Flexor Tendon Injuries

Anatomy
Blood supply
- Diffusion most important within sheath
- Direct vascular supply outside sheath
Pulley system prevents bowstringing
- A2 and A4 most important in fingers
- Oblique pulley most important in thumb

Verdan Injury Zones
1 - Distal to FDS insertion
II - FDS insertion to distal palmar crease
III- Distal palmar crease to carpal tunnel
IV - Carpal tunnel
V - Wrist proximal to carpal tunnel, forearm

Treatment
Nonoperative
- Partial lacerations < 60% tendon width
Operative
- Acute (< 3 wks) - lacerations > 60% width
- Chronic finger - tendon reconstruction
- Chronic thumb - ring FDS to FPL transfer

Technique
Core suture strands
- # crossing repair determines strength
- 4-6 strands adequate for early active ROM
- Ideal purchase 10 mm from cut edge
Epitendinous suture
- Improves strength 20%, tendon gliding
- Decreases gap formation
- Simple running is recommended

WALANT Technique - Intraoperative Active Motion
Intraoperative assessment of gap formation
Allows debulking bunched repairs, venting of A2 and A4 pulleys
Allows tendon repair within flexor sheath
Facilitates postoperative early active motion

Postoperative Rehabilitation
- Early active ROM - mod force, high excursion
- Early passive motion protocols
- Duran - low force, low excursion
- Kleinert - low force, low excursion
- Mayo synergistic - low force, high excursion
- Immobilization - children, noncompliant pts
Complications
Tendon adhesions - most common
Re-rupture - rate 15-25%
• If < 1 cm scar, then resect, revision repair
• If > 1 cm scar, then tendon graft
Joint contracture - as high as 17%

Fingertip Amputations

Fingertip Amputations
Treatment goals
• Sensate, durable tip coverage
• Adequate bone to support nail growth
Factors determining treatment
• Amputation characteristics
• Radiographs showing bone involvement

Treatment Options
Nonoperative - secondary intention
• No bone or tendon involved, < 2 cm skin loss
• Children with exposed bone
Operative treatment
• Revision amputation keeping nail bed support
• FTSG hypothenar, > 2 cm skin loss
• Flap reconstruction

V-Y Advancement Flap
Indicated for transverse or dorsal oblique amputations
Flap carried to new position by sliding technique

Thenar Flap
Volar oblique defect
Index or middle fingers
Age < 30 years
Complicated by PIPJ stiffness

Cross Finger Flap
Volar oblique defect
Age > 30 years
Less digital stiffness

Moberg Flap
Volar thumb defect < 2 cm
Advancement flap < 1 cm
Possible IPJ contracture

Krukenberg Procedure
Convert radius, ulna into claw-like pincer
Radius is mobile ray (BR, FCR, ECRL, ECRB)
Ulna is fixed ray (FCU, ECU, EDQ)
Bilateral upper extremity amputee, blind
Replantations

Indications for Replantation
Primary indications
• Thumb, any level
• Multiple digits
• Through palm, wrist, proximal to wrist
• All part in children
Relative indications
• Single digits distal to FDS (zone I)
• Some ring avulsions
• Through or proximal to elbow

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Contraindications to Replantation
Primary contraindications
• Severe vascular disorder
• Mangled limb, crush injury
• Segmental amputation
• Prolonged ischemia > 6 hrs, large muscle content
Relative contraindications
• Single digits proximal to FDS (zone II)
• Medically unstable, psychiatric, tissue contamination
• Prolonged ischemic > 12 hrs, no muscle content

Sequence of Replantation
Vascular shunt if large muscle content
Bone fixation +/- shortening (after debridement)
Extensor tendon repair
Arterial repair (after bone if ischemia > 4 hrs)
Venous anastomoses
Flexor tendon repair
Nerve repair
Skin +/- fasciotomy

Scaphoid Fractures

Most frequently fractured carpal bone
Incidence - 15% of acute wrist injuries
Location - 65% waist, 25% proximal, 10% distal
Mechanism - axial load, wrist HE, RD
Prognosis - AVN prox third 33%, prox fifth 100%

Scaphoid Vascularity
Major blood supply
• Dorsal carpal branch of radial artery
• Enters dorsal ridge, prox 80%, retrograde flow
Minor blood supply
• Superficial palmar arch of volar radial artery
• Enters distal tubercle, supplies distal 20%

Scaphoid Imaging
Radiographs - scaphoid view - 30° DF, 20° UD  
Bone scan - occult fx at 72 hrs - sp 98%, sen 100%  
MRI - most sensitive for occult fx at 24 hrs, assess proximal pole vascularity on T1 sequence  
CT scan - best for location fx, size fragments, collapse, progression to nonunion

**Nonoperative Treatment**  
Thumb spica cast - long-arm vs short-arm  
Duration of immobilization  
• 3 months - distal waist  
• 4 months - mid-waist  
• 5 months - proximal third  
Pulsed electromagnetic field may help  
< 1 mm displacement - 90% union rate

**Operative Treatment**  
Unstable fractures  
• Proximal pole  
• Displacement > 1 mm  
• 15° humpback deformity  
• Comminuted or oblique fractures  
Non-displaced waist fractures  
• Decrease time to union  
• Faster return to work

**Operative Technique - ORIF vs Percutaneous Fixation**  
Dorsal approach  
• Indicated for proximal pole fractures  
• Preserve dorsal ridge blood supply  
Volar approach  
• Indicated for waist & distal pole fractures  
• Exposes entire scaphoid

**Scaphoid Nonunion w/o SNAC Wrist**  
Minimal deformity - inlay (Russe) BG - 92% union  
Humpback - interposition (Fisk) BG - 72-95%  
Proximal pole, AVN - 1-2 ICSRA vascularized BG  
Prox pole, AVN - MFC vascularized BG using descending genicular artery pedicle  
(from SFA)

**Carpal Tunnel Syndrome**

**Carpal Tunnel Syndrome - Risk Factors**  
Gender (3:1, women: men)  
Obesity  
Hypothyroidism  
Diabetes (14-30%)  
Pregnancy (50%)  
Renal disease  
Inflammatory arthritis  
Mucopolysaccharidoses  
Advanced age (> 50 yrs)  
Genetic factors
Carpal Tunnel Syndrome - Causation
Work causation is controversial - dental hygienists, beef packers, assembly line workers
Positional, mechanical & repetitive stress
Hand-held vibrating tools are causative
Keyboarding is not causative
Athletics - cycling, tennis, throwing
Space occupying lesions (e.g., gout)

Carpal Tunnel Syndrome - Clinical Diagnosis
Median paresthesia aggravated by grasping
Nocturnal paresthesia
Morning numbness
Symptoms relieved by shaking the hand
Grip weakness, fatigue (thenar intrinsics)

Carpal Tunnel Syndrome - Physical Findings
Sensory tests (Semmes-Weinstein, 2 PD)
Provocative tests (Phalen’s, Tinel’s, Durkan’s)
Motor tests (FPB strength, thenar atrophy)

EMG/NCS is Confirmatory
Not necessary for diagnosis
May quantify disease severity
Serves as a preoperative baseline
In early CTS or dynamic CTS, may be normal
If demyelination, increased latencies, decreased conduction velocities
In late CTS, EMG shows fibrillations, abn MUPs

Methods of Carpal Tunnel Release
Standard open
Mini-open
Percutaneous, ultrasound guided
Endoscopic (one or two incision)

Not Required in Carpal Tunnel Release
Release Guyon’s canal
Step-cut lengthening TCL
Flexor tenosynovectomy
External epineurotomy
Internal neurolysis
Preserve subcutaneous nerves

Peripheral Nerve Injuries & Repair

Mechanism of Injury
Stretch - e.g., neurapraxia of bp (stinger)
• 8% elongation decreases microcirculation
• 15% elongation disrupts axons
Compression or crush
• 30 mmHg > paresthesia
• 60 mmHg > conduction block
Laceration initiates nerve regeneration
Wallerian Degeneration
Axoplasm, myelin are degraded distally
Schwann cells proliferate, line up on BM
Proximal budding (1 month delay, 1 mm/day)
Neurotrophic factors attract sprouting axons

Factors Affecting Prognosis
Age - single most important factor
Level of injury - distal is better prognosis
Type of transection - sharp is better
Repair delay - worse prognosis (limit = 18 mo)

Neuron Morphology
Neuron is functional unit
Cell body contains nucleus
• Motor (anterior horn of cord)
• Sensory (dorsal root ganglion)
Axon propagates action potentials (APs)
Dendrites receive adjacent nerve input

Peripheral Nerve Anatomy - Terminology
Epineurium - surrounds group of fascicles
Perineurium - covers individual fascicles, primary source tensile strength, elasticity
Endoneurium - covers axons, participates in formation of Schwann cell tube
Myelin - made by Schwann cells, insulates axons, increases conduction velocity

Seddon Classification
Neurapraxia - focal nerve compression and demyelination, reversible conduction block
Axonotmesis - axon & myelin disruption, conduction block, Wallerian degeneration
Neurotmesis - complete nerve disruption, no recovery w/o repair

Nerve Conduction Study (NCS) - Focal Compression / Demyelination
Increased latencies
• Distal sensory latency > 3.2 ms (for CTS)
• Distal motor latency > 4.3 ms (for CTS)
Decreased conduction velocity < 52 m/sec
Decreased amplitude
• Sensory nerve action potential (SNAP)
• Motor action potential (MAP)

Limitations of NCS
Evaluates only large myelinated axons
Unmyelinated axons are first affected
May have normal latency w/disease
Study quality is examiner dependent

Electromyography (EMG)
Evaluates muscle activity
• Spontaneous activity
• Voluntary activity
Muscle denervation
• Fibrillations
• Positive sharp waves
• Fasiculations

Nerve Grafting
  Autologous graft indicated for gaps > 3 cm, gold standard for defects > 5 cm
  Collagen conduit indicated for defects < 2 cm, outcomes equal to autologous for gaps < 5 mm
  Allograft for defects up to 5 cm

Top Ten Test Taking Hints
  1. Pace yourself
  2. Skip difficult questions
  3. Record answers as you go
  4. Answer on basis of first impression unless you have misread the question
  5. Correct responses have “may” or “can”
  6. Incorrect responses have double negatives, generalizations (“always” or “never”)
  7. Eliminate the wrong answers
  8. Guess most conservative treatment or the longest answer
  9. Choose the completely correct answer
  10. Rest before the test!