The Frozen Shoulder Has A Brain

Academy of Hand and Upper Extremity PT

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Disclosure Statement of Financial Interest

We publish books on pain and receive an honorarium for the sales. These are not being promoted in the presentation. The intent is to share our research and not promote products.

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Frozen Shoulder

1872 Duplay
“Peri-arthritis”

1934 Codman
“Frozen Shoulder”

1945 Naviesar
“Adhesive Capsulitis”


Ernest Amory Codman: 1934

Frozen Shoulder common features:
• Gradual onset
• Pain near insertion of the deltoid
• Inability to sleep on the affected side
• Painful and restricted active and passive ROM
• Normal radiologic appearance


Codman E. The Shoulder. Boston, USA: Thomas Todd; 1934.

Fast Forward to 2018

In Physical Therapy...

The pathophysiology associated with primary (idiopathic) frozen shoulder: A systematic review

Victoria Ryan1,2, Hazel Brown3, Catherine J. Minns Lowe3 and Jeremy S. Lewis1,4,5

- Pathological changes in the anterior shoulder joint capsule and related structures
- Imaging identified pathological changes occurring in the coraco-humeral ligament, axillary fold and rotator interval.
- Obliteration of the sub-coracoid fat triangle also appeared to be pathognomonic.
- Histological studies inconclusive but suggests immune, inflammatory and fibrotic changes are associated with primary frozen shoulder.


Risk Factors

- 2-5% of general population are diagnosed
- Diabetes Mellitus:10-30% of diabetics
- Thyroid dysfunction:11-13% with hyper- or hypothyroidism
- Also associated with myocardial infarct, autoimmune disease, trauma and immobilization
Abnormal villous fronding of the synovium
Highly vascular: thickened scarring spreading across the rotator interval
Synovitis between biceps and subscapularis
Patchy, vascular, matted area of granulation tissue around origin of LH biceps and into the subscapularis recess

Leukocytes and macrophages were scant.
Appears to be a fibrous contracture of the rotator interval and coracobrachial ligament of the shoulder joint.
Composed of a dense collagen matrix, consisting mainly of mature type III collagen.
Highly cellular, and the cells are fibroblasts and contractile myofibroblasts, similar to Dupuytren’s contracture.
Evidence of new nerve growth
Elevated serum cytokine levels causing a sustained intense and protracted inflammatory/fibrotic response affecting the synovial lining and capsular-ligamentous complex.

>25% ROM loss in 2 planes
>50% loss of PROM in ER
<30 degrees of ER
May or may not have capsular pattern as described by Cyriax

Little agreement in the literature
Codman: “...even the most severe cases recover with or without treatment in about 2 years”
Castellarin: “20-40 % of cases do not respond to conservative treatment”

Reeves (n = 41): Ave. 30.1 months
Shaffer, et. al. (n = 62): Ave. 12 months
Miller, et. al. (n = 50): Ave. 14 months

Reeves
— At 5 year f/u: 54% with limited ROM
— 7% with functional limitation
Shaffer, et. al.
— At 7 year f/u: 43% with limited ROM
— 11% had functional limitation
Miller, et. al.
— At 10 year f/u: 100% regained ‘functional ROM’
Physical Therapy: Exercise

- Home exercises are important
- Worse outcomes with aggressive stretching
- Use irritability and severity as guide
  - Hand exercises
  - Door pulleys
  - Self distraction/mobilization
  - Pendulum exercises
  - Lower trap strength
  - Scapular strengthening
- Facilitate normal movement patterns

Stretching at later stages

- Done to remodel collagen matrix
- TERT (Total End Range Time)
  - Frequency × Duration = TERT; e.g., 10 min, 3x/day = 30 min of TERT
  - Start at 30 minutes, recommended 60 minutes/day
  - Adjust frequency, duration and intensity (pain tolerance)
- Increase as irritability decreases
- Emphasis on rotator interval (anterior) and CHL
- No standardized/accepted durations/frequencies or intensities
- Stress/Strain models suggest 30 minutes?
Glenohumeral Joint Mobilization

- Weak evidence to support it over other interventions
- Grade depends on severity and irritability
- High Grade vs. Low Grade
  - 100 subjects, 12 week follow up
  - Both groups showed ↓ in disability
  - Small difference with HG group improved more with P/AROM ER, PROM ABD

Yang, et. al. 2007 - Randomized 20 patients to receive
No adverse events
Increased ROM

Possible Complications
- Significant
- Can be an effective intervention
- Decrease Pain
Both groups showed ↓ in disability
Tissue non-fracture
Increased Function
Defied Concave/Convex Rule
Small difference with HG group
Grade V HVLA thrust
Increased ROM
Increased Function
Decrease Pain
No adverse events

Translation Manipulation by PT

- Grade V HVLA thrust
- Completed under scalene block
  - Increased ROM
  - Increased Function
  - Decrease Pain
- No adverse events


Direction?

- Randomized 20 patients to receive 15 reps of 1 minute sustained glides
  - Anterior Kaltenborn Grade III
  - Posterior Kaltenborn Grade III
- ER ROM significantly better with posterior glides over anterior glides by third visit
- Defined Concave/Convex Rule

Gentle Thawing...

**Supervised neglect (n = 45)**
- Explanation of the natural course of the disease
- Instructed not to exercise in excess of their pain threshold
- Instructed to do pendulum exercises and active exercises within pain-free range
- Resume all activities that were tolerated.

**Physical Therapy group (n = 32)**
- Active exercises up to and beyond the pain threshold
- Passive stretching and manual therapy of the GH joint
- HEP aimed at stretching and maximizing ROM

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**Table IV** Comparison of treatment: Supervised neglect and physical therapy across 24 months

<table>
<thead>
<tr>
<th>Time (mo)</th>
<th>Supervised neglect group (n = 45)</th>
<th>Physical therapy group (n = 32)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>28.60 (8.64)</td>
<td>29.97 (8.46)</td>
<td>.492</td>
</tr>
<tr>
<td>3</td>
<td>55.93 (14.26)</td>
<td>39.50 (8.45)</td>
<td>.000*</td>
</tr>
<tr>
<td>6</td>
<td>63.31 (15.00)</td>
<td>47.91 (7.51)</td>
<td>.000*</td>
</tr>
<tr>
<td>9</td>
<td>69.96 (15.44)</td>
<td>54.59 (7.89)</td>
<td>.000*</td>
</tr>
<tr>
<td>12</td>
<td>76.71 (13.60)</td>
<td>58.97 (8.79)</td>
<td>.000*</td>
</tr>
<tr>
<td>15</td>
<td>81.20 (13.45)</td>
<td>65.06 (11.12)</td>
<td>.000*</td>
</tr>
<tr>
<td>18</td>
<td>86.82 (14.41)</td>
<td>70.69 (12.47)</td>
<td>.000*</td>
</tr>
<tr>
<td>21</td>
<td>87.80 (12.80)</td>
<td>76.75 (14.41)</td>
<td>.0011</td>
</tr>
<tr>
<td>24</td>
<td>88.78 (11.26)</td>
<td>79.56 (16.09)</td>
<td>.0041</td>
</tr>
</tbody>
</table>

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**Table V** Percent of patients reaching a Constant score of 80 or higher in both groups

<table>
<thead>
<tr>
<th>Time (mo)</th>
<th>Supervised neglect group (n = 45)</th>
<th>Physical therapy group (n = 32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>16</td>
<td>0</td>
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<tr>
<td>9</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>64</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>78</td>
<td>16</td>
</tr>
<tr>
<td>18</td>
<td>78</td>
<td>31</td>
</tr>
<tr>
<td>21</td>
<td>84</td>
<td>50</td>
</tr>
<tr>
<td>24</td>
<td>69</td>
<td>63</td>
</tr>
</tbody>
</table>

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**Are we too aggressive with these patients early on?**

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**Frozen Shoulder: Evidence and a Proposed Model Guiding Rehabilitation**

**TABLE 1** Irritability Classification

<table>
<thead>
<tr>
<th>High Irritability</th>
<th>Moderate Irritability</th>
<th>Low Irritability</th>
</tr>
</thead>
<tbody>
<tr>
<td>High pain (&gt;3/10)</td>
<td>Moderate pain (4-6/10)</td>
<td>Low pain (&lt;3/10)</td>
</tr>
<tr>
<td>Persistent night or resting pain</td>
<td>Intermittent night or resting pain</td>
<td>No resting or night pain</td>
</tr>
<tr>
<td>High disability on OARS, ASES, PPS</td>
<td>Moderate disability on OARS, ASES, PPS</td>
<td>Low disability on OARS, ASES, PPS</td>
</tr>
<tr>
<td>Pain prior to ROM</td>
<td>Pain at ROM</td>
<td>Minimal pain at end ROM with overpressure</td>
</tr>
<tr>
<td>ARROM less than PROM, secondary to pain</td>
<td>ARROM similar to PROM</td>
<td>ARROM same as PROM</td>
</tr>
</tbody>
</table>

**Abbreviations:** ARROM, active assisted range of motion; AROM, active range of motion; OARS, American Shoulder and Elbow Surgeons Score; DASH, Disabilities of the Arm, Shoulder and Hand Questionnaire; PAIN, passive range of motion; PSS, Pain Shoulder Score; ROM, range of motion.

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Isn't this the title?


A Pain Science View of Frozen Shoulder

1. Consciousness

- It’s impossible to have pain and not know about it
- Pain is a conscious decision by the brain as a means to protect
- Conscious function is part of the pain neuromatrix via the hypothalamus and thalamus
What if we alter consciousness?

Passive shoulder abduction and external rotation ROM were measured in 5 patients scheduled for capsular release surgery for frozen shoulder before and after the administration of general anesthesia.


2. Neglect and Smudging

**Neuroplasticity**
- Biologically coded
- Environmentally sculpted


Interestingly enough mapping changes have been demonstrated in:
- Amputees
- CRPS
- Chronic back pain
- CTS
- Knee OA
- Arm and hand pain
- Dysxia
- Post-stroke
- Expectation of pain
- Radiculopathy
- Pregnancy
- Aging
- Obesity
- Immobilization
- Anesthesia
- Surgery
- Headaches
- Facial pain


Pain is 100% produced by the brain...

Pain is a multiple system output, activated by an individual’s specific pain neural signature. The neural signature is activated whenever the brain perceives a threat.


Laterality: Frozen Shoulder

- 54 year-old lady with a frozen shoulder
- Right handed
- Denies any trauma
- Increasing pain and limited ROM
- X-Ray normal
- Corticosteroid injection
- “Intensive” physical therapy, but pain and ROM got progressively worse


Laterality: Frozen Shoulder

<table>
<thead>
<tr>
<th>Test</th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Point Discrimination (mm)</td>
<td>40</td>
<td>58*</td>
</tr>
<tr>
<td>Hand Laterality Accuracy (%)</td>
<td>70*</td>
<td>50*</td>
</tr>
<tr>
<td>Hand Speed (seconds)</td>
<td>2.2</td>
<td>4.2*</td>
</tr>
<tr>
<td>Shoulder Laterality Accuracy (%)</td>
<td>80</td>
<td>60*</td>
</tr>
<tr>
<td>Shoulder Speed (seconds)</td>
<td>2.5</td>
<td>4.9*</td>
</tr>
</tbody>
</table>

* Abnormal


Sensory Discrimination: Shoulder

Convenience sample:
- 55 patients with shoulder pain and limited ROM
- Ave. age 56.27 years
- 66% female
- Surgical 42 (76%)
- Ave. duration of pain 32.9 months

Pain and Decreased Range of Motion in Knees and Shoulders: A Brief Sensory Remapping Intervention – Louw, Farrell, Zimney, et.al.; Pain and Rehabilitation 2017
Sensory Discrimination: Shoulder

Treatment:
- 5 minute localization task

Results:
- Immediate significant improvement in active shoulder flexion ($p = 0.001$)
- 50% of the patients meeting or exceeding the minimal detectable change for active flexion

Frozen Shoulder:
- 4/5 dropped pain score ≥ 1 point
- Fear physical activity: Dropped 45%
- Flexion improved 5 degrees

Mirror Therapy: Shoulder

- 69 consecutive patients with shoulder pain and limited active ROM
- 35 female (50.7%)
- Ave. age 57.3 years
- Ave. duration of pain 28.2 months
- 49.3% had shoulder surgery

Treatment
- 10 times active flexion of the unaffected arm and observed in the mirror
- Ave. duration 3 minutes

Results
- Significant differences in:
  - Self-reported pain ($p = 0.014$)
  - Pain Catastrophization ($p < 0.001$)
  - Tampa Scale of Kinesiophobia ($p = 0.012$)
  - There was a significant increase (mean = 14.5°) in affected shoulder flexion AROM immediately post-mirror therapy ($p = 0.001$)

Frozen shoulders:
- PCS dropped 15%
- Flexion improved 10 degrees (range 0-20°)
3. Threat

Pain is a multiple system output, activated by an individual's specific pain neural signature. The neural signature is activated whenever the brain perceives a threat.


3. Threat

- 11 patients with primary frozen shoulder
- Targeted the phases of frozen shoulder:
  - Pain predominant (n=5)
  - Stiffness predominant (n=4)
  - Residual stiffness predominant following hospital treatment (n=2)
- 6 Females
- Predominantly between 50-59 years of age
- 3 Patients diabetic


3. Threat

- The most important themes:
  - Pain which was severe as well as inexplicable
  - Inconvenience/disability arising from increasing restriction of movement
  - Confusion/anxiety associated with delay in diagnosis and uncertainty about the implications for the future
  - Treatment-related aspects
- There was a general lack of information from clinicians about the condition with over-reliance on verbal communication and very little written information.


4. Multiple System Output

Gifford LS. Pain, the tissues and the nervous system. Physiotherapy. 1998;84:27-33.

4. Multiple System Output
4. Multiple System Output

- Sympathetic
- Immune
- Endocrine
- Parasympathetic
- Motor
- GI System
- Other

5. Nerve Growth

- Increased nerve fibers
- Inflammation with fibroblastic proliferation

5. Nerve Growth: Demyelination

- Removing myelin:
  - Mechanical
  - Immune
  - Chemical

5. Nerve Growth: Ion Channel Expression

6. Cytokines and Inflammation

Significant increased chronic inflammatory response with fibroblastic proliferation

Gifford LS. Pain, the tissues and the nervous system. Physiotherapy. 1998;84:27-33.
HPA Axis, Pain and Frozen Shoulder?

BRAIN
- Steroid and inflammatory line
- Depressed mood and concentration
- Increased anxiety
- Immunosuppression
- Cognitive changes

TISSUES
- Decreased corticosteroid secretion
- Increased pro-inflammatory cells
- Increased corticotrophin releasing factor
- Epinephrine secretion

Cortisol regulates...Cytokines
- Messengers of the immune system
- Produced by a broad range of cells, including immune cells (macrophages, B lymphocytes, T lymphocytes and mast cells)
- Participate in synaptic transmission in neurons and glial cells
- Cytokines regulate inflammation

Frozen Shoulder and Cytokine Balance...
- A disproportion of pro-inflammatory and anti-inflammatory cytokines leads to a chronic peripheral sensitization of nervous system.
- Release of chemokines and cytokines that elicit peripheral sensitization.

Females, FS and Hormones...
- Woman: heightened inflammatory responses than men
- Peripheral afferent nerves contain estrogen receptors, resulting in increased afferent discharge, possibly linking to increased central sensitization

Females, FS and Hormones...
- Total number of subjects presenting with adhesive capsulitis of the shoulder

<table>
<thead>
<tr>
<th>Study</th>
<th>Total number of subjects presenting with adhesive capsulitis of the shoulder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ryan et al., 2005 [35]</td>
<td>180</td>
</tr>
<tr>
<td>Carette et al., 2003 [34]</td>
<td>93</td>
</tr>
<tr>
<td>Buchbinder et al., 2004 [33]</td>
<td>49</td>
</tr>
<tr>
<td>Astrain &amp; Celiker, 2001 [32]</td>
<td>20</td>
</tr>
<tr>
<td>Daniels &amp; Stevens, 2008 [26]</td>
<td>77</td>
</tr>
<tr>
<td>Vermeulen et al., 2006 [27]</td>
<td>100</td>
</tr>
<tr>
<td>Griggs et al., 2000 [26]</td>
<td>75</td>
</tr>
</tbody>
</table>

7. Fear-Avoidance
8. Microcirculation

- Inflammatory disease?
- Studies showing no significant inflammatory cells in capsular tissue


- Decreased microcirculation


- The brain and spinal cord: 2% of the total body mass
- Consume 20-25% of the available oxygen in the circulating blood


8. Microcirculation and Axoplasm

Axoplasm
- Cellular transport
- To/from the cell body
- Viscosity: 3-4 times thicker than water
- Twice as thick in diabetic patients

9. Central Sensitization and Allodynia

There is some evidence that a subgroup of shoulder patients, including frozen shoulder, with central mechanisms dominant in their clinical presentation.


Could it be?

TABLE 1

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<tr>
<th>Irritability Classification</th>
</tr>
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<td>Low pain (&lt;30)</td>
</tr>
<tr>
<td>Intermittent pain</td>
</tr>
<tr>
<td>Intermittent pain</td>
</tr>
<tr>
<td>No pain or silent pain</td>
</tr>
<tr>
<td>Pain to end ROM</td>
</tr>
<tr>
<td>Pain at end ROM</td>
</tr>
<tr>
<td>Minimal pain at end ROM</td>
</tr>
<tr>
<td>AROM loss from PROM</td>
</tr>
<tr>
<td>AROM loss from PROM</td>
</tr>
</tbody>
</table>

(continued)


Identifying Central Sensitization in the Clinic

- Symptom and sign cluster (486 times) for CS
  - Disproportionate pain
  - Disproportionate aggravating and easing factors
  - Diffuse palpatory tenderness
  - Psychosocial issues
    - Fear-Avoidance
    - Pain Catastrophization
    - Depression

Central Sensitization Inventory

- Muscle pain
- Disproportionate?
- No CS
- Diffuse Pain?
- CS Inventory ≥ 43
- Yes = CS
- No = No CS
- Yes = CS


Testing a Sensitive Nervous System

Overview of the clinical examination of patients with suspected central sensitization.

Clinical tests

1. Assessment of pressure pain thresholds at sites remote from the symptomatic site
2. Assessment of sensitivity to touch during manual palpation at sites remote from the symptomatic site
3. Assessment of sensitivity to vibration at sites remote from the symptomatic site
4. Assessment of sensitivity to heat at sites remote from the symptomatic site
5. Assessment of sensitivity to cold at sites remote from the symptomatic site
6. Assessment of pressure pain thresholds during and following exercise
7. Assessment of joint end feel
8. Brachial plexus provocation test
Don’t forget the brain

Clinical Tests

Screening Tools/Outcome Measures

So what?

? Add Neurogenic


Central Sensitization Inventory

Pain Catastrophization

Fear-Avoidance

Body Charts (brain mapping)

High intensity:
• Motorphobia:
  • Neck pain modulation
  • Electrical stimulation for pain modulation
  • Self care home management training
  • Patient education on positions of comfort and activity modifications to local tissue inflammation and pain

Manual Therapy:
• Low intensity joint mobilization
• Joint mobilization
• Pain free joint range of motion exercises

Moderate intensity:
• Motorphobia:
  • Neck pain modulation
  • Electrical stimulation for pain modulation
  • Patient education on positions of comfort and activity modifications to local tissue inflammation and pain

Manual Therapy:
• Low intensity joint mobilization
• Joint mobilization
• Pain free joint range of motion exercises
• Pain free passive ROM exercises
• Pain free active assisted ROM exercises

Low intensity:
• Motorphobia:
  • Neck pain modulation
  • Electrical stimulation for pain modulation
  • Patient education on positions of comfort and activity modifications to local tissue inflammation and pain

Manual Therapy:
• Low intensity joint mobilization
• Joint mobilization
• Pain free joint range of motion exercises
• Pain free passive ROM exercises
• Pain free active assisted ROM exercises


What do patients want from us?

- Clear diagnosis
- Education about their problem
- Personalized and individualized care
- Prognosis and plan of care
- Explanation of treatment
- Pain relief and improved function
- Thorough physical examination


Puentedura EJ, Cleland JA, Landers MR, Mintken PE, Louw A, Fernandez-de-Las-Penas C. Development of a clinical prediction rule to identify patients with neck pain likely to benefit from thrust joint manipulation to the cervical spine. The Journal of orthopaedic and sports physical therapy. 2012;42(7):577-592.


The “ah-ha” moment...

Who needs PNE?

- Central sensitization
- Chronic pain
- Patients who have had multiple treatment “failures”
- Patients referred to therapy specifically for PNE
- Patients with high levels of fear (FABQ)
- Patients displaying various pain catastrophization characteristics

Who needs PNE?

- Central sensitization
- Chronic pain
- Patients who have had multiple treatment “failures”
- Patients referred to therapy specifically for PNE
- Patients with high levels of fear (FABQ)
- Patients displaying various pain catastrophization characteristics

Remember her?

Pain neuroscience education, also initiated in the first week, included the following key concepts: (1) pain is an output produced by our brain in response to what it perceives as danger; (2) pain is not necessarily associated with tissue damage; (3) a variable relationship exists between nociception and pain; (4) environment can influence perceived pain intensity; (5) persistent pain creates an upregulation in nociception; and (6) the nervous system is plastic and adaptable.18

Frozen Shoulder PNE

Don’t forget the person attached to the frozen shoulder
The efficacy of PNE on musculoskeletal pain: A systematic review of the literature

- Moseley 2002
- VibeFersum 2012
- Moseley 2003
- Gallagher 2013
- Moseley 2004
- Van Costerwijk 13
- Ryan 2010
- Rersum 2014
- Meeus 2010
- Pires 2015
- Louw 2014

In all but one of these studies did patients have statistically significant (p<0.05) decrease in pain ratings

The other group: NONE

PNE+: A non-pharmacological program

- PNE
- Nutrition
- Breathing
- Biofeedback
- Guided motor imagery
- Safe, healing environment with compassion and empathy
- Manual Therapy
- Neural mobilization
- Mobilization
- Yoga
- Relaxation and meditation
- Aerobic exercise
- Humor
- Aquatic therapy
- Social interaction
- Costing skills
- Sleep hygiene
- Soft tissues/frigger point therapy
- Stabilization and resistance training
- Journaling
- Stretching, movement, and body awareness

Finally: It isn't all brain either....

Tissue

Brain

Thank you & acknowledgements...

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steve.schmidt.pt@gmail.com
paul.mintken@ucdenver.edu

Our families
- Louis Puentedura
- Kory Zimney
- Ina Diener
- Louis Gifford
- Cesar Fernandez
- John Childs
- Tim Flynn
- Jo Nijs
- Merill Landers
- ISPI staff and faculty