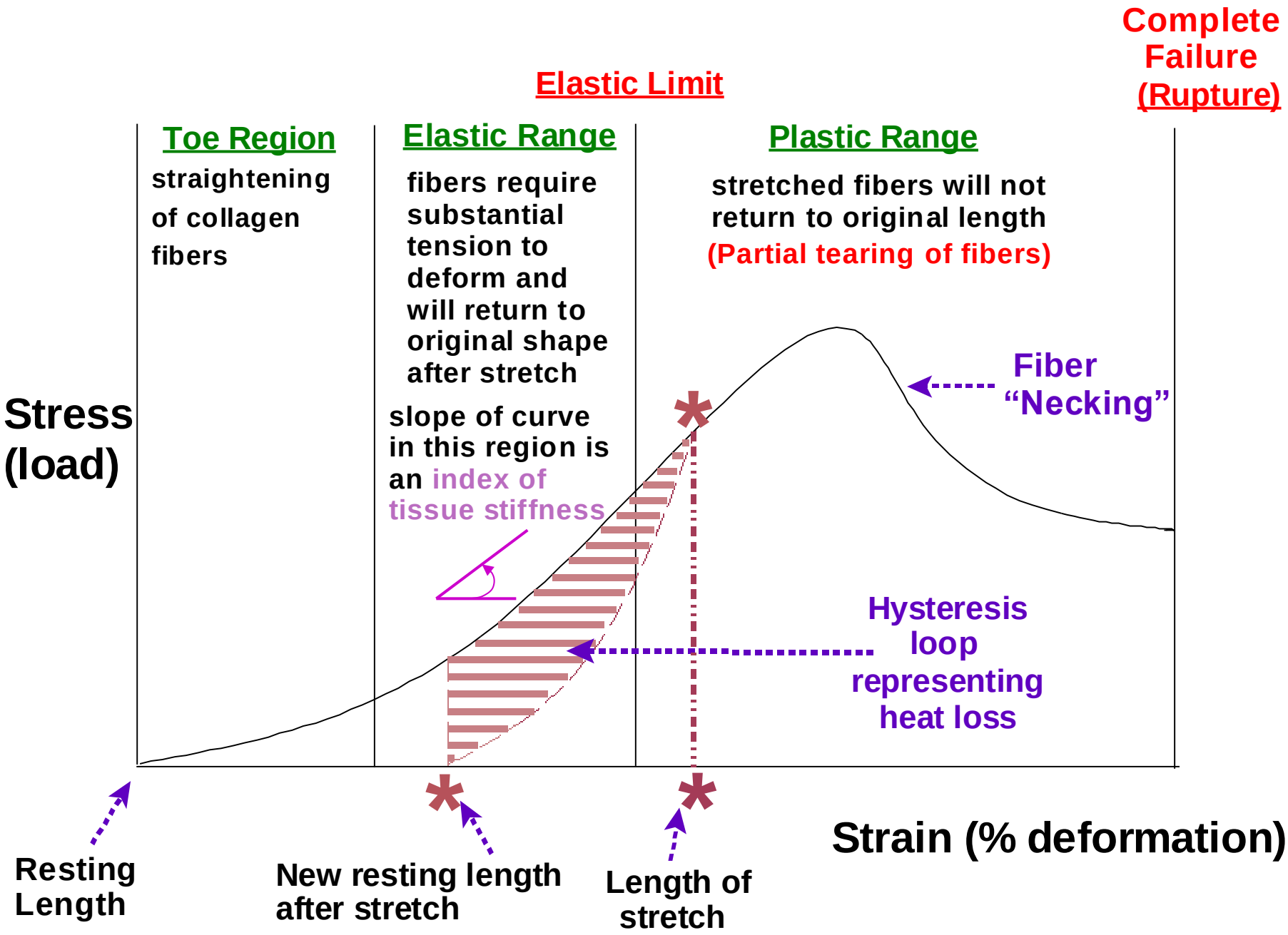
STRESS - STRAIN CURVE OF MUSCULOTENDINOUS TISSUE



Microtrauma

- Microtrauma (“overuse syndromes” “cumulative cell-matrix adaptive response”)
- Repetitive maximal or submaximal movement in the “elastic range” causes:
  - Pathological microscopic tears or lesions ➞ inflammation and or tissue malformation
  - Overwhelming of cell metabolism ➞ can’t maintain structural integrity by ⬆ tissue synthesis
    - **Tissues that are formed in response to this overload stimulus are of inferior quality**
- Responsible for 30% - 50% of sports injuries (Herring & Nilson, 1987)
- These types of injuries are very “individualistic” in nature
- Structures most often affected in microtraumatic syndromes:
  - Bursa - synovial fluid sacs that ⬇ friction between: skin-bone, tendon-bone, muscle-muscle
  - Tendon sheath (paratenon - fat & areolar tissue - “extended bursa” surrounding tendon)
  - Tendon (tendonopathies)
  - Bone (stress fractures)
  - Muscle (delayed onset muscle soreness)
- Symptomology progression of microtraumatic overuse syndromes:

  Phase 1: pain after activity (immediate - 12 hours) which is palpable at injury site

  Phase 2: pain during & after activity - no significant impairment - eventually resolves

  Phase 3: pain during & after activity - significant impairment - eventually resolves

  Phase 4: pain all the time accompanied by significant impairment - no resolution

Currently Accepted Theory as to the Cause of DOMS

Dr. Bob Armstrong - TAMU muscle biology laboratory - 1991

- Eccentric contractions → sarcomere inhomogeneities + sarcolemma (membrane) disruption
  - Disturbance in Ca++ homeostasis reduces ATP production → ↓ [ATP]
  - Intracellular [Ca++] ↑ faster than Calcium extrusion mechanisms can pump it out
  - Cellular membrane destruction → cell death
- Prostaglandin & histamine → edema and inflammation → stimulation of free nerve endings
- ↑ protease & phospholipase activity begin to degrade the myofibril & associated membrane
- Phagocytes & macrophages invade cell 2-6 hours after the injury - continues for 2-3 days
- Cells adapt → future bouts of the same exercise causes less injury

Armstrong et al. (1991) Sports Medicine 12 (3) 184-207

MRI of Delayed Onset Muscle Soreness

- Note ↑ signal intensity in entire bicep compared to triceps

Tendinitis or Tendinosis ????

- **Tendinitis** - inflammation of tendon (rare) – inflammation of sheath is more common
  - **the correct terms for inflammation of the tendon sheath are "tenosynovitis" & "paratenonitis"**
- **Tendinosis -** degeneration & deleterious changes in tendon without inflammation
- **What most clinicians in the past have termed "tendonitis" is actually "tendinosis" or more generally, "tendinopathy"**
  - **Both tendinitis & tendonopathy can occur together!**
- **Regardless, the following observations for the malady may be made:**
  - The problem is most often accompanied by :
    - tissue degeneration (necrosis) and vascular abnormalities (disorganized vascularization)
    - collagen disorganization & fiber separation by mucoid or lipoid ground substance (➞ inferior tissue)
  - The problem may lead or contribute to complete or partial tendon rupture
  - Chronic tendonopathy ➞ fibrinous adhesions ➞ diminished tissue strength & function
  - Although cause & etiology are debatable, recent opinions purport causes to be related to:
    - The sliding of tendon over other structures (compressive forces)
    - Subjecting the tendon to loads close to tensile strength & exceeding its anabolic capabilities
    - Eccentric contractions
      - Negative direction on force velocity curve ➞ what about plyometric training??????
    - Chronic anabolic steroid use ➞ ↓ tissue quality and tensile strength ➞ ↑ incidence of tendon rupture
    - Malnutrition influences: ↓ vitamins A & C, ↓ copper ➞ ↓ collagen synthesis and crosslinking
    - Menopause ➞ ↓ [E_2] ➞ ↓ connective tissue elasticity ➞ ↑ tendinitis & other overuse injuries
    - Note: Collagen production is impaired in smokers ➞ Tendinopathies heal slower

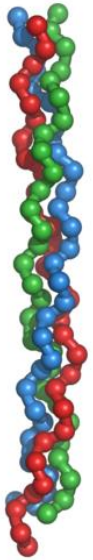
http://sportsmedicine.about.com/od/paininjury1/a/tendonitis.htm

General Steps in the Healing of Tendon Microtrauma Pathology

Stage	Pathology, Healing, & Objectives	Treatment Implications
Inflammation	**- ↑ GAG & collagen synthesis**	**- REST (activity cessation)**
(if present)	**-** Prevent prolonged course of inflammation (if present)	**-** NSAID's, oral corticosteroids
(days 1 - 6)	**-** Prevent injury to developing collagen	**-** Low level ROM exercises
Some authors:		**-** Cryogenic therapy
(day 1 or 2 only)		**-** Load reducing devices: casting, bracing, heel lifts, etc.
Fibroplastic	**-** ↑ rate of collagen synthesis by fibroblasts	**-** Low level / low duration exercise
Proliferation	**- Synthesized collagen fibers need to be aligned**	**- Stretching → align collagen**
(days 5 - 21)		**-** Cryogenic-thermogenic therapy
		- Ultrasonography **-** Laser
		- Electricity → ↑ fibroblast activity
Remodeling	**-** ↑ rate of crosslinkage formation & fibril size	**-** Strengthening exercises
Maturation	**-** Replacement of initial and / or inferior tissues	**-** ↑ intensity & duration
(20 days – 6 months)		**-** Stretching exercises to further stimulate collagen alignment

* **Note: almost all body tissues follow this paradigm of healing only with a different timeframe**

Immobilization vs. Mobilization: A Fine Line



- **Effects of immobilization on injured tendinous tissue**
  - Protein degradation exceeds protein synthesis → net ↓ in collagen quantity
  - Reduction in the number of collagen crosslink bonds
  - Atrophy of tissues at myotendinous (muscle - tendon) junction
    - **2% loss of total collagen mass at 9 weeks……27% loss at 12 weeks.**

- **Benefits of mobilization (movement) on injured tendinous tissue**
  - The cross-sectional area of the healed tendon is greater
  - Improvement in collagen fiber type and fiber arrangement in the repair
    - Type I – most abundant type humans – highest tensile strength of the 3 types
      - In tendons, muscle endomysium, fibrocartilage, bone, “final” scars
    - Type II - found in hyaline cartilage
    - Type III – found in granulation tissue, reticular tissue, & basement membranes
  - Greater number of crosslink bonds
  - Better quality of ground substance in the tendon

Common Therapies for Tendon Microtrauma

- **NSAID drugs**
  - In the 80'S and 90'S, approximately 73% of studies show NSAID's to be effective in:
    - ↓ healing time ↓ inflammation
  - Other, more recent studies show **no measurable benefit of NSAID's**
    - Note: Approximately 50% of those using NSAID drugs will have adverse side effects
- **Corticosteroids**
  - **Oral Corticosteroids:** Short term use of such drugs as (**MEDROL DOSEPACK, PREDNISONE**) appear helpful for some ailments including:
    - Neuritis
    - Paratenonitis
    - Bursitis

    (Conditions where **inflammation** is indeed present)
  - **Corticosteroid (Cortisone) Injections** Injections:http://orthopedics.about.com/cs/paindrugs/a/cortisone.htm
    - **Will reduce pain but usefulness in ↓ inflammation & ↓ healing time has not been proven**
    - Side effects: collagen disarray, tendon rupture, skin depigmentation, atrophy at injection site
    - Used only after a 6-week trial of rest then re-conditioning
    - Used only when site of pain is palpable - avoid injection directly into tendon (inject in sheath only)
    - Allow 2 - 6 weeks after injection before re-conditioning
    - Avoid more than 3 injections
    - Avoid injections just prior to competition (↓ pain → ↑ likelihood of injury exacerbation)
- **Surgery - excision / debridement of damaged tissue - release & repair**
  - Replace "bad scar" with "good scar" - not always successful (success rate 70% - 90%)
  - Does not remove microtraumatic injury stimulus – same recurrent stimulus → problems can re-appear

Chondromalacia – "Runner's Knee" – "Patellofemoral syndrome"

Chondromalacia – degeneration & inflammation of articular cartilage:

- Usually affects the underside of the patella (most common)
- Often involves bottom of femur and top of tibia
- More common in women (greater Q-angle ➡ ⬆ lateral forces on kneecap)

Causes

- Excessive running with tight hamstrings, tight calf muscles, pronation from ITB syndrome
- Muscle imbalance results in a tracking abnormality of the tibia in the femoral groove
  - Vastus lateralis tends to be more powerful than the vastus medialis

Risk Markers & Clinical Signs

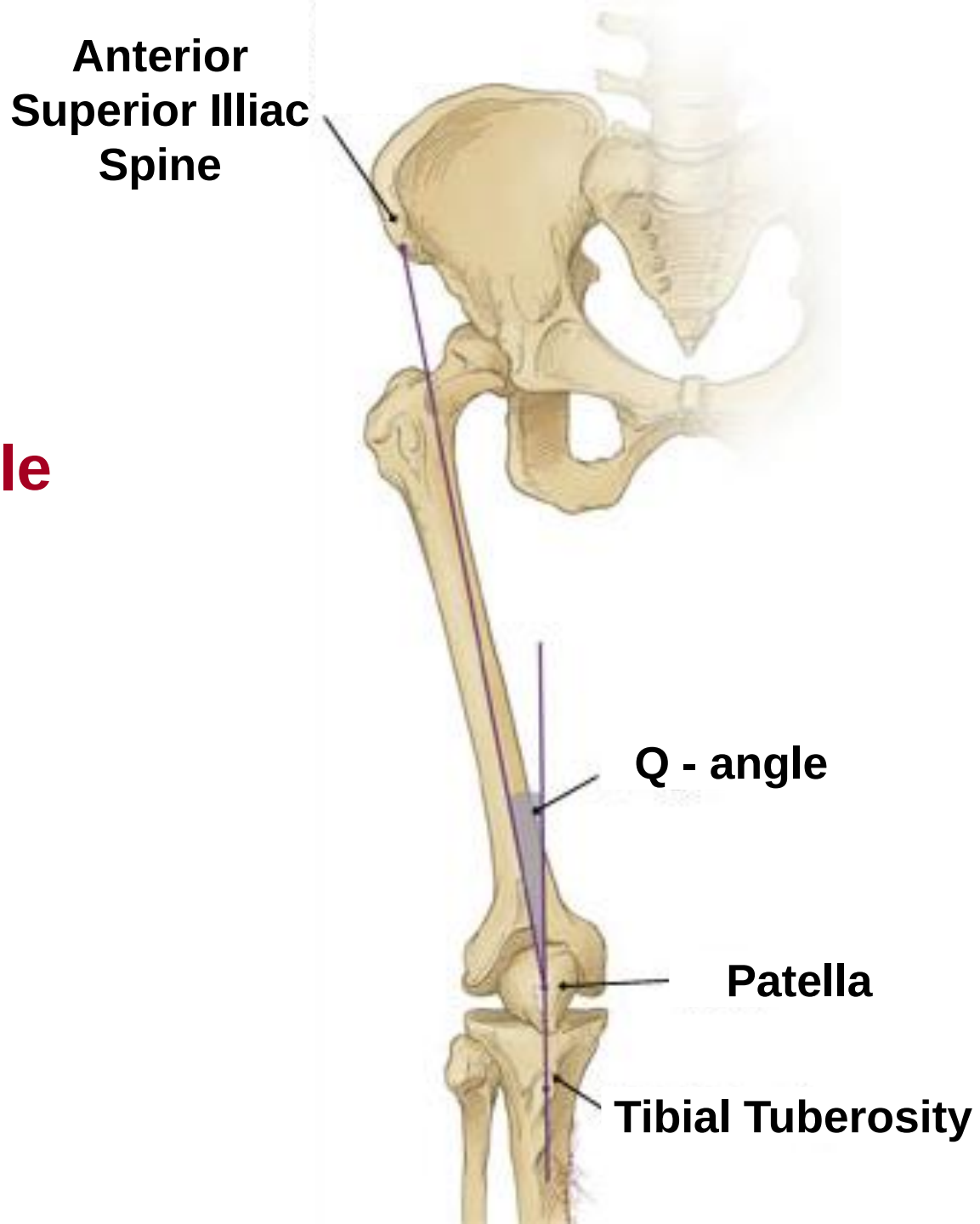
- Q-angle > 15 degrees (associated with Gena Valgum – "knock knees")
- Pain with contraction of quadriceps while patella is held in groove

http://www.return2fitness.co.uk/injury_advice/knee_injuries/cmp.php

Treatment – 1st: removal of inflammatory stimulus

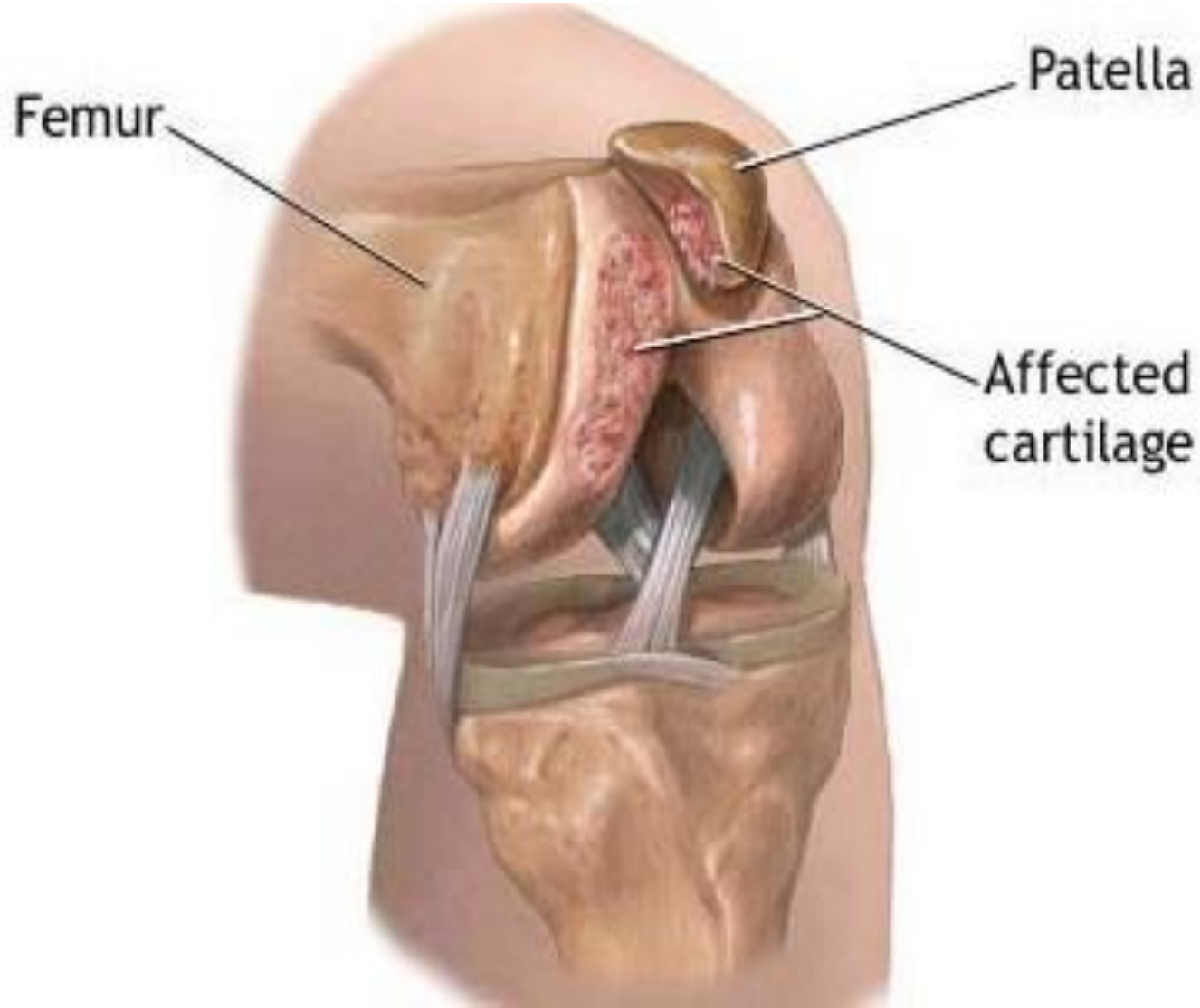
- **R**ICE – NSAID's
- Orthotics to correct pronation
- Stretching to ⬆ flexibility in hamstrings, calf muscles, & ITB
- Strengthen quads, hamstrings, hip flexors, hip adductors, and hip abductors
- Avoid downhill running (eccentric contractions) when returning to activity
- Surgery
  - 1. Lateral release (cutting lateral patellar retinaculum ➡ better patella tracking)
  - 2. Smoothing down the underside cartilage of the patella
    - Successful about in 90% of cases

The Q - Angle


Anterior
Superior Illiac
Spine
Q - angle
Patella
Tibial Tuberosity

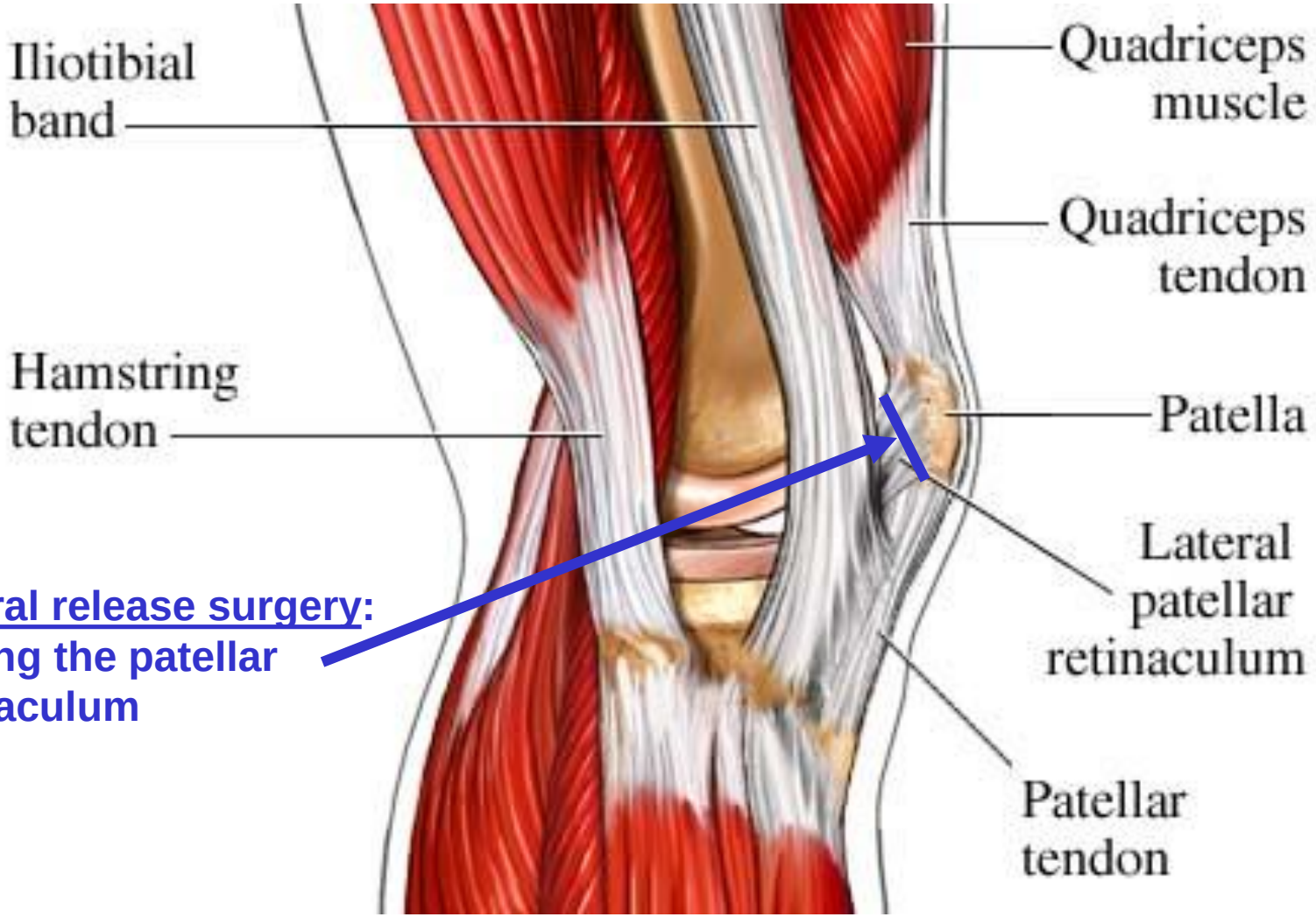
Chondromalacia – “Runner’s Knee” – “Patellofemoral syndrome”

Left Knee



Chondromalacia – “Runner’s Knee” – “Patellofemoral syndrome”

Right Knee



Lateral release surgery: cutting the patellar retinaculum

Lateral release Using Thermal Cauterizing Scalpel

Chondromalacia – “Runner’s Knee” – “Patellofemoral syndrome”

Arthroscopic / Laser Correction of Chondromalacia

White “whispy” material is roughening of the cartilage of the underside of the patella

New smooth surface after laser removes damaged cartilage

Patellar Tendinitis (Tendinosis / Tendinopathy) – "Jumper's Knee"

Patellar tendinitis – degeneration and or inflammation of patellar tendon or tendon sheath

- Usually affects participants of "explosive" sports involving jumping or quick movements
  - Basketball & volleyball players most affected (frequent "stops", "starts", & "jumps")
- Once again, the controversy – tendinitis vs. tendinosis (tendinopathy)
  - Most now agree that most tendon overuse injuries involve little inflammation
  - Mucoid deposits (soft greenish brown disorganized tissues) are present
  - Patellar tendonopathy may be accompanied by micro-ruptures and necrosis
  - It may predisposes the tendon to rupture

http://www.return2fitness.co.uk/injury_advice/knee_injuries/jumpers_knee.php

Causes

- Excessive activity (especially a rapid increase in the frequency or intensity of training)
- Improper mechanics of training
- Excessive weight on person doing a lot of weight bearing exercises

Symptoms

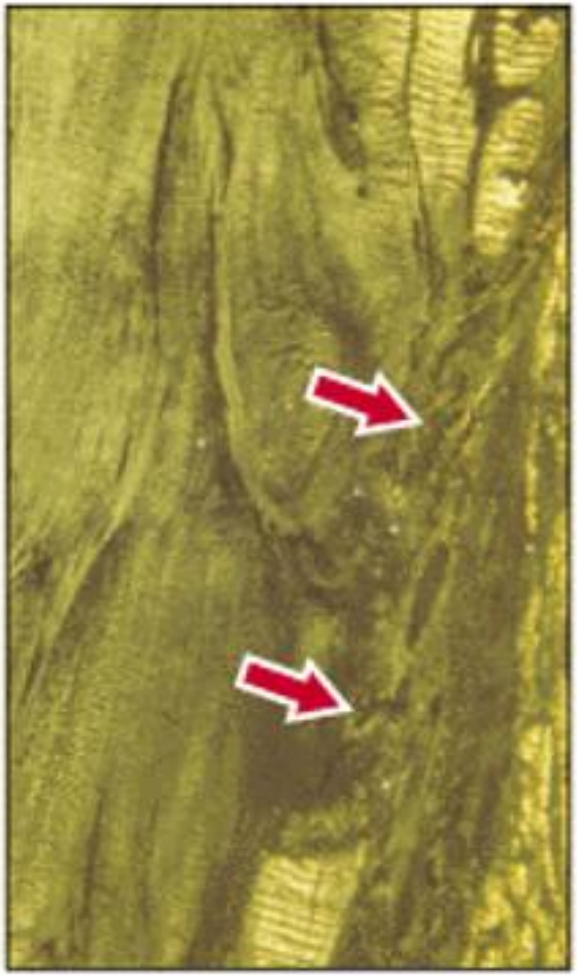
- Pain / tenderness in the patellar tendon below the knee when jumping, running, or walking
- Pain or "tightness" in the knee when bending, squatting, or straightening the leg

Treatment- first, removal of injury stimulus

- **R**ICE – emphasis on rest followed by quadricep strengthening exercises
- Ultrasound & laser photostimulation ➞ increase collagen synthesis
- NSAID's & corticosteroids have, for the most part, found to be ineffective
- Surgery
  - Excision of the damaged portion of tendon

Patellar Tendinosis

Normal Patellar Tendon



Patellar Tendinosis – note greenish-brown mucoid appearance with tissue degeneration (red arrows)

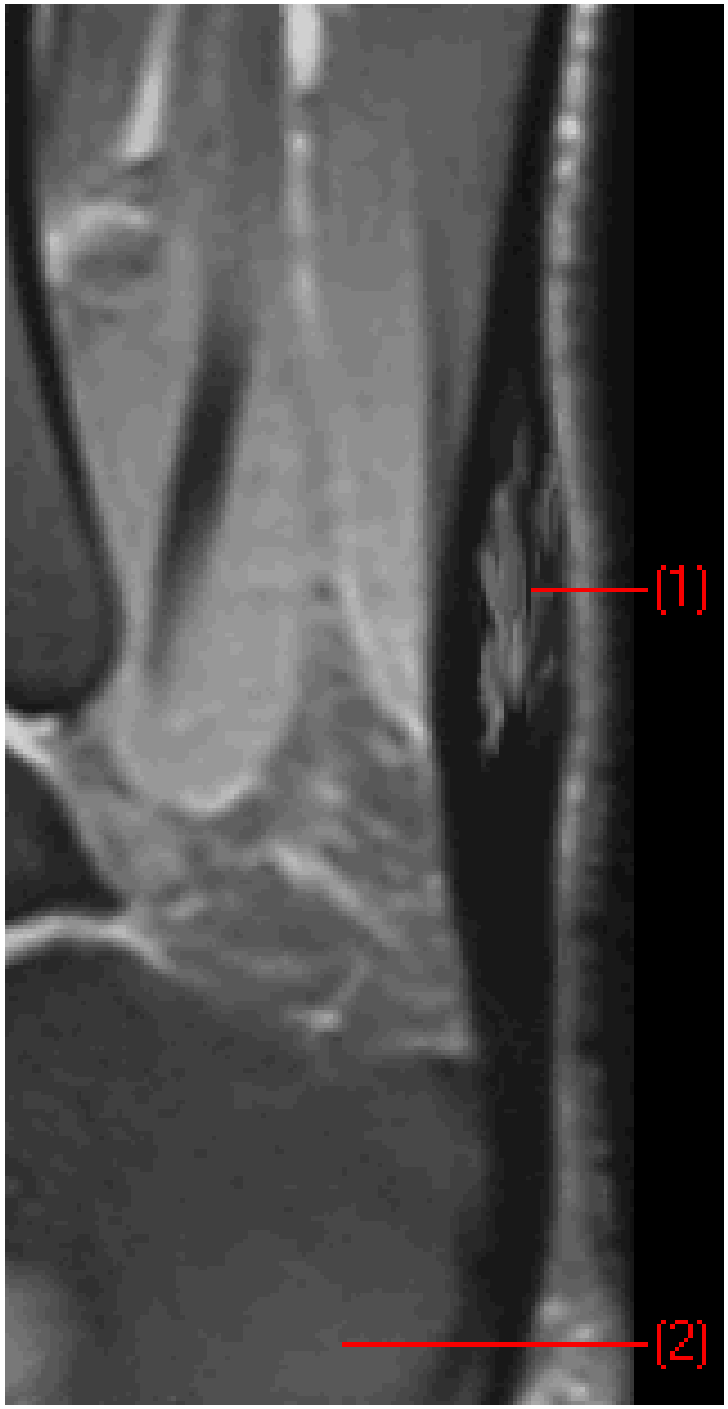
Achilles Tendinosis

- [1] ↑ signal intensity → fluid + tissue degeneration
- [2] Calcaneous

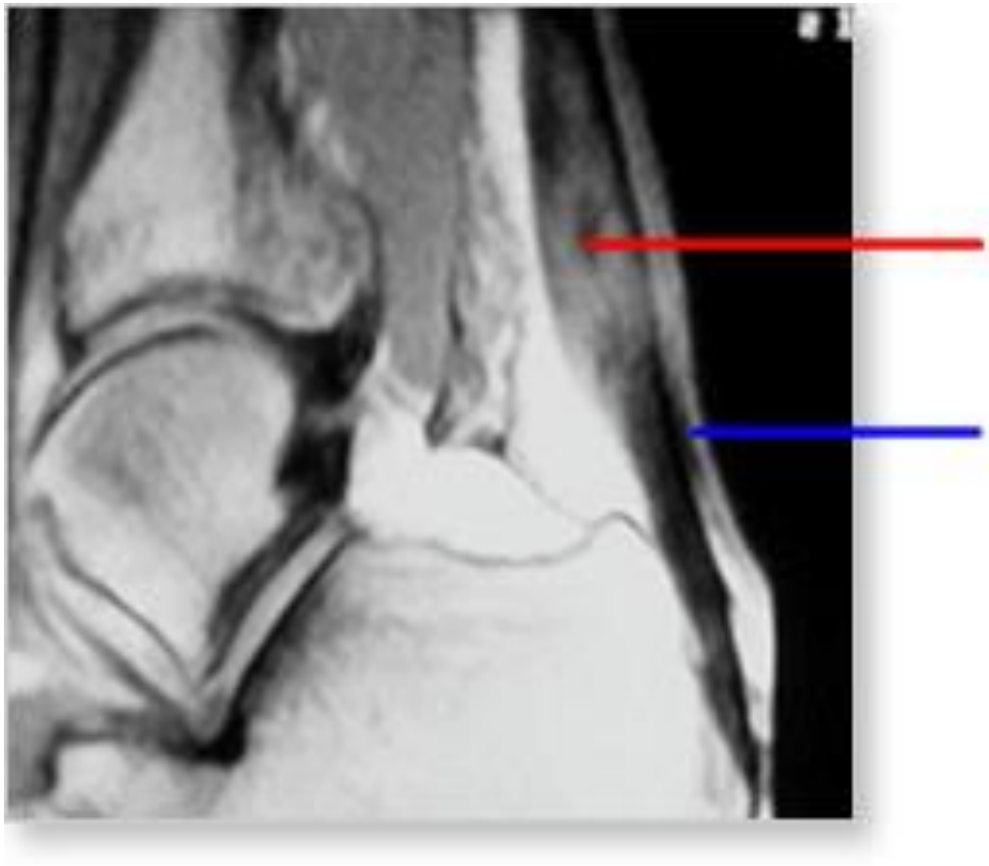
- **Histopathology of Achilles Tendinosis**
  - ↑ vascularity (neovascularization)
  - Collagen fiber disorganization
  - Thinning of tendon fibers
  - Mucoid or lipoid deposits between fibers
  - Inflammatory cells at sites of micro-rupture (rare)

- **Symptoms & Diagnosis**
  - Painful push-off when walking or running
  - Palpable nodule on achilles tendon
  - Tendon may be swollen or thickened

- **Treatment**
  - Cessation of activity and / or immobilization
  - Stretching exercises
  - Modalaties
  - Heel lift orthotics
  - Surgery in extreme cases
  - Gradual return to activity



MRI of Achilles Tendinosis



Here again is an MRI of a chronic degenerative tendinopathy. Note the the thickening and swelling (⬆ fluid) which is visible as the “whispy” light gray color (red line) on the regular black Achilles Tendon “tube” (blue line)

Achilles Tendinosis Surgery

Achilles tendon is exposed revealing a split in the tendon

The necrotic portion of the tendon is removed

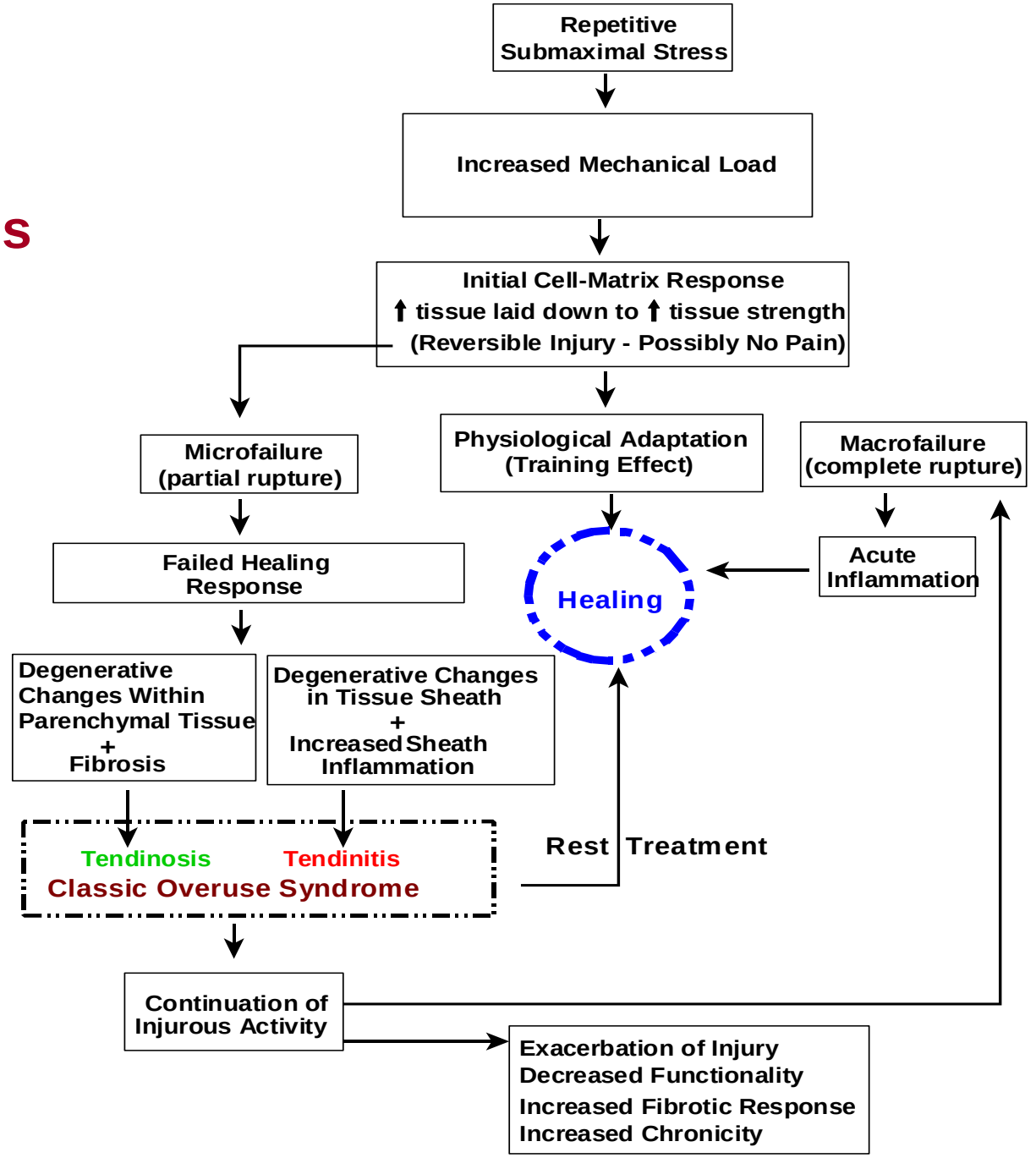
The ends of the tendon are brought together and sutured

True Achilles Tendonitis (Inflammation of Paratenon)

- Diagnosed by pain syndrome and palpating the tendon where it is slightly thickened and tender along its inner edge, about four-centimeters above the attachment to the heal bone
- May be caused by excessive pronation in runners
- Treated with cessation of activity / **RICE**, physical therapy, orthotics to ↓ pronation, NSAIDS, heal lifts to reduce stress on tendon
- Physical therapy usually has the patient back to activity in 2 – 3 months
- Severe cases: surgery may be needed to remove inflamed paratenon

http://emedicine.medscape.com/article/85115-overview

Healing of Microtraumatic Tendinous Injuries



Stress Fractures (Hairline Fractures)

Bone Stress Continuum:

Stress Reaction ⟷ **Stress Fracture**

- **Stress Reaction**:
  - Accelerated adaptive bone remodeling
  - Most often asymptomatic
  - Occurs most often in tarsals, metatarsals, femur, & tibia
  - Sometimes seen on X-ray as increased callus (“bone”) deposits

- **Stress Fracture**:
  - Complete defect or “crack” in the bone
  - Easily seen on X-ray

Stress Fractures

- **Occurs only in race horses, greyhounds, & man**
  - Intensity and / or volume of activity is not natural
- **Most stress fractures heal by themselves without clinical manifestations**
- **Causes:**
  - Repetitive torque across a bone http://orthoinfo.aaos.org/topic.cfm?topic=A00112
  - Weight bearing impact forces
    - Bone does not adapt as well as muscle to impact forces
  - Inability of weak musculature to facilitate shock absorption
  - Low bone mineral density
  - Structural malalignments (leg length discrepancy)
- **Stress fractures ↑ risk of complete fracture at the stress fracture site**
- **Early stage stress fractures (stress reactions) don't show up well on X-rays**
  - Better detected by bone scan - shows up as "hot spots" (areas of increased remodeling)
- **Symptoms:**
  - Tenderness & pain over the fracture site and pain during activity
    - Early on, pain is light and occurs at end of activity….later….pain is more severe and occurs earlier
    - Pain relieved by rest but becomes progressively more frequent & persistent
  - Overlying soft tissue may exhibit swelling
  - Ultrasound or struck tuning fork placed over the fracture site will elicit pain
  - Muscle atrophy may occur at or near the stress fracture site

Stress Fractures

- **Types of stress fractures:**
  - Oblique / Transverse
    - Angled to / perpendicular to the long axis of the bone
    - Most common
    - Dangerous due to the chance of complete fracture & bone “displacement”
  - Longitudinal (paralell to the long axis of the bone)
  - Compression

- **Two Common Examples of Stress Fractures:**
  - Tibial stress fracture in runners
    - Weight bearing impact related
  - Humerus stress fracture in a “thrower” (pitcher, javelin thrower, etc.)
    - Related to muscle trying to accelerate a “resisting” bone (torque)

Stress Reaction of Left Tibia

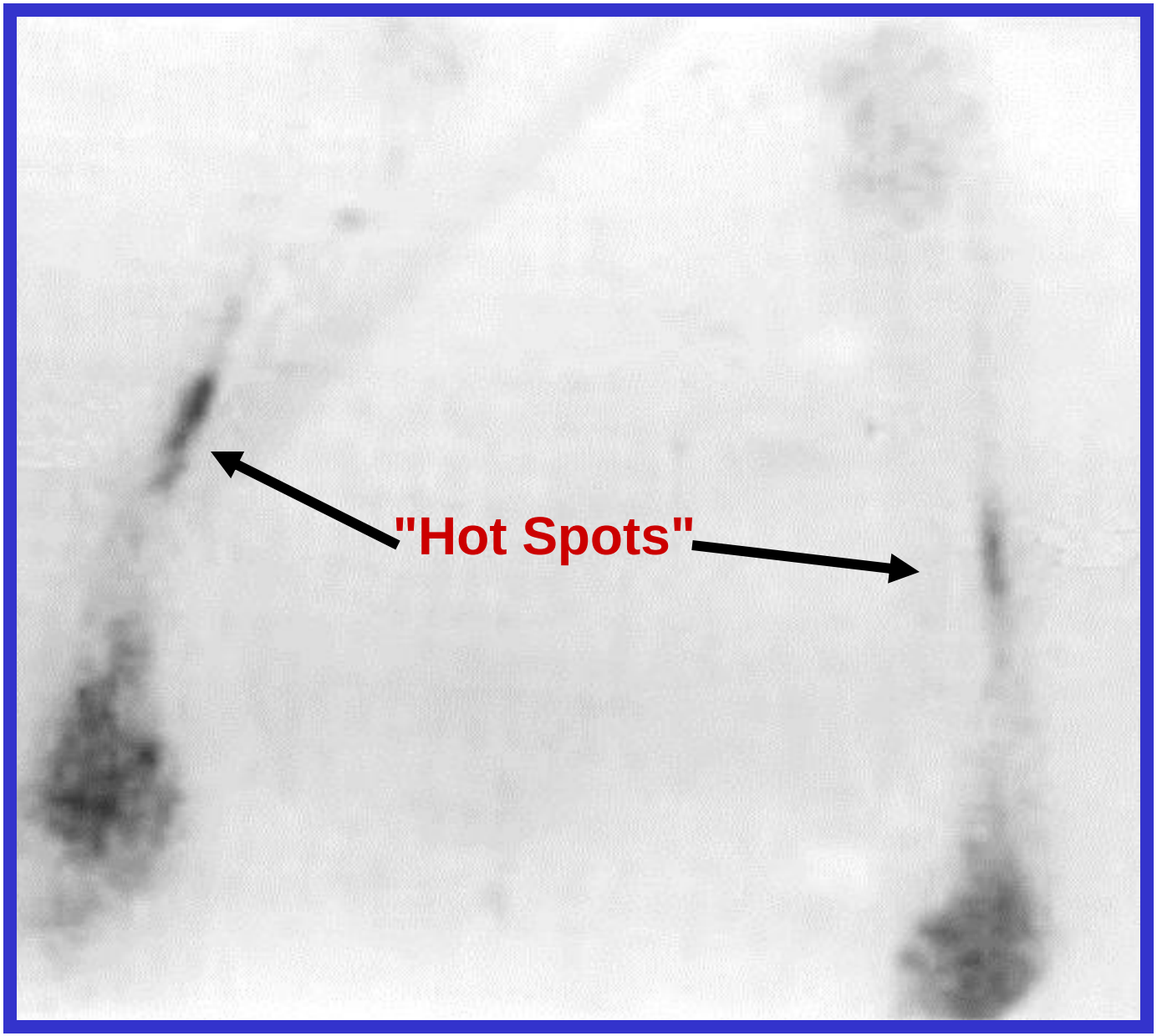
Stress Fracture of Tibia in a Runner

Note clearly defined "Crack" in addition to Extra Callus

"Crack"

MRI of Stress Fracture of the Calcaneous

Bilateral Stress Fractures of the Ulna in a Weight Lifter



Stress Fractures

Stress Fracture of 3rd Metatarsal in a Runner

Note the extra callus increasing the girth of the bone