The Stiff Hand
Clinical Reasoning & Problem Solving Approach

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What is STIFFNESS?

• **Stiffness** is the rigidity of an object — the extent to which it resists deformation in response to an applied force.
• The complementary concept is flexibility or pliability: the more flexible an object is, the less stiff it is.

Wikipedia

What is STIFFNESS?

• Collagen provides tensile strength of tissues
• Collagen fibers are inelastic
• Movement between collagen fibers provides elasticity of tissues

MA Hardy 1989

What is STIFFNESS?

• Normal hand motion occurs when connective tissue structures glide
• Stiffness occurs when gliding motion is restricted by inelastic crosslinks binding collagen fibers together

MA Hardy 1989
Injury to one structure effects the entire hand!

- Wound healing process may affect entire hand & UE
- Inflammatory process extends into adjacent uninjured soft tissue structures, digits, proximal joints
- Fibroplastic process & Remodeling process: Uninjured structures undergo collagen turnover

WH Merritt 1998

Phases of Healing

- Different tissues heal at different rates
- One wound can have various stages of healing

Phases of Healing

- Hours – Days: Vascular Dependence
  - Bleeding
  - Clot formation
- Days – Weeks: Cellular Dependence
  - Inflammation
Tissue repair
  - Proliferation / Fibroplasia
  - Tissue remodeling

Inflammatory Phase
  - Wound prepare for healing
Fibroplastic Phase
  - Tissue structure is rebuilt
Remodeling Phase
  - Tissue differentiates into final form

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Inflammatory Phase

- 1-7 days after insult
- Inflammatory cells invade wound
- Disruption of blood vessels and bleeding
- Release of histamine from mast cells, bradykinins & serotonin from platelets causing vasodilation & increased cellular permeability
- Phagocytosis of necrotic tissue
- Macrophages attract fibroblasts producing basic collagen matrix to make wound plug

Inflammatory Phase

- Intercellular bonds are weak
- Wounds can be disrupted easily
- Acute injuries & surgical repairs are immobilized

Inflammatory Phase

- Cells in injured tissues release histamine
- Histamine causes vasodilation in non-injured vessels
- Red, hot, swollen, painful
- Inflammatory edema fills spaces & surrounds all injured, uninjured and repaired structures binding them together in one wound
- Inflammatory fluid is high in fibrinogen which coagulates wound & surrounding tissues
- Coagulated gel matures into dense binding scar
- Excessive swelling must be controlled to minimize scar

Inflammatory Phase

- Ering & Murphy, 1964
  - Excessive edema affects joint position
  - Joint assumes position to lessen tension on joint receptors

MA Hardy 1989

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Inflammatory Phase

- Young 1987, DeAndrade 1965
  - Swelling causes joint receptors to facilitate muscle action drawing the joint into a “comfortable” position & neurologically inhibits antagonistic muscles

Fibroplastic Phase

- 4-21 days after insult
- Period of collagen formation
- Fibroblasts evolve into myofibroblasts
- Myofibroblasts are responsible for collagen fiber synthesis & wound contracture
- Disorganized collagen fibers randomly deposited & invade wound matrix to form scar bridge across wound

Fibroplastic Phase

- Collagen production
- Epithelialization
- Wound contraction

Fibroplastic Phase

- With immobilization
  - Disorganization of cellular & fibril components of ligaments & joint capsule
  - Random orientation of collagen fibers limits movement between fibers
  - Adhesions develop between folds of synovial lining, formation of fibro-fatty connective tissue within joint space
  - Atrophy of cartilage & osteoporosis
Fibroplastic Phase

- Rate of collagen synthesis & degradation is accelerated
- Overall collagen mass is reduced resulting in weakening of soft tissues in & around joint
- New scar is 15% of normal strength
- Joints have firm end feel
- Excessive force can tear fibrils provoking inflammatory response

Fibroplastic Phase

- Extracellular matrix becomes progressively more disorganized
- Collateral ligaments, joint capsule, volar shorten & tighten forming contracture

Remodeling Phase

- 21 days to months after insult
- Collagen deposition & lysis reach equilibrium
- Collagen fiber orientation

Glasgow 2010
Remodeling Phase

• Remodeling of scar tissue into more organized & stronger structure
• Collagen fibers that were deposited during Fibroplastic Phase are replaced and reorganized in response to tensile loads placed across them
• If AROM is limited, new collagen will be deposited in shortened position, restrictions become more fixed

Glasgow 2010

Remodeling Phase

• Hypertrophic scars
  – Rate of collagen synthesis > collagen lysis
  – Collagen synthesis is oxygen dependent; Collagen lysis is not oxygen dependent
  – Prolonged scar pressure causes ischemia, synthesis is depressed & lysis continues until collagen turnover reaches equilibrium & scar is flattened
  – Collagen turnover is accelerated as old fibrous tissue is removed; new fibrous tissue is formed

MA Hardy 1989

Remodeling Phase

• Scar changes to fit the tissue
• Repaired ligament must be firm, unyielding but pleat when off tension
• Scar between moving structures must have thin, lengthy adhesions to allow glide and movement

Remodeling Phase

• Scar is inelastic
• Scar that forms with redundant folds will permit mobility of the structures to which it is affixed
• Gliding tendons have lengthy, elongated adhesions
• Restricted tendons had short, dense adhesions
Remodeling Phase

- Physical change of scar length can be achieved through the application of stress during the appropriate healing phase
- Stretching scar achieves only a temporary lengthening
- Permanent elongation of scar requires long-duration application of stress for scar tissues to remodel to the new position
  KE Light 1984

Hand Therapy

- Influence on scar biology
- Movement re-education
- Function re-education

Remodeling Phase

- Goal: reintroduce a controlled stress as the scar matures to influence scar formation

Hand Therapy Based on Scar Biology

- "Hand therapy is behavioral modification of the fibroblast during the healing response. How to apply the correct stress to the correct tissue at the correct time is the behavioral modification of scar that we strive to achieve."
  Weber & Davis 1978
Hand Therapy Challenge: 
Preserve function in structures not directly injured!

- Injured connective tissue has greater acceleration of collagen synthesis than skin wounds for at least a month after injury
- 20-fold increase in collagen proliferation and deposition into the thin areolar surface of fascia occurs within five days
- Disorganized “coat” of collagen restricts mobility of collateral ligament, capsule, tendon
- Modification of the collagen response requires judicious application of stress

WH Merriett 1975, 1977

ICAM orthosis

- Orthosis & yoke position involved extensor tendons on slack
- Extension pull from uninvolved digits assists extension of involved fingers

Inflammation of Uninjured Tissue

- Stress will not modify collagen strength or deposition, it modifies the shape & potential mobility when applied before cross-linking occurs
- To minimize risk of inflammation of adjacent uninjured hand organ connective tissue provide early motion

Arem and Madden, 1976

ICAM orthosis

- Full composite flexion of involved digit is limited
- Allows tendon excursion of involved & uninvolved fingers without excessive stress on repair

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Treat what you see. Treatment must be problem specific.

- Detailed evaluation must identify every problem contributing to stiffness
- Treat the problems you see, not the diagnosis or protocol you read
- The phases of healing don’t always follow the period of insurance authorization for therapy treatment
- Treat the patient not the insurer
- We are pressured to standardize care and limit resources & make the patient fit the protocol
- We must do what the individual patient needs

Art & Science of Hand Therapy

- Exactly how much tension to apply to mobilize a stiff joint to encourage glide of uncross-linked collagen instead of causing inflammatory response, is an art, not a science!
- No objective criteria available to indicate exactly how much force should be applied
- Therapist must evaluate the patient’s pain, the heat of the joint, the feel of the resistance
- Therapist must motivate, and inspire the patient

Hand Therapy Requirements for Successful Outcome

- Problem specific Plan of Care
- Based on sound understanding of wound healing & knowledge of anatomy & biomechanics
- Objective measurement & analysis of the measurements
  – Guides therapy treatment
  – Encourages patient efforts and compliance

Therapeutic Emphasis: Inflammatory Phase

- Decrease pain
- Decrease edema
- Promote wound healing

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**Therapeutic Emphasis: Fibroplastic Phase**
- Decrease edema
- Begin controlled stress specific for involved tissue
- Avoid provocation of inflammatory phase!!!
Detailed Assessment: Key to Effective Treatment

PROBLEMS CAUSING “STIFF HAND & WRIST”

- Pain / Hypersensitivity
- Edema
- Muscle contracture
- Ligament contracture / Joint capsule contracture
- Tendon pathology
- Scar contracture
- Co-contraction
- Poor posture / poor body mechanics
- Paralysis / paresis

Pain Evaluation

- Neurogenic pain: median nerve, ulnar nerve, SBRN
- Hypersensitivity: neurogenic, scar hypersensitivity
- Dysesthesia: disagreeable sensation is produced by ordinary stimuli; caused by lesions of the sensory pathways, peripheral or central

Pain Dysfunction

- Protective muscle guarding / co-activation of agonistic and antagonistic muscles
- CNS response to injury or threat of injury
- Prolonged co-contraction: release of bradykinin, substance P & histamine that produce pain
- Co-contraction for hours or days: muscle dysfunction
- Referral pain
- Trigger points
- Autonomic response
- Hypersensitivity
- Anxiety, emotional stress, depression

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Pain Evaluation & Treatment

• Evaluate for optimal pain management modalities
  – TENS
  – Desensitization
  – Graded Motor Imagery
  – Muscle re-education
  – Relaxation

STIFF HAND
Intrinsic Muscle Contracture

• Intrinsic muscle damage
  – Ischemia or chronic edema
  – Crush injuries
• Prolonged immobilization
• Other pathology

STIFF HAND
EDEMA

Intrinsic Muscles:
Interossei, Thenar & Hypothenar
Intrinsic Muscles: Interossei & Lumbricals

Interossei Muscle Tightness Test
Bunnell – Littler Test

- Measure passive PIP flexion with tension
- Compare PIP flexion without tension

Forearm Muscle Compartment Tightness

- Measure wrist angle with muscle compartment on composite tension

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STIFF HAND
Joint Capsule Contracture
• Limited PROM of joint with muscle–tendon unit off tension

STIFF HAND
Extensor Tenodesis / Adherence Test
• Positive if passive IP flexion is greater with MCP held in extension than when MCP is flexed
• Measure passive PIP flexion with tension
• Compare PIP flexion without tension

Flexor Tenodesis / Adherence Test
• Positive if passive IP extension is greater with the MCP held in flexion than when the MCP is extended
• Measure passive MCP extension without tension
• Compare MCP extension with tension

STIFF HAND
Scar Contracture
STIFF HAND
Muscle Co-Contracting

- The simultaneous contraction of agonist and antagonist muscles around a joint.
- Over time there is joint stiffness, muscle tightness and imbalance.
- May lead to altered pattern of movement and change in cortical map.
- Pain dysfunction.

Range of Motion Measurement

AROM
- Assessment of tendon excursion.
- Reflects muscle ability to move joint via tendon.

PROM
- Assessment of joint or capsular motion.
- Reflects ability of joint to be moved through the normal arc of motion.

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ROM of Thumb CMC

Radial Abduction  Palmar Abduction

ROM of Wrist

Thumb
Opposition Lag

Opposition Lag  Retroposition Lag

ROM of Wrist

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TREATMENT OF THE STIFF HAND & WRIST

Plan of Care must be problem specific to be effective
PROBLEMS CAUSING “STIFF HAND & WRIST”

- Pain / Hypersensitivity
- Edema
- Muscle contracture
- Ligament contracture / Joint capsule contracture
- Tendon pathology
- Scar contracture
- Co-contraction
- Movement Dysfunction
  - Poor posture / poor body mechanics
- Weakness
- Paralysis / paresis

Tissue Temperature Changes

- As collagen tissue temperature exceeds 40°C (104° F) there is a 25% increase in potential elongation
  - Laban, 1962
- Elevating tendon temperature to 45°C allowed optimal stretching without damage
  - Warren, 1976

Modalities

- Heat
- US
- TENS
- E Stim: IFC, HVG stim

Fluidotherapy vs. Whirlpool vs. Paraffin

  - Comparison of in vivo temperatures produced by hydrotherapy, paraffin wax treatment, & Fluidotherapy.
  - Phys Ther 60: 69-71. 1980
- Borrell RM and others:
EDEMA CONTROL: Effects of Edema

- Moving structures bathed in sero-fibrinous exudate
- Fibroblasts become connective collagen tissue
- Folds of joint capsule, synovial membranes, tendons and sheaths adhere
SCAR MANAGEMENT

- Friction Massage
- Myofascial release / soft tissue mobilization
- Scar traction with muscle / tendon glide
- Loosens superficial scar adhesions allowing tissue glide & flexibility

SCAR MANAGEMENT

IASTM: Instrument Assisted Soft Tissue Mobilization

- Controlled microtrauma to affected soft tissue stimulates local inflammatory response
- Microtrauma initiates reabsorption of inappropriate fibrosis or excessive scar tissue & facilitates remodeling of affected soft tissue

ACTIVE RANGE OF MOTION

Six Pack Exercises

FLEXION

ABDUCTION

ADDUCTION

INTRINSIC PLUS

INTRINSIC MINUS

OPPOSITION

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Tendon Gliding Exercise

AROM Blocking Exercises
- Isolation of FDP
- Isolation of FDS

AROM Blocking Exercises
- Isolates EDC, EIP, EDQ, EPL, intrinsic IP extension

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AROM
Wrist DF / VF
• Avoid use of long finger flexors and extensors

ACTIVE ROM EXERCISE
• Hold 5 seconds each
  – Facilitates maximum voluntary effort
  – Maximum muscle contraction
  – Full available end range of capsule & tendon glide
• Sets & Reps as appropriate
  – 15 reps
  – 3 sets of 10 reps
• Optimal posture of digits & wrist for stabilization
• Avoid guarding, co-contraction
• Hand elevated

AROM of Shoulder
Elbow Pointing Exercises

PASSIVE RANGE OF MOTION

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Stress Strain Curve for Connective Tissue

- Initial rapid elongation
- With maintained stress, tissue will attempt to reduce this increased tension by growing & lengthening to adapt to their new resting length
- Low load, long duration hold increases tissue length

Principles of PROM

Patient should be relaxed

- Co-contraction: the simultaneous contraction of agonist and antagonist muscles around a joint.

Principles of PROM

- Increase PROM by stretching tissues and not by tearing them
- Stretch to the point of discomfort, not pain
- Force should be steady & prolonged
- Patient should be relaxed
- Stretch each involved structure

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Increase ROM

- Joint mobilization
- Contract – Relax
- Hold – Relax
- Muscle Energy Techniques

Grip Strengthening

- Paper towel exercise
  - Tendon glide
  - Finger flexion end range
- Intrinsic muscle strengthening
- Wrist stabilization

STRENGTHENING
Hand & Wrist

- Grip & pinch
  - Wrist muscles co-contract
  - Proximal stability for distal function
- Forearm rotation
  - Primary supinator & pronator muscles at elbow
  - Wrist & grip muscles co-contract
  - Elbow & shoulder muscles co-contract

Grip Strengthening

- Golf ball exercise for tendon glide & end range
- Intrinsic muscle strength and endurance
- Wrist stabilization
Grip Strengthening

- Therapy putty
- Isometric - like
- Wrist stabilization

Grip Strengthening

- Wrist curls
- Grip
- Wrist strength
  – Power
  – Endurance

Grip & Proximal Strengthening

- Body Blade

Grip Strengthening

Power vs Endurance

- 3 sets of 10 reps
- 100 reps throughout day, 5 sec. hold
- Grip on 1 minute, grip off 1 minute, ...10-15 cycles
- Grip 100 repetitions as fast as possible for 5 cycles
Pinch Strengthening

- Therapy putty
- Clothes pin, clip, etc.

UE Strengthening

- PRE’s
- PNF
- Isotonic, isometric, isokinetic
- Concentric / eccentric exercise
- Proximal stability & distal function
- Lift / carry, Push / pull
- Plyometrics
- Open & closed chain exercise
- Etc.

UE Strengthening

- Function specific
- Job specific
- Sport specific

Manipulation Activities
UE Strengthening

Wrist Stabilization Exercise

Wrist Stabilization Exercise

Grip & Wrist Stabilization Exercise

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Grip & Wrist Stabilization Exercise

Work Simulator - BTE

Plyometric Exercise

FUNCTIONAL ACTIVITIES

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Pain Dysfunction Therapy Treatment

- ROM within pain free limits
- Change pattern of active motion
- Wrist support
- Orthosis for active redirection of corrective forces
- Influence cortical re-mapping

Management of the Stiff Hand & Wrist
Clinical Reasoning & Problem Solving Approach

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Pain Dysfunction Therapy Treatment

- Patient awareness of dysfunctional co-contraction
- Relaxation
- Muscle re-education