

Movement-Based Examination and Treatment of Temporomandibular Joint Disorder

Combined Sections Meeting 2017



Mary Kate McDonnell PT, DPT, OCS
Vanessa M Lanier PT, DPT, OCS
Jesse Civello PT, DPT



Session Learning Objectives

1. Describe altered movement patterns of the Temporomandibular joint (TMJ).
2. Describe impairments of alignment & movement of the thoracic, neck and shoulder girdle, when corrected, result in improved TMJ function.
3. Discuss the rationale for movement based treatment of the TMJ and adjacent regions.
4. Describe a movement based examination of the neck, shoulder and TMJ.
5. Describe movement based treatment strategies for management of patients with Temporomandibular Disorder (TMD).

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Disclosure

- The speakers do not have any relevant financial disclosures

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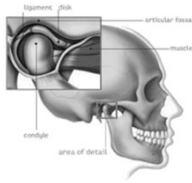
Today

- Present key concepts related to movement based examination and treatment of Temporomandibular Disease (TMD)
- Provide specifics regarding our exam of the Temporomandibular Joint (TMJ) and the Adjacent Regions.
- Provide two Case Studies that illustrate the application of the concepts related to movement based examination and treatment.

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Temporomandibular Disease

- Temporomandibular Disease (TMD) is a collective term, which describes clinical problems that involve the function of the masticatory muscles and the jaw joint.



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Temporomandibular Disease

Lack of consensus regarding etiology, diagnosis & management of TMD.

Various types of physical therapy treatments have shown to be effective especially with focus on posture, active exercise and manual therapy.

List T 2010, Armijo-Olivo 2016, Medcott 2006

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Temporomandibular Disease (TMD)

TMD is a public health problem and a main source of chronic orofacial pain that interferes with daily activities.

Gremillion HA 2000

TMD is commonly associated with symptoms in the head and neck region including headaches, ear and neck pain.

Gremillion HA, 2000, deWijer A, 1996

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Temporomandibular Disease (TMD)

Recent systematic review in PTJ regarding effectiveness of manual therapy (MT) & exercise reported poor quality of evidence. Uncertainty of the effectiveness of exercise and MT with TMD.

Armijo-Olivo S et al. PTJ. Jan 2016

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- Our focus in managing patients with TMD has an emphasis on addressing patient specific movement impairments at the TMJ along with alignment and movement impairments of the upper quarter.
- Create an exercise / functional activity program based on our assessment of the patient specific impairments.

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Muscle Considerations for TMJ function

Typical patient

- **Complaints of pain in the TMJ, facial region, headaches and neck pain.**
- **Complaints of pain and/or clicking popping with eating, speaking and mouth opening.**
- **Limited mouth opening**
- **Associated poor posture including:**
 - Forward head position
 - Forward shoulders
 - Thoracic kyphosis
 - Scapulae that are abducted and / or depressed
- **Typically younger – teens and older adults**

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Muscle Considerations for TMJ function

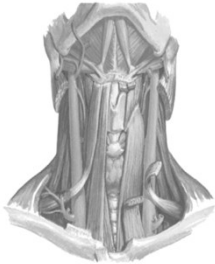
Key Muscles

- **Opening**
 - Suprahyoid
 - Infrahyoid
 - Lateral Pterygoid
- **Closing**
 - Masseter
 - Temporalis

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Muscle Considerations for TMJ function
Suprahyoid Muscles

Infrahyoid and Suprahyoid Muscles



Novartis 1997

Mylohyoid
Geniohyoid
Stylohyoid
Digastric

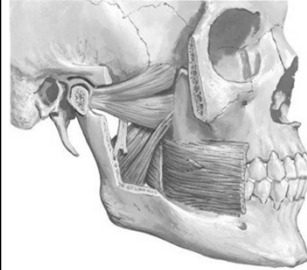
Attaches from mandible to hyoid

Depress and Retract the Mandible with mouth opening.



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Muscle Considerations for TMJ function
Lateral Pterygoid



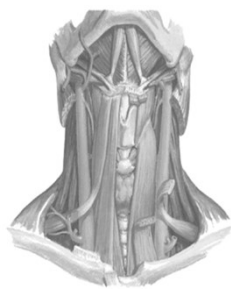
Netter

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Attachments:

superior & inferior heads: from sphenoid bone and pterygoid plate **traveling horizontally to the neck of mandible, articular capsule and disk of the TMJ**

Muscle Considerations for TMJ function
Infrahyoid Muscles



Novartis 1997



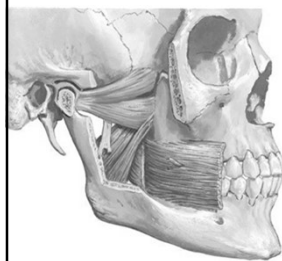
Sternohyoid
Sternothyroid
Thyrohyoid
Omohyoid

• **Attaches from sternum, clavicle, & scapula to the hyoid**

Depress and Retract the Hyoid with mouth opening.

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Muscle Considerations for TMJ function -
Lateral Pterygoid



Netter

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Mouth Opening - anterior translation of condyle of the mandible

Controls backward gliding of disk and condyle during closing

Ipsilateral deviation of mandible if acting with temporalis

Contralateral deviation of mandible if acting with medial pterygoid

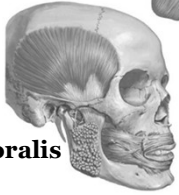
Muscle Considerations for TMJ function
Masseter and Temporalis

Masseter



Elevates mandible with Closing

Lateral deviation of the mandible



Temporalis

Trigger Points common with clenching/ grinding

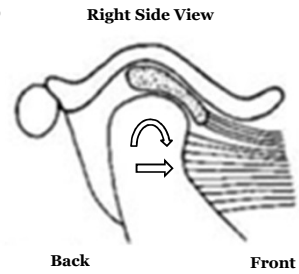
Stiff/ Short? Contribute to limited opening?

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Normal Mandible Depression / Mouth Opening

- **Early phase** – 1st 35% - 50% of rom, involves **primarily rotation [rolling]** of the condyle. The mandible moves inferiorly and posteriorly during this phase.
- **Late phase** – final 50% - 65% of the total range of motion, transition of primary rotation to **primary translation**. Can be palpated at the condyles.

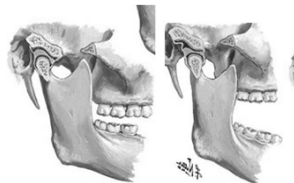


Neumann DA. 2010

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Muscle Considerations Mouth Opening –
 Mandible Depression

- **Suprahyoid and Infrahyoid muscles**
Mandible depression and retraction
- **Lateral Pterygoid muscle**
Anterior translation



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Palpation of condyle movement



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Normal Mandible Depression / Mouth Opening

- **Early phase** – 1st 35% - 50% of rom, involves **primarily rotation [rolling]** of the condyle. The mandible moves inferiorly and posteriorly during this phase.
- **Late phase** – final 50% - 65% of the total range of motion, transition of primary rotation to **primary translation**. Can be palpated at the condyles.



Neumann DA. 2010

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Specific Movement Impairment of the TMJ - Translation

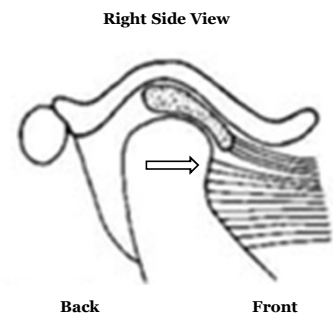
Two Components of Normal Movement of Mandibular Depression – Mouth Opening

- **Condylar Rotation**
 - Condylar movement about a frontal axis – sagittal rotation of the condyle
 - Primary muscles responsible for rotation of condyle = **supra & infra hyoid muscles**
- **Condylar Translation**
 - Forward translation of the condyle.
 - Primary muscles responsible for translation = **lateral pterygoid**

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Movement Impairment of the TMJ Translation

- **Greater motion of anterior TRANSLATION of the condyle than anterior sagittal rotation of the condyle.**
- **Early Translation, lack of condylar rotation**



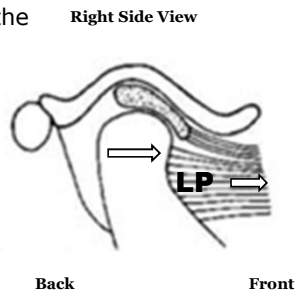
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Movement Impairment of the TMJ Translation

INCREASE & early recruitment of the **Lateral Pterygoid (LP)**

and

INSUFFICIENT recruitment of the mandible depressors – **Supra and Infra Hyoid muscles.**

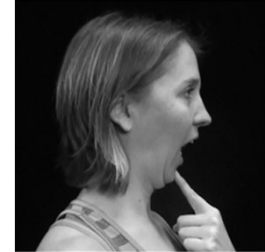


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Preferred – Early condylar translation.

Limited opening, clicking, pain



Corrected with mandible retraction > early condylar rotation & delayed translation

Less pain & clicking

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Dx: TMJ Anterior Translation Preferred Pattern



Preferred – Early condylar translation.

Limited opening, clicking, pain

Corrected Pattern with Mandible Retraction



Corrected with mandible retraction > early condylar rotation & delayed translation

Less pain & clicking

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MOVEMENT IMPAIRMENT OF THE TMJ Associated movement impairments

- Upper cervical extension during mouth opening
 - Neck pain & headaches

- Correction – “do not lift nose during mouth opening”



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TMD – Consideration of Adjacent Regions

Considerations of adjacent regions – cervical spine, thoracic spine and scapulae are critical when managing TMD.

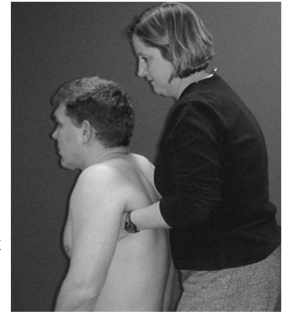
TMD commonly associated with cervical spine disorders and cervical impairments. *La Touche R 2009*

Weakness and reduced endurance of the cervical flexor muscles in pts with TMD. *Armijo-Olivo, 2010*

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Effect of Adjacent Regions - Cervical

- Effect of shoulder alignment & weight of the upper extremities on neck function.
- Passively elevating the shoulder girdle & supporting the weight of the upper extremities results in improved neck rom & decrease pain.
- Mechanism - decreasing compressive loads on the neck by unloading the weight of the extremities through the attachments of the cervicoscapular muscles.



VanDillen 2007, Ha 2011

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Effect of poor posture on TMJ Rom and pain > patient with increase thoracic kyphosis, scapulae abducted and forward head position

Opening with poor posture = **30 mm and pain**



↑ Poor Posture

Corrected posture = **37 mm and decrease pain**



TMJ opening AROM
normal opening = 45 -55 mm

Corrected Posture ⇨

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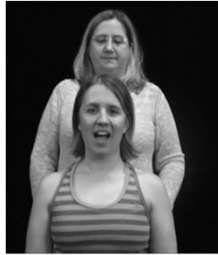
Effect of Adjacent Regions - TMJ

- Pilot work demonstrating effect of shoulder girdle alignment & the weight of the extremities on TMJ function.
- Passively elevating & supporting the shoulder girdle improves TMJ Range of Motion (ROM) and decreases pain.
 - Muscles attaching to clavicle, scapula and neck to the mandible may have a similar effect of decompression on the TMJ.

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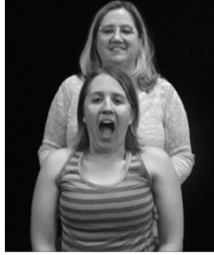
Mouth Opening with Passive Scapular Elevation

Preferred Posture



Limited & painful opening

Passive Elevation



Increased rom & decrease pain

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Treatment Considerations for TMD

Effect of Adjacent Regions

- Findings from elevated shoulder girdle test directs treatment
- Treatment will include support of the upper extremities & correction of thoracic / scapulae alignment during exercises and functional activities.

*McDonnell MK 2005
Sahrmann SA 2011*



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Treatment of TMJ Movement Impairment

- First address trunk, scapulae and cervical **alignment and movement impairments**

Then

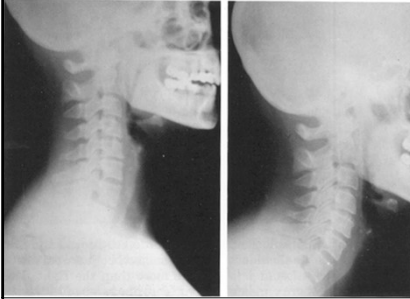
- Improve function of mandible depressors to **restore early condyle rotation** – partial opening with **RETRACTION** of the mandible towards front of neck

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Treatment > Start with Alignment

Good alignment

Effect of slumping



Correction of the Forward head posture allows improved tmj alignment and recruitment of anterior muscles in the correct length.

Olmos SR 2005
Uritani D 2014

Kendall

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Tongue in roof of mouth, open by pulling chin towards adam's apple > no clicking or popping



Hand assist for ***opening with mandible retraction***
> improve anterior condylar rotation
> early phase of movement

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Key Exercises to address adjacent regions & TMJ movement impairment



- Correct alignment – Lumbar, thoracic, scapulae & neck
- Perform limited opening with correct strategy
- Tongue in roof of mouth, open by pulling chin towards adam's apple > retract mandible > limited opening

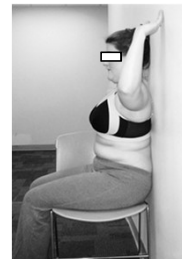
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Patient Specific Exercises to address adjacent regions



Capital flexion – stretch posterior neck structures & engage deep neck flexors



Forward shoulders – short pectoral muscles

Depressed scapulae – scapulae elevation - shrugs



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• **If unable to do in sitting can do all exercises in supine**

↑ **Capital Flexion**

Decrease EMG activity of Lateral Pterygoid in supine

↓ **Shoulder flexion**

↑ **Limited opening with retraction**

Significant change in ROM

- Opening ROM before treatment = 39.03mm±8.66
- Follow up = 42.04mm±6.22 (alpha=.01, mean diff 3.01mm. 95% CI 1.47 to 4.55)

Subset of 16 pts with joint signs reported no clicking or clicking that came on later in the range

- Initial rom before clicking = 29.12mm±10.70
- Follow up = 39.94mm±6.65 (alpha=.001, mean diff 10.82mm. 95% CI 8.90 to 12.74)

All patients reported a reduction in pain, 42% were pain free at follow-up & 50% of pts with joint signs reported no clicking or popping on follow-up.

A patient performed exercise program of precise jaw movements and instruction of proper alignment of the head, neck, shoulder girdle and trunk **may provide a low cost effective option for TMD management.**

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McDonnell MK, Kinney M, Sahrman SA, Fink D. A Movement System Approach to TMD.

McDonnell MK et al, Craniofacial Research 2008.

A retrospective analysis of clinical records on patients with TMJ pain and signs of joint disturbances (clicking/popping)

26 patients w/ TMD (25 F, 1 M) Mean age 31.88±17.49 yrs

Patients received 4±2.46 PT treatments over the course of 1.5 mnths

Treatment – home exercise program of specific exercises aimed at restoring correct movement patterns of the TMJ and proper alignment of the jaw, head, neck, shoulder girdle and trunk

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SUMMARY

- Evaluation and Treatment for TMD should include:
 - CONSIDERATION OF THE SPECIFIC MOVEMENT IMPAIRMENT OF THE TMJ
 - CONSIDERATION OF THE EFFECT OF ADJACENT REGIONS – Cervical, Thoracic, Scapulae & Lumbar
- Next
 - Description of our Examination
 - Two Case Studies

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- Acknowledgements
- Dr. Debra Fink – orthodontist
- Colleagues at Washington University in St. Louis
- Dr. Shirley Sahrmann PT, Phd, FAPTA
- Dr. Linda Vandillen PT, Phd, FAPTA

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**Washington University
Program in Physical Therapy Opportunities:**

- **PhD in Movement Science**
- **Movement System Clinical Fellowship**
- **Clinical Residency in Women's Health**
- **Movement System Impairment
Syndromes Courses**

Contact: jennifer.brown@wustl.edu
Visit Booth # 936

Movement-Based Treatment of Temporomandibular Joint Disorder: Case Example

Vanessa Lanier, PT, DPT, OCS

Washington University in St. Louis
SCHOOL OF MEDICINE

Patient – Chief Complaint

- **Age:** 44
- **Gender:** Female
- **Chief Complaint:**
 - TMJ pain, popping, clicking
 - Headache
 - Neck pain
 - Pain in the past week – Best 3/10, Worst 8/10, Average 6/10
- **History:**
 - Initial onset at age 22 after braces (>20 years)
 - Initially pain, progressing to popping, clicking
 - Neck pain – posterior, suboccipital
 - Headache 2x/week, Posterior, L ear, L side of face

Washington University in St. Louis School of Medicine

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Patient – History

- **Medications:** Naproxen/Ibuprofen every other day
- **Diagnostic test/results:** none
- **Previous treatment:** Custom night splint
- **Work activities:** Veterinary technician – lifting animals
- **Recreational activities:** Prior to increased pain – cycling and weight lifting 4x/week.

Washington University in St. Louis School of Medicine

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Patient – Chief Complaint

- **Activities/positions increase symptoms**
 - Eating – hard or chewy foods
 - Dental care
 - Yawning
 - Driving to various job sites
 - Lifting animal cages
- **Activities/positions that decrease symptoms**
 - Rest
 - Medication
 - Soft tissue massage

Washington University in St. Louis School of Medicine

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Initial Examination – Alignment

- **Alignment**
 - Forward head, increased flexion at C-T junction, upper cervical extension
 - Thoracic kyphosis
 - Depressed, internally rotated scapulae

Initial Examination – TMJ Range of Motion

	ROM	Pain/Location	Faulty Movement
Mouth Opening	50mm	L TMJ	Excessive anterior translation L>R R deviation

Initial Examination – TMJ Range of Motion

	Movement	Pain/Location
Protrusion	R deviation	L TMJ
Lateral deviation R	R>L	No pain
Lateral deviation L	R>L	L TMJ

Initial Examination – Key Tests/Findings

- **Cervical ROM**
 - Pain with extension and R rotation
 - Excessive anterior translation with cervical flexion and rotation
- **Cervical – Passive shoulder girdle elevation**
 - Improved ROM/pain with elevation
- **Shoulder flexion**
 - Insufficient scapular elevation and external rotation

Initial Examination – Length Tests

- Pectoralis Minor
 - Short/stiff
- Sternal Pectoralis Major
 - Short/stiff
- Latissimus Dorsi
 - Short/stiff

Movement Impairments

- **TMJ:** Translation
- **Cervical:** Extension/Forward Head
- **Scapular:** Depression, Internal Rotation
- **Thoracic:** Flexion/Kyphosis

Functional Activities

- Driving
- Lifting Animal Cages
- Yawning
- Dental Care
- Eating
- Exercise – Bicycling and Weight Lifting

TREATMENT

EXERCISE

Alignment Cues

Lumbar/Thoracic Spine	Contract abdominals Lift sternum without arching low back
Scapular Depression and Internal Rotation	Lift shoulder blades UP and Back
Cervical Extension/Rotation	Roll your chin down and gaze at top of knees



MOUTH OPENING: Tongue to the roof your mouth. Open your mouth, pulling your chin back toward your Adam's apple. Use your finger to help guide the movement.

Alignment Cues

Lumbar/Thoracic spine	Contract abdominals Lift sternum without arching low back
Cervical Extension/Rotation	Roll your chin down and gaze at top of knees
TMJ	Tongue to the roof of the mouth, lips together, teeth slightly apart.



SHOULDER ABDUCTION/LR: Start with arms raised to 90 degrees, forearms facing each other. Bring arms apart by squeezing your shoulder blades UP and back

Alignment Cues

Lumbar/Thoracic spine	Contract abdominals Lift sternum without arching low back
Cervical Extension/Rotation	Roll your chin down and gaze forward
TMJ	Tongue to the roof of the mouth, lips together, teeth slightly apart



WALL SLIDES: Slide your arms up the wall, shrugging your shoulder blades toward the ceiling when your arms reach shoulder level

FUNCTION

Standing Posture



Alignment Cues	
Lumbar/thoracic spine	Tighten abdominals and lift your sternum slightly
Scapulae	Lift shoulder blades UP and back
Cervical Extension/Forward Head	Lengthen the back of your neck Roll your chin downward and gaze straight ahead
TMJ	Tongue to the roof of the mouth, lips together, teeth slightly apart

Driving



Taping



Visit 2

- Pain
 - Visit 1 – average 6/10, best 3/10
 - Visit 2 – average 2/10, best 0/10 while taped
- Function
 - Dentist's visit
 - No headaches after driving

Lifting



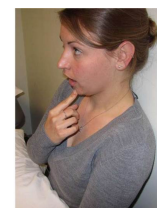
Preferred



Corrected

EXERCISE PROGRESSION

Mouth Opening



Visit 1	Visit 2	Visit 3	Visit 4	Visit 5
Hooklying	Hooklying	Sitting/Standing	Sitting/Standing	Sitting/Standing

Shoulder Abduction/LR



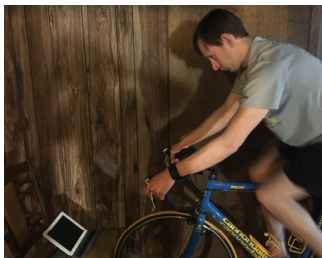
Visit 1	Visit 2	Visit 3	Visit 4	Visit 5
Hooklying	Hooklying, slide arms overhead	Standing	Standing, Yellow TB	Standing, Green TB

Wall Slides

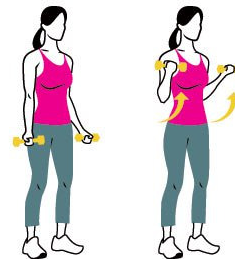


Visit 1	Visit 2	Visit 3	Visit 4	Visit 5
Standing	Standing, Yellow TB	Standing, Green TB	Standing, Green TB	Standing, Green TB

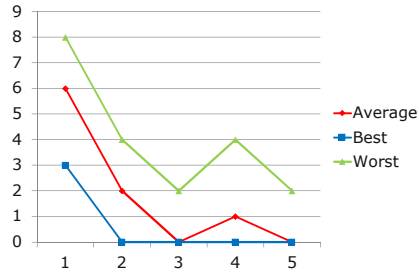
Functional Activities – Cycling



Functional Activities – Weight Lifting



Outcomes - Pain



Outcomes – TMJ ROM

	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5
Opening	50mm pain				45mm no pain
Protrusion	R translation pain				No translation no pain
R deviation	R>L				R=L
L deviation	R>L pain				R=L no pain

Outcomes – Function

- No pain with lifting animals/cages at work
- No pain with driving
- No pain with eating or yawning
- 8 headaches/month → 1 headache in 6 weeks of treatment
- Returned to weight lifting, cycling

Key Concepts

- Improve TMJ rolling/retraction in the early phase of mouth opening
- Address adjacent regions with all exercise and functional activities
 - Lumbar/thoracic spine
 - Scapulae
 - Cervical Spine
- Taping → correction of scapulae and reduction in TMJ symptoms

Movement-Based Treatment of Temporomandibular Joint Disorder: Case Example #2

Jesse Civallo, PT, DPT



Patient – History

- **Age:** 18
- **Gender:** Female
- **Medications:** None
- **Diagnostic test/results:** none
- **Previous treatment:** Custom night splint
- **Work activities:** High school senior
- **Recreational activities:** Field hockey and cello. Not continuing in college.



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Patient – Chief Complaint

- **Chief Complaint:**
 - Bilateral TMJ pain, popping, clicking, and locking
 - Pain at rest and worsened with movement
 - Best: 1/10
 - Worst: 8/10
 - TMD Disability Index: 35/40
 - Headache
 - Neck pain
 - Shoulder pain
- **History:**
 - 1-year history of jaw pain
 - Pain is worse with stress, studying, and exams
 - Pain is constant
 - Grinding/clenching



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Patient – Chief Complaint

- **Aggravating Factors**
 - Talking
 - Eating
 - Stress
 - Yawning
 - Sleeping on stomach
 - Wearing backpack
- **Relieving Factors**
 - Soft tissue massage



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Initial Examination – Alignment

- Forward head
- Depressed scapulae
- Scapular internal rotation and anterior tilt
- Kyphosis / depressed chest



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Initial Examination – Key Tests/Findings

- **Movement**
 - Bilateral Shoulder Flexion
 - Scapular internal rotation
 - Insufficient scapular elevation
 - Thoracic flexion with posterior sway



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Initial Examination – Key Tests/Findings

Movement

- Cervical AROM
 - Pain with extension
- Passive shoulder girdle elevation
 - Sxs abolished during cervical extension

Initial Examination – TMJ Range of Motion

	ROM	Pain/Location	Faulty Movement
Opening with preferred alignment	30mm	Pain and popping bilaterally	Early condyle translation
Opening with correction of movement pattern	30mm	No pain/popping	
Passive Elevation of Shoulder Girdle	35mm	No pain/popping	

Initial Examination – Length Tests

Muscle Length

- Short/stiff:
 - Pec minor
 - Latissimus
 - Scapulohumeral muscles
 - Suboccipitals

Sahrmann, SA 2011

Strength

- Intrinsic Cervical Flexors: 3-/5, anterior translation

Jull, G 1999

Movement Impairments

- **TMJ:** Translation and Hypomobility
- **Cervical:** Extension
- **Scapular:** Depression, Anterior Tilt
- **Thoracic:** Flexion

Movement Impairments: Cues

Movement Impairments	Cue
TMJ Translation	Open your mouth drawing your chin back toward your Adam's apple Rest tongue on top of mouth
Cervical Extension	Roll your chin downward
Scapular Depression and Anterior Tilt	Lift your shoulder blades up and back

TREATMENT

Treatment Goals

- Improve mouth opening mechanics
- Improve resting alignment of cervical spine and scapulae
- Improve movement pattern with cervical and shoulder movement

EDUCATION

Treatment – Patient Education

- Pain relief
 - Support arms when possible
 - Decrease cervical extension/forward head with resting posture



FUNCTION

Studying / Classroom Sitting



- Support arms when possible with shoulders resting **up** and back
- Keep chin level
- Practice gazing eyes from desk to white board without forward head alignment
- "Check in" and relax jaw muscles, consider doing 3-5 reps of mouth opening exercise

Standing Posture



- Slightly lift sternum
- Bring shoulder blades **up** and back
- Roll chin downward / level with the ground
- Tongue on roof of mouth, jaw relaxed

Sleeping



- Pillow under axilla to prevent scapular depression
- Small towel roll under neck
- Decreased forward head in resting alignment

EXERCISE

Alignment Cues

Scapulae	Lift shoulder blades up and back without arching low back
Cervical Spine	Roll your chin downward, may feel slight stretch in back of neck but no pain



Alignment Cues

Lumbar/thoracic spine	Tighten abdominals and lift your sternum slightly
Scapulae	Bring shoulders slightly up and back
TMJ	Keep jaw relaxed and tongue on roof of mouth



Hooklying. Tongue resting on roof your mouth. Roll your chin downward until you feel a stretch in back of neck, but not pain.

Alignment Cues

Lumbar/thoracic spine	Tighten abdominals and lift your sternum slightly
Scapulae	Bring shoulders slightly up and back
TMJ	Keep jaw relaxed and tongue on roof of mouth



Hooklying. Tongue resting on roof your mouth. Bring arms overhead keeping elbows turned forward (lateral rotation). Elevate scapulae throughout movement.

Alignment Cues

Lumbar/thoracic spine	Lift your sternum slightly and prevent sway
Cervical spine	Roll your chin downward and gaze straight ahead
TMJ	Tongue to the roof of the mouth, jaw relaxed



Slide your arms up the wall, shrugging your shoulder blades toward the ceiling when your arms reach shoulder level

EXERCISE PROGRESSION

Alignment Cues

Scapulae	Lift shoulder blades up and back without arching low back
Cervical Spine	Roll your chin downward, may feel slight stretch in back of neck but no pain



Sitting with back to the wall. Tongue resting on roof your mouth. Open your mouth by pulling your chin back toward your Adam's apple. Use your finger to help guide the movement. Pain-free range of motion only.

Alignment Cues

Lumbar/thoracic spine	Tighten abdominals and lift your sternum slightly. Avoid extending lumbar spine.
Scapulae	Bring shoulders slightly up and back
TMJ	Keep jaw relaxed and tongue on roof of mouth



Sitting back to the wall. Tongue resting on roof your mouth. Bring arms overhead keeping elbows turned forward (lateral rotation). Elevate scapulae once elbows reach level of shoulders.

Outcomes - Pain

	Visit 1	Visit 8
Best (in 2 weeks)	1	0
Worst (in 2 weeks)	8	3

Outcomes – TMD Disability Index

- Initial: 35/40
- Discharge: 15/40

Outcomes – TMJ ROM

	Visit 1	Visit 2	Visit 4	Visit 8
Opening	30mm Pain/ popping	35mm no pain/ popping	44mm no pain/ popping	45mm no pain / popping

Outcomes – Function

- No headaches over last month
- Joint and face pain
 - Initial: constant
 - Discharge: less than 2x/week

Summary

- Freq/Duration
 - 1x/week, 4 visits
 - 2x/month, 3 visits
 - 1 month follow up
- Focus on quality of movement
 - Improved early phase rotation
- Addressed adjacent regions