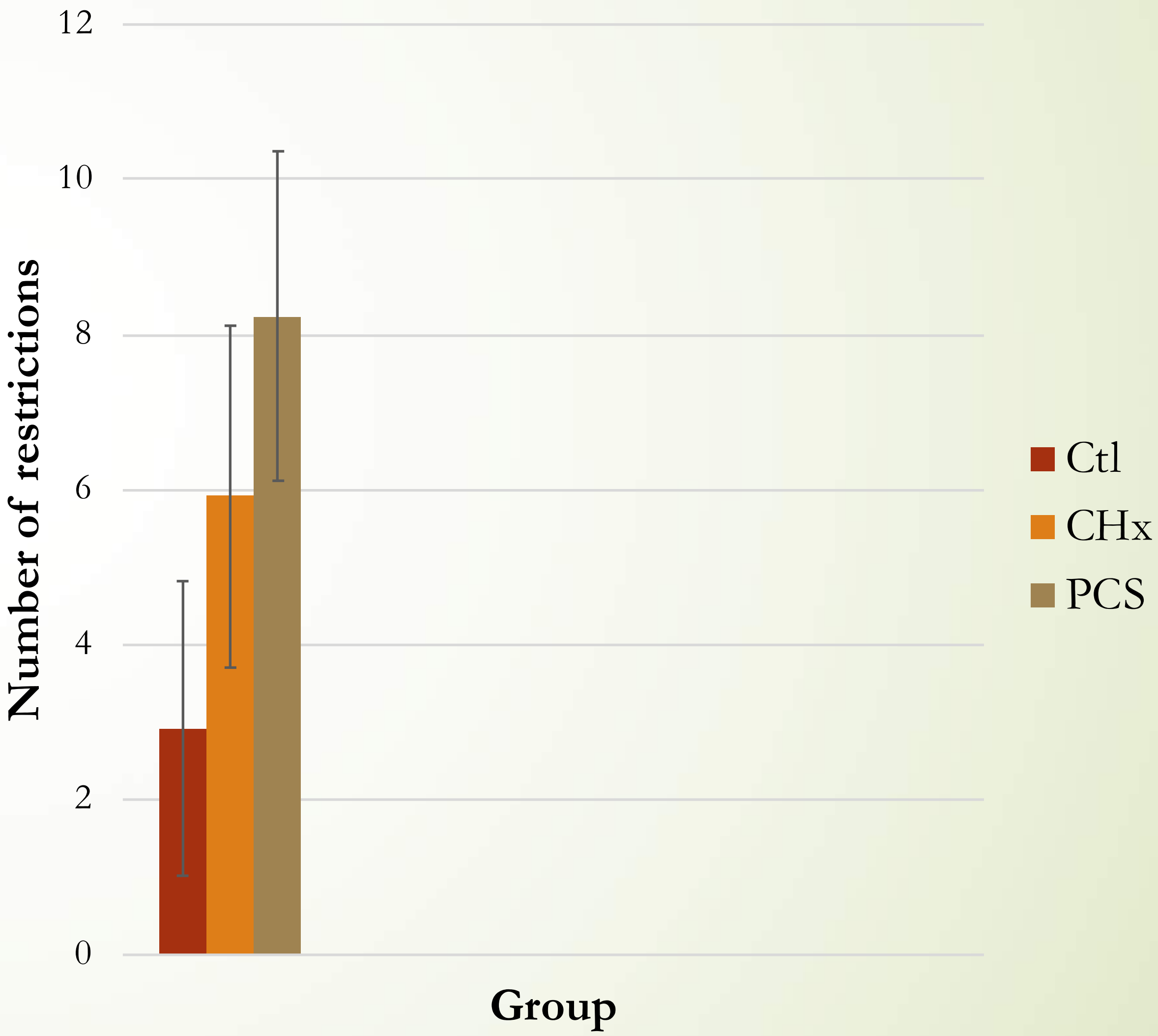
Manual assessment measures

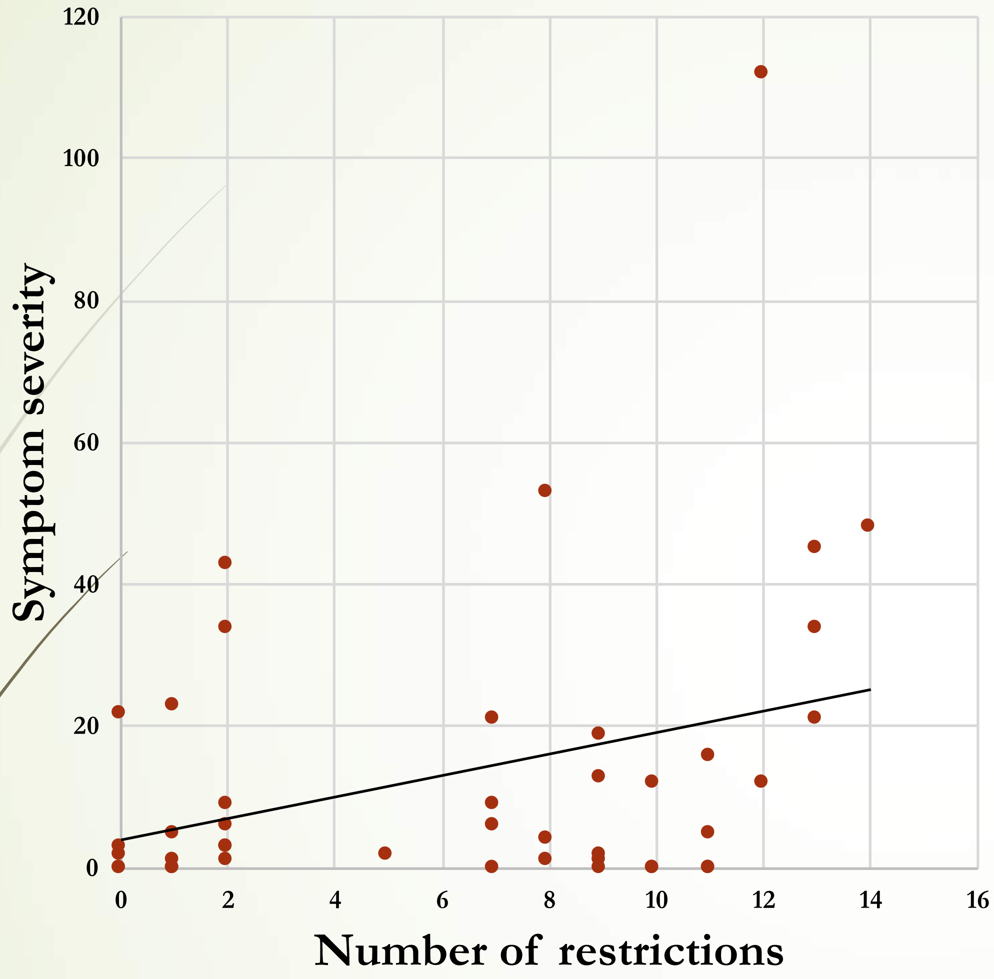
- Occiput (C0), atlas (C1) and axis (C2) passive mobility test.
- Spheno-basilar strain (SBS) patterns, temporal, parietal, frontal bone mobility test.

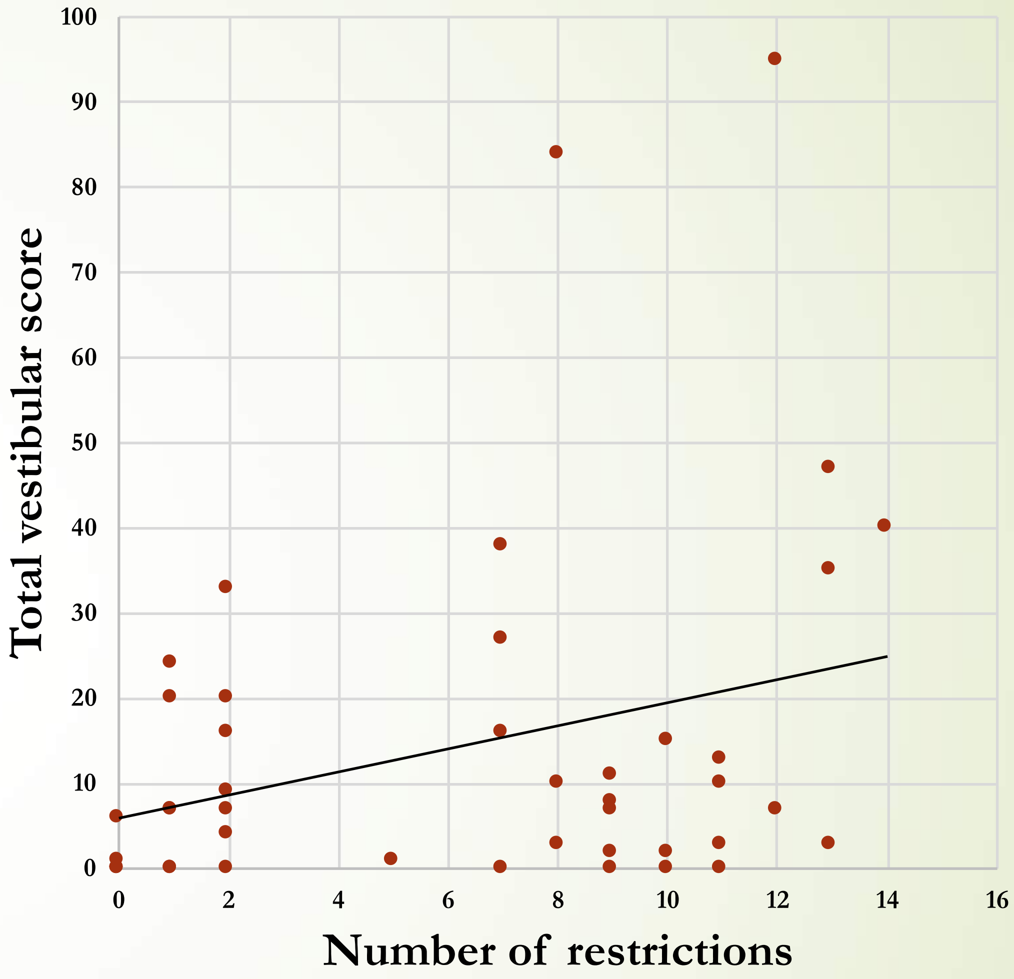
NR Group Differences

Anova ($F_{(2,41)}$= 6.231, p= .004)

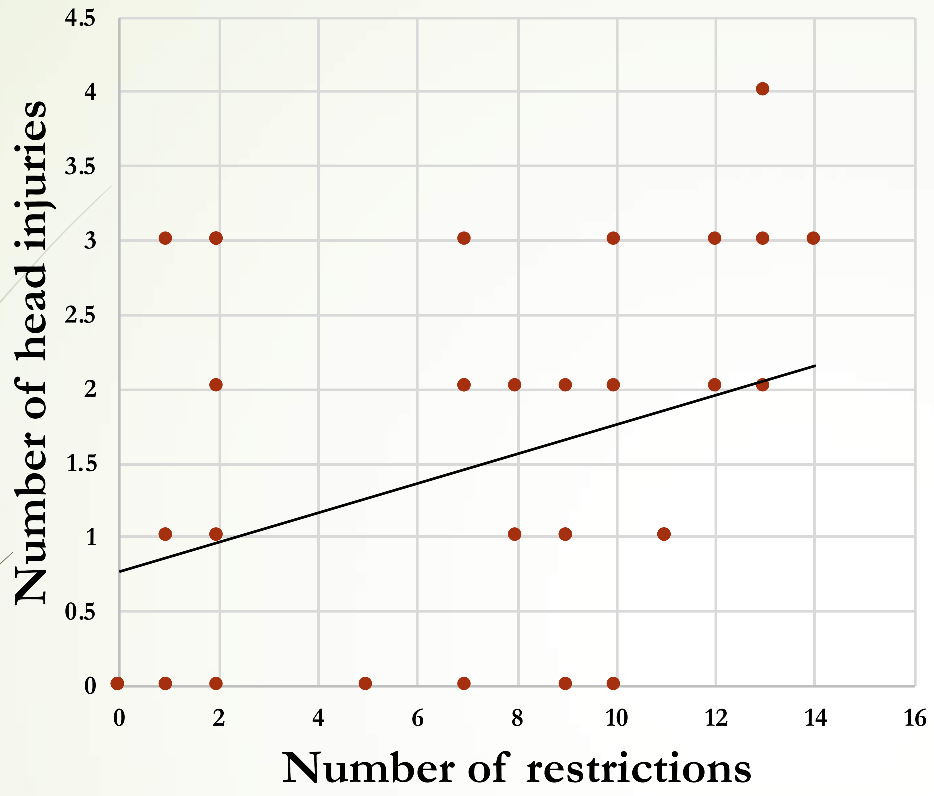
	Mean	**Std Dev**	
PCS	8.24	4.25	
CHx	5.91	4.41	
Ctl	2.92	3.8	
	Mean difference	Std Dev	p-value
PCS/Ctl	5.32	1.51	.003
PCS/CHx	2.33	1.56	.303
CHx/Ctl	2.99	1.74	.212

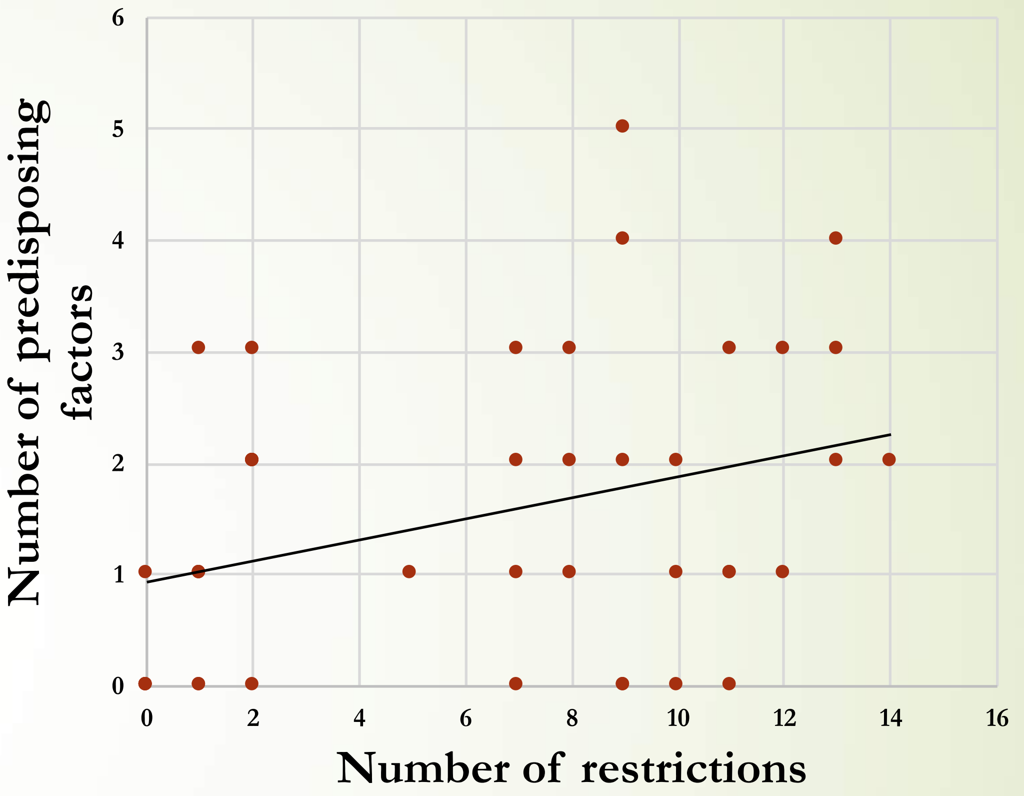






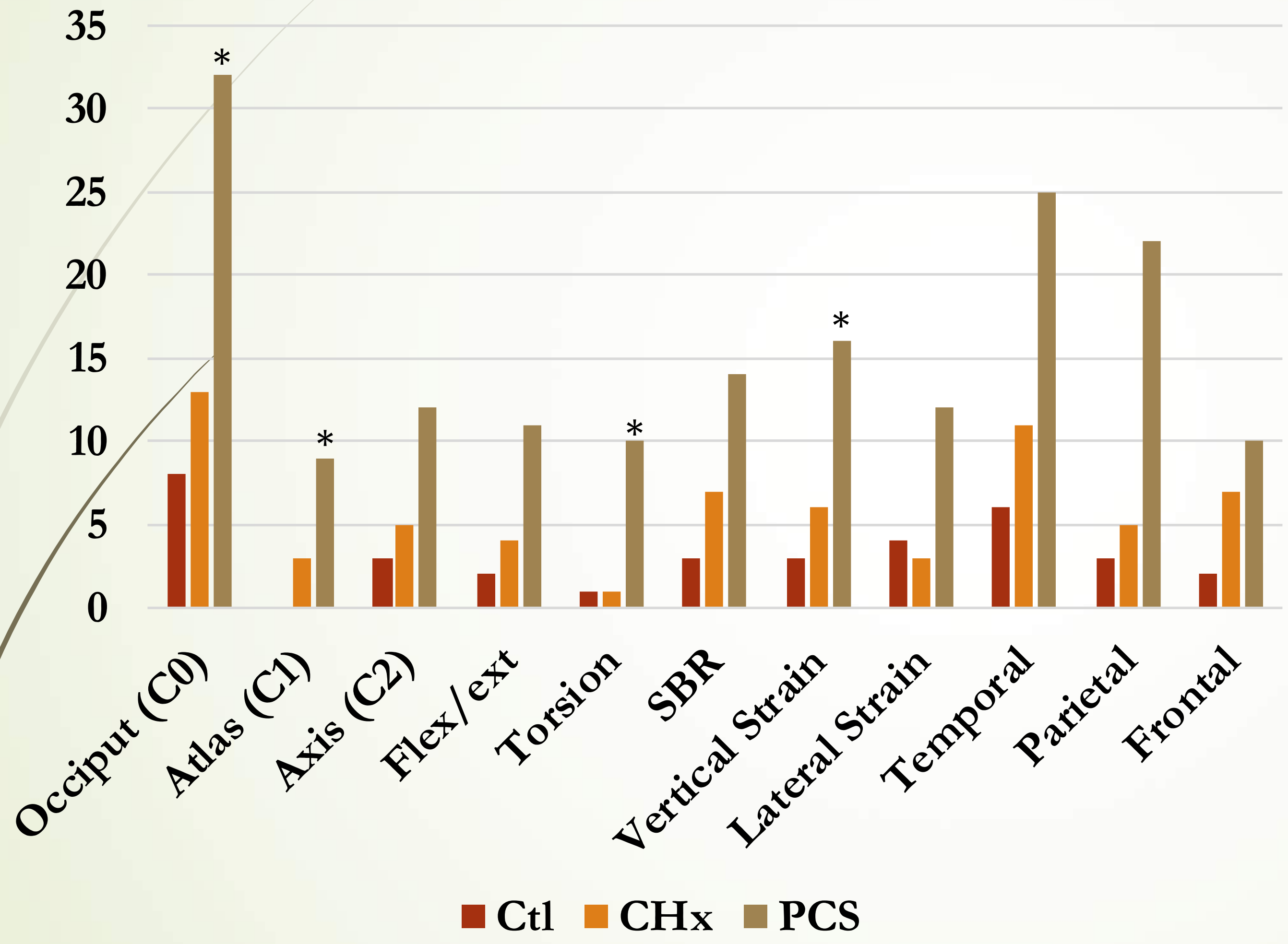
Comparison	Pearson Correlation	Sig.
NR with SxSev	.333	.027*
NR with TVest	.305	.044*





Comparison	Pearson Correlation	Sig.
NR with HI	.396	.008*
NR with PF	.338	.025*
NR with #Sx	.283	.062
NR with TVis	.267	.079
NR with TScore	.293	.054

Group differences for each individual bone



Structure	Pearson Correlation	Sig.
C0	14.633*	.001
C1	7.071*	.029
C2	3.182	.204
Flex/ext	4.140	.126
Torsion	8.386*	.015
SBR	5.836	.054
Vertical Strain	8.187*	.017
Lateral Strain	3.277	.194
SBS	2.37	.307
Temporal	5.928	.052
Parietal	5.752	.056
Frontal	5.483	.064

Pearson Chi-Square correlations between mobility restrictions of the cranial bones and upper cervical vertebrae (n=44).

	C0	C1	C2	SBS	Temporal	Parietal	Frontal
C0	1	**4.243***	.670	**15.121***	**16.343***	**8.599***	**8.599***
		0.039	0.413	**0.000**	**0.000**	**0.003**	**0.003**
C1	**4.243***	1	**2.994**	**4.872***	**7.243***	3.709	0.313
	0.039		**0.084**	**0.027**	**0.007**	0.054	0.576
C2	.670	2.994	1	3.240	**6.631***	2.087	0.695
	0.413	0.084		0.072	**0.010**	0.149	0.405
SBS	**15.121***	**4.872***	3.240	1	**32.874***	**17.297***	**12.368***
	0.000	**0.027**	0.072		**0.000**	**0.000**	**0.000**
Temporal	**16.343***	**7.243***	**6.631***	**32.874***	1	**23.151***	**17.577***
	0.000	**0.007**	**0.010**	**0.000**		**0.000**	**0.000**
Parietal	**8.599***	3.709	2.087	**17.297***	**23.151***	1	**5.439***
	0.003	0.054	0.149	**0.000**	**0.000**		**0.020**
Frontal	**8.599***	0.313	0.695	**12.368***	**17.577***	**5.439***	1
	0.003	0.576	0.405	**0.000**	**0.000**	**0.020**	

Discussion – NR group differences

- Number of mobility restrictions significantly higher in PCS than Ctl group
- First study to describe the prevalence of cranial mobility restrictions in a post-concussion population
- Tiwari et al. (2019) assessed prevalence of C0C1 and C1C2 mobility restrictions in 73 participants (8-18yo.) = 71%.
- Our study 63% of PCS group presented C0C1C2 mobility restrictions
- Higher # of participants, younger population

Discussion – NR with clinical tests

- Significant relationship between number of mobility restrictions and:
  - Symptom severity
  - Vestibular score
  - Number of head injuries
  - Number of predisposing factors
  - Trend with #Sx, Tvis, Tscore

- Results demonstrate that mobility restrictions could contribute to persistent symptoms (PCSS) and influence underlying structures responsible for visual and vestibular function (VOMS).

Discussion

Strengths :

- Methodology
- Consensus training
- Experience of the health care professionals

Limiting factors :

- Phone interviews
- Medical questionnaires
- Post-Concussion Symptom Scale self-reported
- Sample size

Importance

- Mobility restrictions may contribute to the persistent symptoms of a concussion
- Include a cranial and upper cervical manual assessment in the concussion assessment.
- This study lays a foundation for reliable methodologies to be used to determine the prevalence of cranial mobility restrictions in adult populations consulting osteopathic care.

Future direction

- Future investigation:
  - Are mobility restrictions a results of the concussion impact or develop over time?
  - Do mobility restrictions influence KD, SOT and TGT in the acute phase of a concussion
  - Do mobility restrictions, if left untreated, becoming a contributing factor to PCS?
  - Research on the potential physiological and functional impacts of mobility restrictions.
  - Intervention studies to determine clinical efficacy and improve knowledge of conditions that may benefit from cranial osteopathy

Anatomy

- Cranio-cervical junction
- Vasculature
- Falx cerebri and tentorium cerebeli
- Sutures and bones
- Cranial nerves
- Pituitary gland
- Autonomous nervous system ganglions
- Cardio-pulmonary plexus

STRUCTURE	FUNCTION	SYMPTOM
Optic nerve (II)	Visual acuity, perception, accommodation	Headache, light sensitivity
Oculo-motor nerves (III, IV, VI)	Innervates oculo-motor muscles	
Trigeminal nerve (V)	The ophthalmic branch (V-1) innervates the dura mater and blood vessels, and responsible for pupillary reflex	Headache, neck pain, pressure in the head, vision
Vestibulocochlear nerve (VIII)		Dizziness and balance
Vague nerve (X)	Responsible for nausea and contributes to the para-sympathetic control of the heart, lungs and digestive tract	Nausea and ANS
Accessory nerve (XI)	Inn. SCOM and trapezius muscle	Neck pain
Superior cervical ganglion	Sympathetic innervations: pineal gland, the blood vessels, the eyes and the peripheral vestibular system	Circadian rhythm sleep patterns, vision, sensitivity to light, balance and dizziness
Falx cerebri	Houses sagittal sinus, links frontal, parietal, occiput	Headache, vision, ANS
Tentorium cerebelli	Houses transverse and superior petrosal sinuses, wraps pituitary gland, trigeminal nerve, endolymphatic sac, links temporal and occiput	Headache, dizziness, balance, ANS
Pituitary gland – HPA axis	Controlling blood pressure, heart rate, thyroid gland, metabolism, body temperature, pain relief, thirst, fatigue, and sleep circadian rhythms	Fatigue, dizziness

Anatomo-physiological relationships

- Occiput (C0) and Atlas (C1)
- Falx cerebri
- Multiple muscles insertions connecting the upper cervical vertebrae to the occiput, temporal, and temporo-mandibular joint.
- Passage CN V, X, XI, XII
- Superior cervical ganglion at C2
- Vasculature: carotid, vert. artery, jug. Vein
- **Headache, neck pain, nausea, sleep, vision, dizziness, balance, blood flow and ANS**

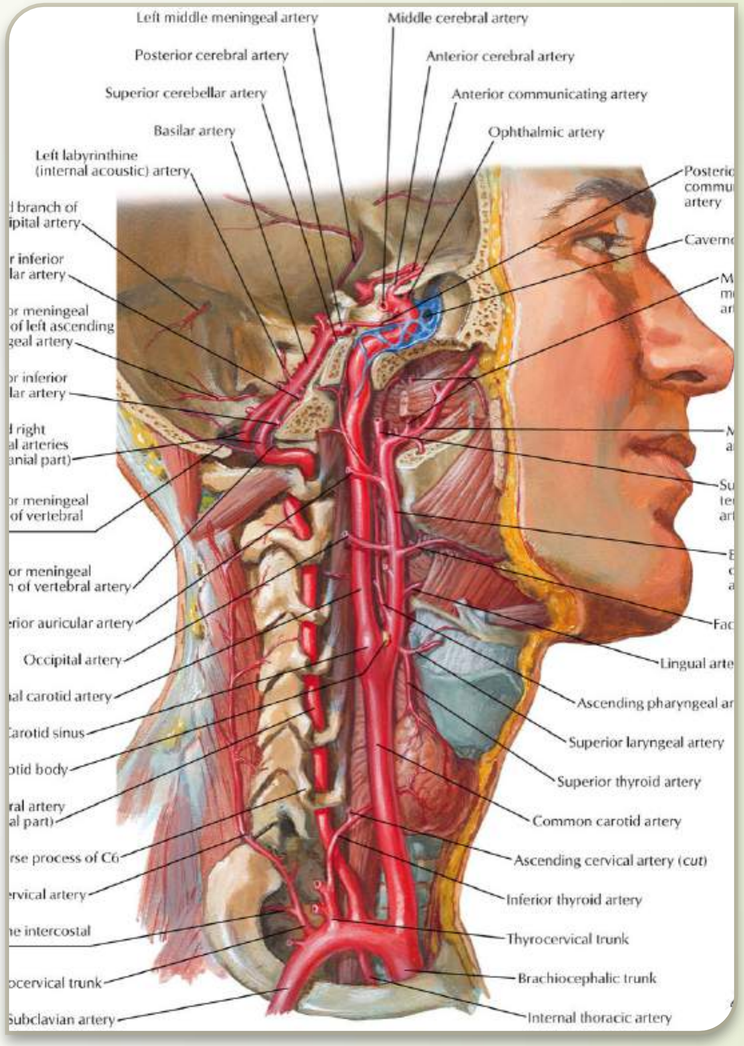
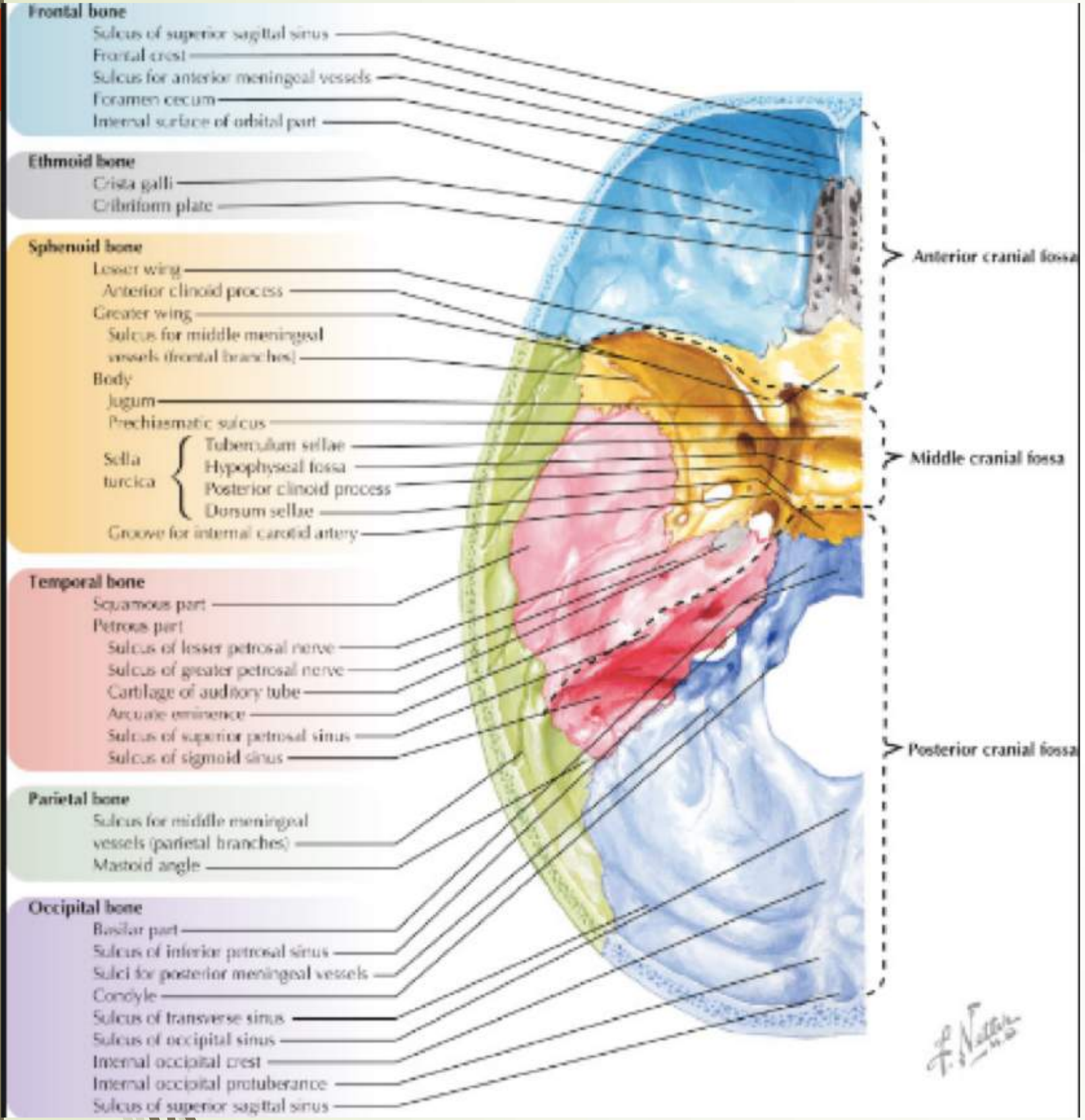
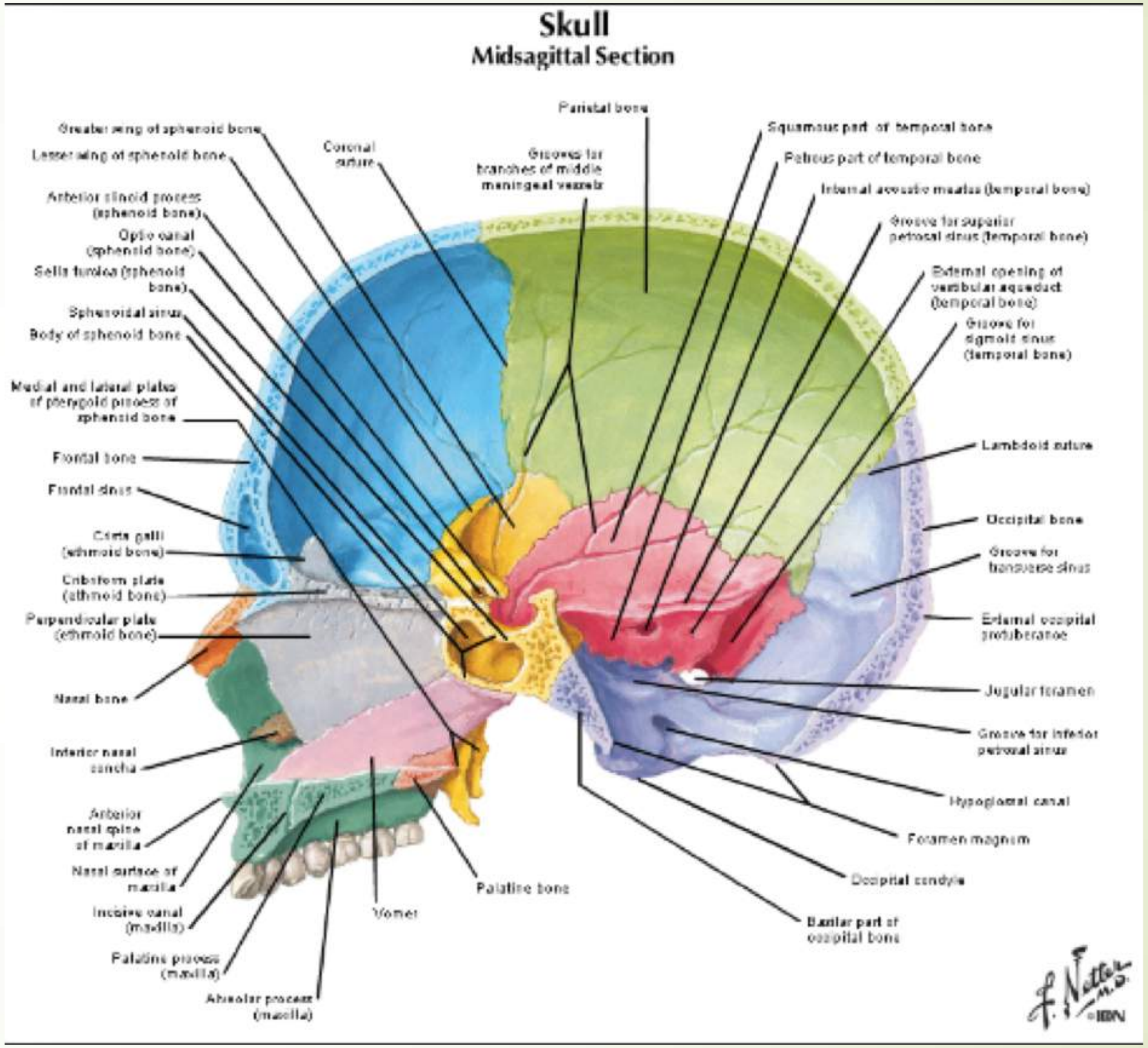


PLATE 130. ARTERIES OF THE BRAIN AND MENINGES. NETTER FH. ATLAS OF HUMAN ANATOMY. NEW JERSEY, NOVARTIS, 1997



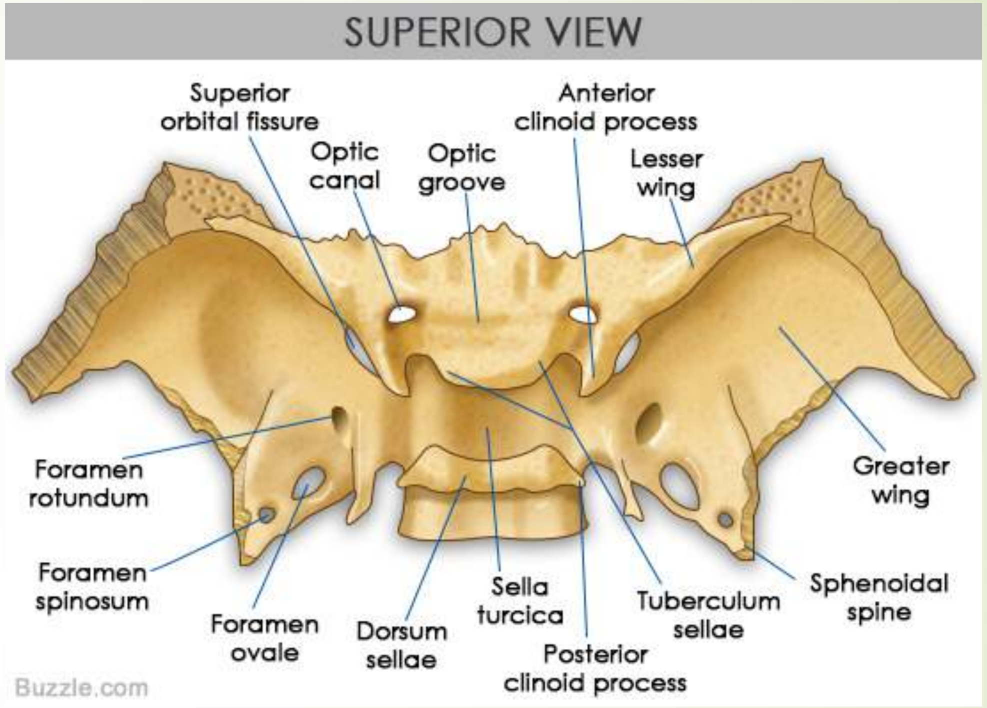
Frontal bone
Sulcus of superior sagittal sinus
Frontal crest
Sulcus for anterior meningeal vessels
Foramen cecum
Internal surface of orbital part
Ethmoid bone
Crista galli
Cribriform plate
Sphenoid bone
Lesser wing
Anterior clinoid process
Greater wing
Sulcus for middle meningeal vessels (frontal branches)
Body
Jugum
Prechiasmatic sulcus
Sella turcica
Tuberculum sellae
Hypophyseal fossa
Posterior clinoid process
Dorsum sellae
Groove for internal carotid artery
Temporal bone
Squamous part
Petrous part
Sulcus of lesser petrosal nerve
Sulcus of greater petrosal nerve
Cartilage of auditory tube
Arcuate eminence
Sulcus of superior petrosal sinus
Sulcus of sigmoid sinus
Parietal bone
Sulcus for middle meningeal vessels (parietal branches)
Mastoid angle
Occipital bone
Basilar part
Sulcus of inferior petrosal sinus
Sulci for posterior meningeal vessels
Condyle
Sulcus of transverse sinus
Sulcus of occipital sinus
Internal occipital crest
Internal occipital protuberance
Sulcus of superior sagittal sinus
Anterior cranial fossa
Middle cranial fossa
Posterior cranial fossa



Skull
Midsagittal Section
Greater wing of sphenoid bone
Lesser wing of sphenoid bone
Anterior clinoid process (sphenoid bone)
Optic canal (sphenoid bone)
Sella turcica (sphenoid bone)
Sphenoidal sinus
Body of sphenoid bone
Medial and lateral plates of pterygoid process of sphenoid bone
Frontal bone
Frontal sinus
Crista galli (ethmoid bone)
Cribriform plate (ethmoid bone)
Perpendicular plate (ethmoid bone)
Nasal bone
Inferior nasal concha
Anterior nasal spine of maxilla
Nasal surface of maxilla
Incisive canal (maxilla)
Palatine process (maxilla)
Alveolar process (maxilla)
Vomer
Palatine bone
Coronal suture
Grooves for branches of middle meningeal vessels
Parietal bone
Squamous part of temporal bone
Petrous part of temporal bone
Internal acoustic meatus (temporal bone)
Groove for superior petrosal sinus (temporal bone)
External opening of vestibular aqueduct (temporal bone)
Groove for sigmoid sinus (temporal bone)
Lambdoid suture
Occipital bone
Groove for transverse sinus
External occipital protuberance
Jugular foramen
Groove for inferior petrosal sinus
Hypoglossal canal
Foramen magnum
Occipital condyle
Basilar part of occipital bone

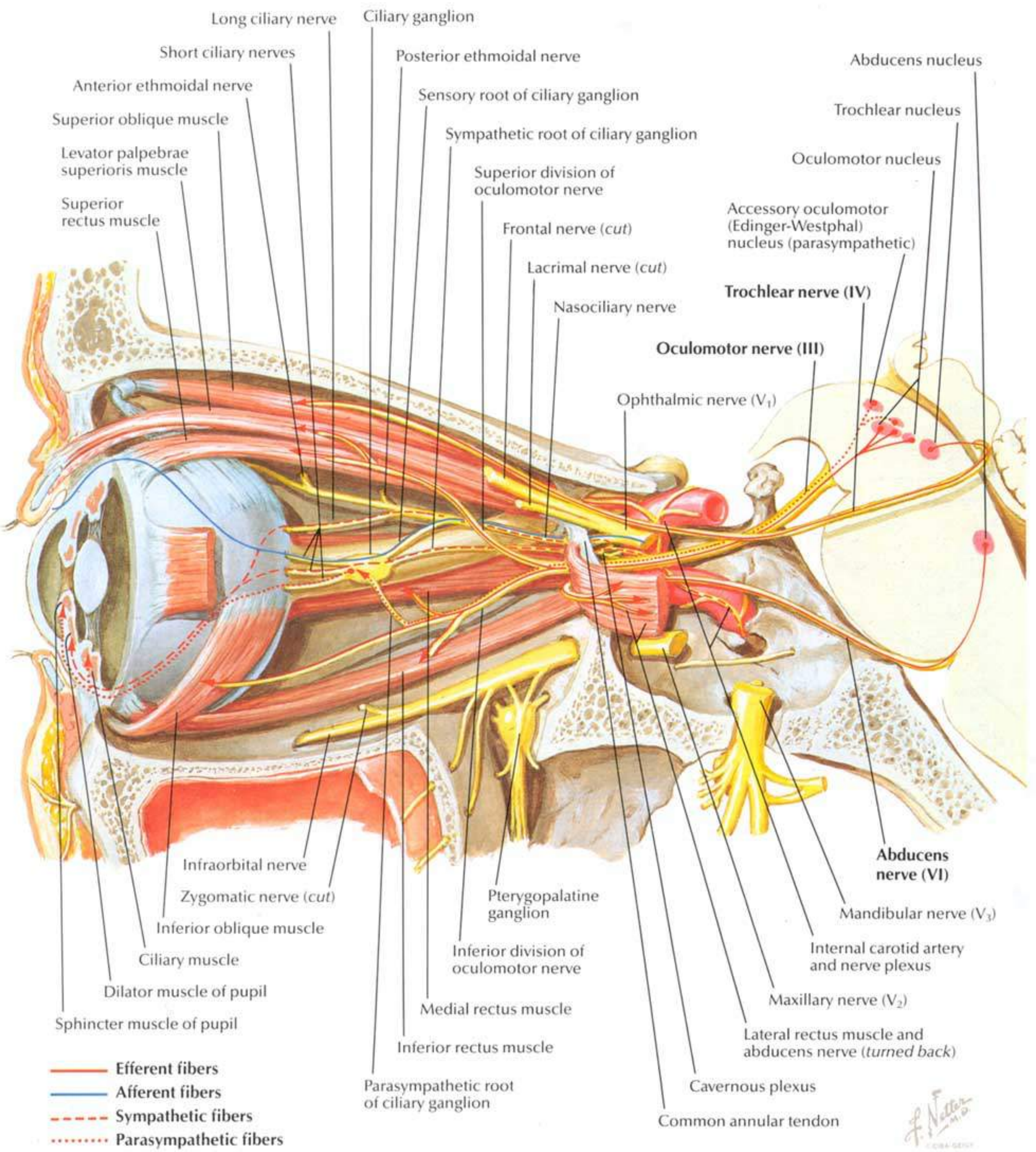
Anatomo-physiological relationships

- Sphenoid
- Trigeminal nerve
- Passage of oculomotor nerves (II, III, IV, VI)
- Insertions of OM muscles
- Houses pituitary gland
- Tentorium cerebelli
- **Headaches, vision, blood flow, ANS.**



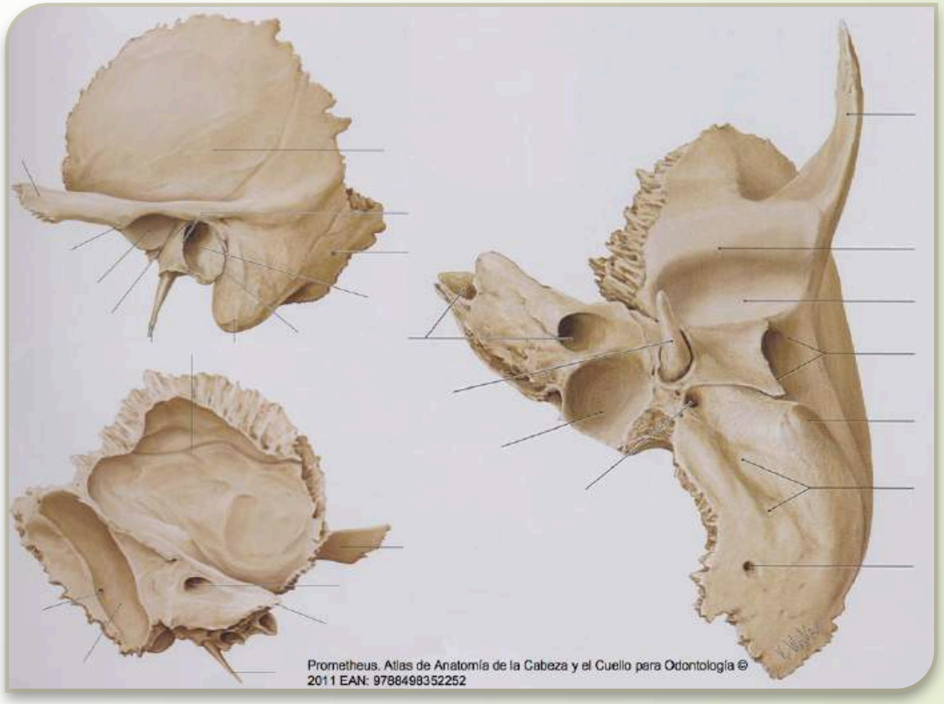
Oculomotor, Trochlear and Abducens Nerves: Schema

SEE ALSO PLATES 81, 126, 153



Anatomo-physiological relationships

- Temporal
- Vestibular apparatus, vestibularcochlear nerve, endolymphatic sac
- Carotid artery
- Jugular vein, IX, X, XI CN
- Tentorium cerebelli
- **Dizziness, balance, blood flow, head aches, neck pain, nausea.**



PROMETHEUS. ATLAS OF ANATOMY. 2011

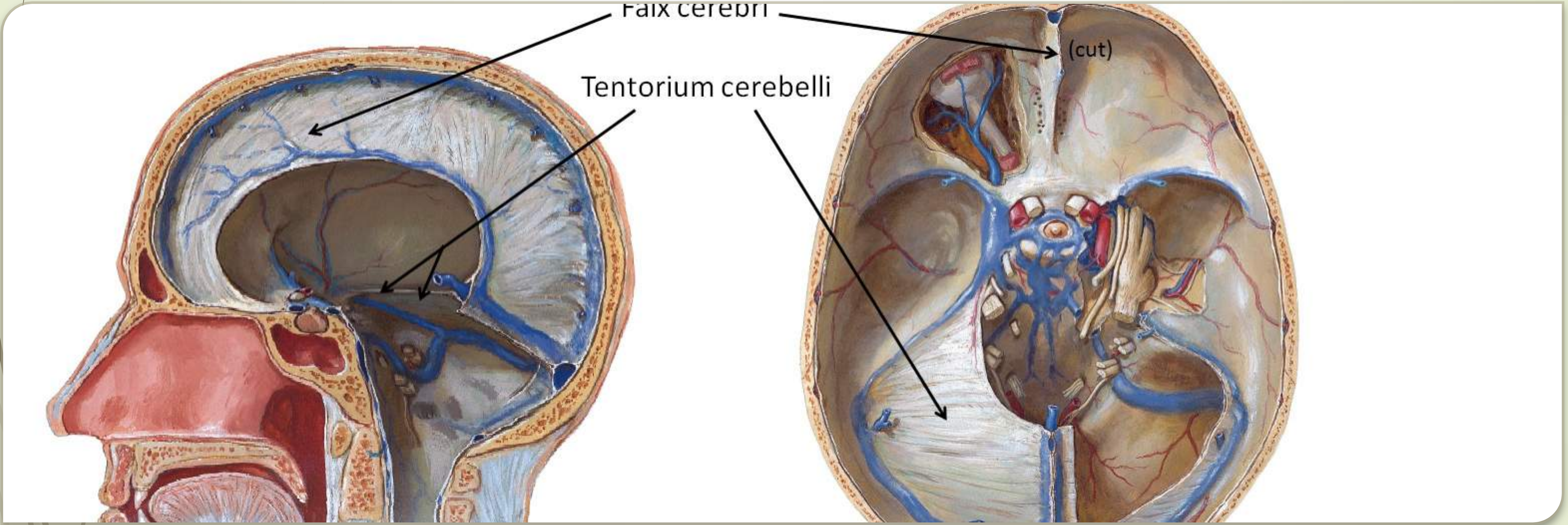
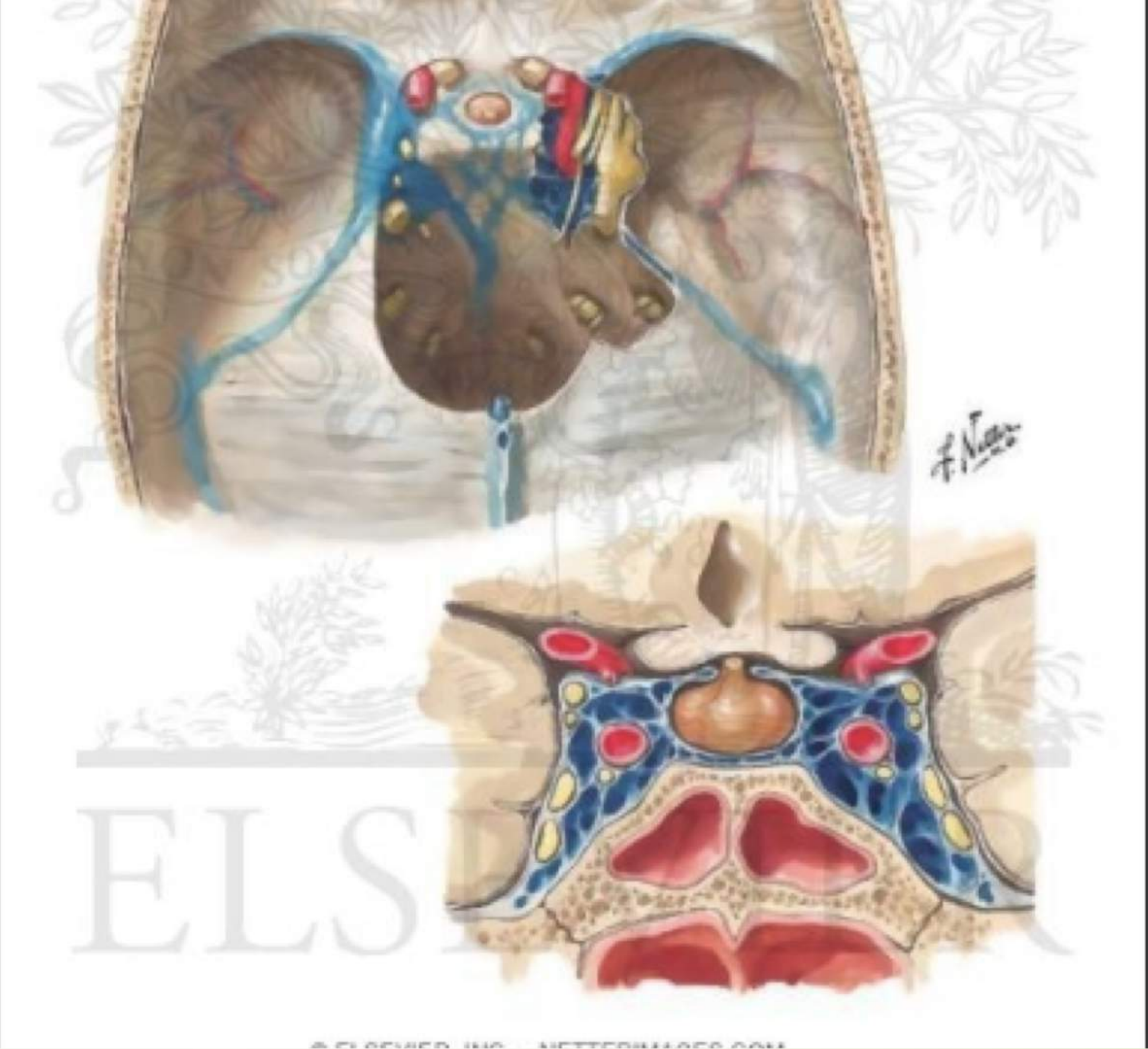
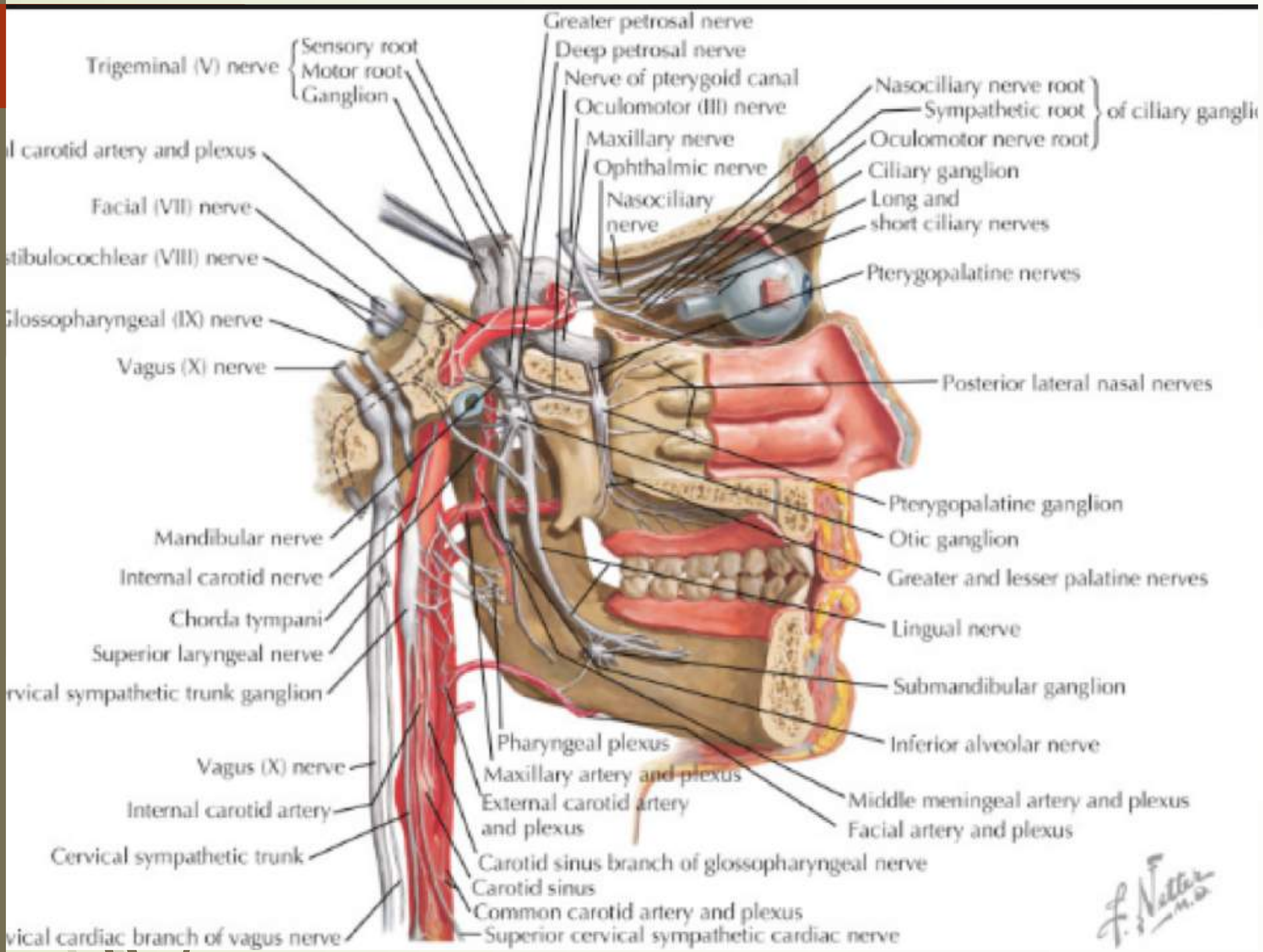


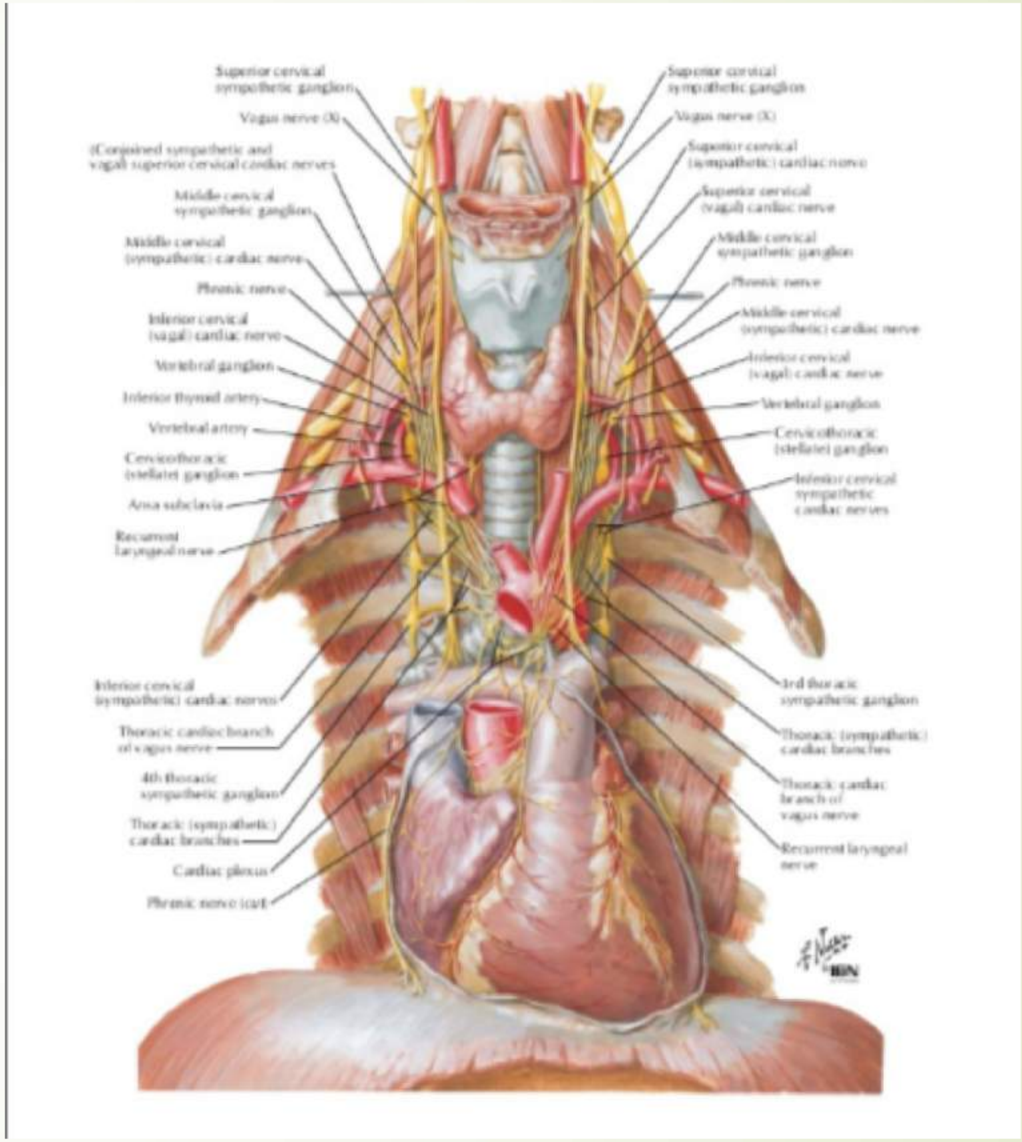
PLATE 97-98. DURAL VENOUS SYSTEM.
NETTER FH. ATLAS OF HUMAN ANATOMY. NEW JERSEY, NOVARTIS, 1997

Pituitary gland

- Role in controlling:
  - blood pressure
  - heart rate
  - thyroid gland
  - metabolism
  - body temperature
  - pain relief
  - thirst
  - fatigue
  - sleep circadian rhythms




Greater petrosal nerve
Deep petrosal nerve
Nerve of pterygoid canal
Oculomotor (III) nerve
Maxillary nerve
Ophthalmic nerve
Nasociliary nerve
Trigeminal (V) nerve
Sensory root
Motor root
Ganglion
l carotid artery and plexus
Facial (VII) nerve
stibulocochlear (VIII) nerve
Glossopharyngeal (IX) nerve
Vagus (X) nerve
Nasociliary nerve root
Sympathetic root
Oculomotor nerve root
of ciliary gangli
Ciliary ganglion
Long and short ciliary nerves
Pterygopalatine nerves
Posterior lateral nasal nerves
Pterygopalatine ganglion
Otic ganglion
Greater and lesser palatine nerves
Lingual nerve
Submandibular ganglion
Inferior alveolar nerve
Middle meningeal artery and plexus
Facial artery and plexus
Mandibular nerve
Internal carotid nerve
Chorda tympani
Superior laryngeal nerve
rvical sympathetic trunk ganglion
Pharyngeal plexus
Maxillary artery and plexus
External carotid artery and plexus
Vagus (X) nerve
Internal carotid artery
Cervical sympathetic trunk
Carotid sinus branch of glossopharyngeal nerve
Carotid sinus
Common carotid artery and plexus
vical cardiac branch of vagus nerve
Superior cervical sympathetic cardiac nerve


Superior cervical sympathetic ganglion
Vagus nerve (X)
(Combined sympathetic and vagal) superior cervical cardiac nerves
Middle cervical sympathetic ganglion
Middle cervical (sympathetic) cardiac nerve
Phrenic nerve
Inferior cervical (vagal) cardiac nerve
Vertebral ganglion
Inferior thyroid artery
Vertebral artery
Cervicothoracic (stellate) ganglion
Recurrent laryngeal nerve
Superior cervical sympathetic ganglion
Vagus nerve (X)
Superior cervical (sympathetic) cardiac nerve
Superior cervical (vagal) cardiac nerve
Middle cervical sympathetic ganglion
Phrenic nerve
Middle cervical (sympathetic) cardiac nerve
Inferior cervical (vagal) cardiac nerve
Vertebral ganglion
Cervicothoracic (stellate) ganglion
Inferior cervical sympathetic cardiac nerves
Inferior cervical (sympathetic) cardiac nerves
Thoracic cardiac branch of vagus nerve
4th thoracic sympathetic ganglion
Thoracic (sympathetic) cardiac branches
Cardiac plexus
3rd thoracic sympathetic ganglion
Thoracic (sympathetic) cardiac branches
Thoracic cardiac branch of vagus nerve
Recurrent laryngeal nerve

Levels of treatment

- Mobilizations / Structural
- Balanced ligamentous tension / membranous
- Fluidic / biodynamics

Demo

- Sutures
- Spheno-basilar synchondrosis
- Facial bones
- Cervical spine
- Pericardium and cardio-pulmonary plexus
- Diaphragm

Other therapies and their parallels

- Physical therapy
- Chiropractic care
- Massage therapy
- Acupuncture

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- Thank you!