TMJ, Chronic Pain and Neurological Disorders

International Pain Foundation
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- Fellow International College of Craniomandibular Orthopedics
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- Registered Polysomnographic Technologist
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• Pomona valley Medical Center Sleep Panel 2008-2014
• Kaiser Fontana Sleep Center 2014 - Present
• Project Scientist UCLA School of Dentistry, Department of Oral Biology and Medicine 2014-2018
• Published “Temporomandibular Joint and Airway Disorders, a Translational Perspective” Springer 2018
The TMJ is a hinge and gliding joint and is the most constantly used joint in the body.
TMJ - Temporomandibular Joint

- Ear Canal
- Lateral Pterygoid Muscle
- Articular Disk
- Head of Mandible
Normal Temporomandibular Joint relationship and Movement

Anterior Disc Displacement with Reduction
Posteriorized Condyle
Anterior Disc Displacement non-reducing

Degenerative Arthritis
Iceberg et al. described an arthrokinetic reflex in the muscles of mastication associated with disc displacements. Continuous muscle activity was provoked by disc displacements and ceased when the disc position was normalized on mouth opening, only to occur again every time the disc became displaced on mouth closure. These findings were in line with previously published on limb joints that indicated that joint derangements are a cause of muscle hyperactivity.
Arthokinetic Reflex

- The arthokinetic reflex causes the supporting muscular system to undergo protective spasm that can cause muscular pain. This component in conjunction with muscular hyperactivity has many times been misconstrued as myofascial pain dysfunction.


- When a muscle assumes the guarding of a strained ligament, it becomes tense and fatigues.


- Demerjian GG, Sims AB, Patel M, Balatgek TL, Sabal EB. Head and Neck Manifestations of Temporomandibular Joint Disorders. Temporomandibular Joint and Airway Disorders, A Translational Perspective. Springer 2018 Chapter 5, Pg 78.

- Chiappelli F, Barkhordarian A, Demerjian GG. Patient-Centered Outcomes Research and Collaborative Evidence-Based Medical and Dental Practice for Patients with Temporomandibular Joint Disorders. Temporomandibular Joint and Airway Disorders, A Translational Perspective. Springer 2018, Chapter 11, Pg 224.
Trigeminal Nerve

- Sensory root
- Motor root
- Auriculotemporal nerve

Diagram showing:
- Mandibular nerve (CN V²)
- Meningeal branch (nervus spinosus)
- Auriculotemporal nerve
- Parotid branch of auriculotemporal nerve
- Nerve to mylohyoid
- Lingual nerve
- Inferior alveolar nerve
- Masseter
- Nerves to temporalis
- Masseteric nerve
- Nerves to medial and lateral pterygoid
- Lateral pterygoid
- Buccal nerve
- Medial pterygoid
- Interior dental nerves
- Mental nerve
TMD Symptoms

**EARS**
1. Hissing, buzzing or ringing
2. Decreased hearing
3. Ear pain, ear ache, no infection
4. Clogged, "itchy" ears
5. Vertigo, dizziness

**JAW**
1. Clicking, popping jaw joints
2. Grating sounds
3. Pain in cheek muscles
4. Uncontrollable jaw and/or tongue movements

**NECK**
1. Lack of mobility, stiffness
2. Neck pain
3. Tired, sore muscles
4. Shoulder aches and backaches
5. Arm and finger numbness and/or pain

**THROAT**
1. Difficulty swallowing
2. Laryngitis
3. Sore throat with no infection
4. Voice irregularities or changes
5. Frequent coughing or constant clearing of throat
6. Feeling of foreign object in throat constantly

**HEAD PAIN, HEADACHE**
1. Forehead
2. Temples
3. "Migraine" type
4. Sinus type
5. Shooting pain up back of head
6. Hair and/or scalp painful to touch

**EYES**
1. Pain behind eyes
2. Bloodshot eyes
3. May bulge out
4. Sensitive to sunlight

**MOUTH & TEETH**
1. Discomfort
2. Limited opening of mouth
3. Inability to open smoothly
4. Jaw deviates to one side when opening
5. Locks shut or open
6. Can't find bite
7. Clenching, grinding teeth at night
8. Looseness and soreness of back teeth
Auriculotemporal Nerve

Peripheral Sensitization
• Compression of the AT nerve may result in a focal neuroinflammation.
• Neuroinflammation spreads from the site of nerve entrapment to the trigeminal ganglion via the mandibular nerve, then to the spinal trigeminal nucleus, as well as the reticular formation of the brainstem.
• Neuroinflammation in the brainstem centers could act as physiological drivers of aberrant reflexive behaviors, as well as supra brainstem changes within the nervous system.
Central Sensitization

• Central sensitization is a condition of the nervous system that is associated with the development and maintenance of chronic pain. When central sensitization occurs, the nervous system goes through a process called wind-up and gets regulated in a persistent state of high reactivity. This persistent or regulated, state of reactivity lowers the threshold for what causes pain and subsequently comes to maintain pain even after the initial injury might have healed.

• Pain
• CNS Changes
Central Sensitization

- exaggerated response of the CNS
- changes following tissue injury and/or nerve damage
- increase in noxious stimulation
- sensory input from a site of peripheral trauma into the CNS
Blepharospasm

CBCT of TMJ

MRI of TMJ
Cervical dystonia
Non-invasive orthopedic treatment
Symptoms of Comorbid Conditions clinically effected by orthopedic TMJ treatment

• Spasmodic Torticollis/Cervical Dystonia
• Parkinson’s Disease (Balance, Gait, Posture)
• Tourette's
• Blepharospasm
• Strabismus
• Functional Tremor

• Complex Regional Pain Syndrome/Reflex Sympathetic Dystrophy
• Fibromyalgia
• Multiple Sclerosis
• Trigeminal Neuralgia
• Hemi-facial Spasm
• Chiari Malformation
Biomarkers and local responses to Temporomandibular Joint Disorders and Related Neurological Pathologies

International Pain Foundation
UCLA, November 16, 2019
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Cranial Nerves
## Nerve Fibers

### Motor fiber types

<table>
<thead>
<tr>
<th>Type</th>
<th>Erlanger-Gasser Classification</th>
<th>Diameter (μm)</th>
<th>Myelin</th>
<th>Conduction velocity (m/s)</th>
<th>Associated muscle fibers</th>
</tr>
</thead>
<tbody>
<tr>
<td>α</td>
<td>Aα</td>
<td>13–20</td>
<td>Yes</td>
<td>80–120</td>
<td>Extrafusal muscle fibers</td>
</tr>
<tr>
<td>γ</td>
<td>Aγ</td>
<td>5–8</td>
<td>Yes</td>
<td>4–24 [2][3]</td>
<td>Intrafusal muscle fibers</td>
</tr>
</tbody>
</table>

### Sensory fiber types

<table>
<thead>
<tr>
<th>Type</th>
<th>Erlanger-Gasser Classification</th>
<th>Diameter (μm)</th>
<th>Myelin</th>
<th>Conduction velocity (m/s)</th>
<th>Associated sensory receptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ib</td>
<td>Aα</td>
<td>13–20</td>
<td>Yes</td>
<td>80–120</td>
<td>Golgi tendon organ</td>
</tr>
</tbody>
</table>
| II   | Aβ                              | 6–12         | Yes    | 33–75                     | Secondary receptors of muscle spindle  
                      |                   |            |                   | All cutaneous mecanoreceptors  
                      |                   |            |                   | Some Nociceptors [5]          |
| III  | Aδ                              | 1–5          | Thin   | 3–30                      | Free nerve endings of touch and pressure  
                      |                   |            |                   | Nociceptors of neospinothalamic tract  
                      |                   |            |                   | Cold thermoreceptors          |
| IV   | C                               | 0.2–1.5      | No     | 0.5–2.0                   | Nociceptors of paleospinothalamic tract  
                      |                   |            |                   | Warmth receptors               |

### Diagram of Primary Afferent Axons

- **Axon Type**
  - Diameter (μm)
    - Aα: 13–20
    - Aβ: 6–12
    - Aδ: 1–5
    - C: 0.2–1.5
  - Speed (m/s)
    - Aα: 80–120
    - Aβ: 35–75
    - Aδ: 3–30
    - C: 0.5–2.0

- **Function**
  - Aα fiber: Responsible for proprioception
  - Aβ fiber: Secondary receptors of muscle spindle
  - Aδ fiber: All cutaneous mecanoreceptors
  - C fiber: Free nerve endings of touch and pressure

- **Subjective pain intensity**
  - First pain
  - Second pain

- **Receptors**
  - Nociceptors of neospinothalamic tract
  - Cold thermoreceptors
  - Nociceptors of paleospinothalamic tract
  - Warmth receptors
Sensory receptors are classified into five categories: mechanoreceptors, thermoreceptors, proprioceptors, pain receptors, and chemoreceptors.

Somatosensory receptors of the oral tissues are generally divided into mechanoreceptors, nociceptors, and thermoreceptors.

- There are four principal types of mechanoreceptors:
  - Meissner corpuscles, rapidly adapting type I, respond to light touch and adapt rapidly to changes in texture.
  - Ruffini endings, slowly adapting type II, detect tension deep in the skin and fascia.
  - Merkel discs, slowly adapting type I, detect sustained pressure.
  - Pacinian corpuscles, rapidly adapting type II, in the skin and fascia detect rapid vibrations.

Proprioceptors:
- Muscle Spindles: mechanoreceptors between muscle fibers
- Golgi Tendon Organs: mechanoreceptor

- Free nerve endings detect temperature, mechanical stimuli (touch, pressure, stretch), or nociception (polymodal receptors)
- Most A-delta and C fibers end as free nerve endings.
Trigeminal Nerve
CAVERNOUS SINUS  Superior orbital fissure  ORBIT  EYE

Ophthalmic n.:  Nasociliary n.  Long ciliary nerves  Sympathetic fibers  Sensory fibers  Parasympathetic fibers

Carotid plexus  Sensory root  Ciliary ganglion  Short ciliary nerves  Motor root

Oculomotor n.:  Inferior division

mandibular nerve
Inferior alveolar nerve
Auriculo-temporal nerve
Lingual nerve
Posterior auricular nerve
Nerve to stylohyoid
Parotid gland
Mandibular
Cervical
Trigeminal Pathway for Touch & Pressure
Trigeminal Pathway for Pain & Temperature
Branchiomotor Innervation Trigeminal Nerve

- Muscles of mastication
- Mylohyoid
- Anterior belly of digastric
- Tensor tympani
- Tensor veli palatini
Neuropeptides

Nociceptive fibers

SP

CGRP

Tachykinin family

SP

Strong vasodilatory effect in joints and muscles, increases blood flow

In contrast to SP it does not increase permeability. It is assumed to participate in pain perception.

Macrophages, B lymphocytes, PMN cells, Leukocytes, Synoviocytes

Activates

IL-1

Main cause of neurogenic inflammation
Regulation and Function of inflammatory TH Cells

PAMPs

DAMPs

TH9

The Signaling and Transcriptional Regulation of Th17 Polarization

Muranski P, Restifo N. Essentials of Th17 cell commitment and plasticity. BLOOD, 28 MARCH 2013 Vol. 121, No. 13
Osteoblasts

- Mononucleated cells derived from terminally differentiated MSCs
- Line surface of the bone and produce osteoid
- Become bone cells or osteocytes
Osteoclasts

- Derived from hematopoietic stem cells (myeloid-monocyte and macrophage precursor cells)
- Multinucleated cells responsible for bone resorption
- Release lysosomes, organic acids and hydrolytic enzymes and break down bone matrix
- Two parts: ruffled border, clear zone
RANK, RANKL and OPG

At Molecular Level

Osteoclastogenesis and bone destruction

DAMPs

Blood vessel

Synovial macrophage

Inflammatory cytokines such as TNF, IL-1 and IL-6

Increased RANKL

Synovial fibroblast

Synovial T cell (T<sub>H17</sub> cell)

Osteoclast

Osteoclast precursor cell

IL-17

SP
- MPRAGE.

- Resting state network was studied using BOLD. Scans were then post processed on a 3D workstation and the (ICA) was performed separating out the various networks.

- Arterial Spin Labeling.

- Tractography and fractional anisotropy.
Cervical Dystonia
Tourettes
Hemi-facial spasm
Thank you