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Lateral ankle instability – surgical considerations

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- No Conflicts

Overview

- Epidemiology
- Anatomy
- Classifications
- Acute Injury
- Clinical Findings
- Radiology
- Conservative Treatment
- Surgical Treatment

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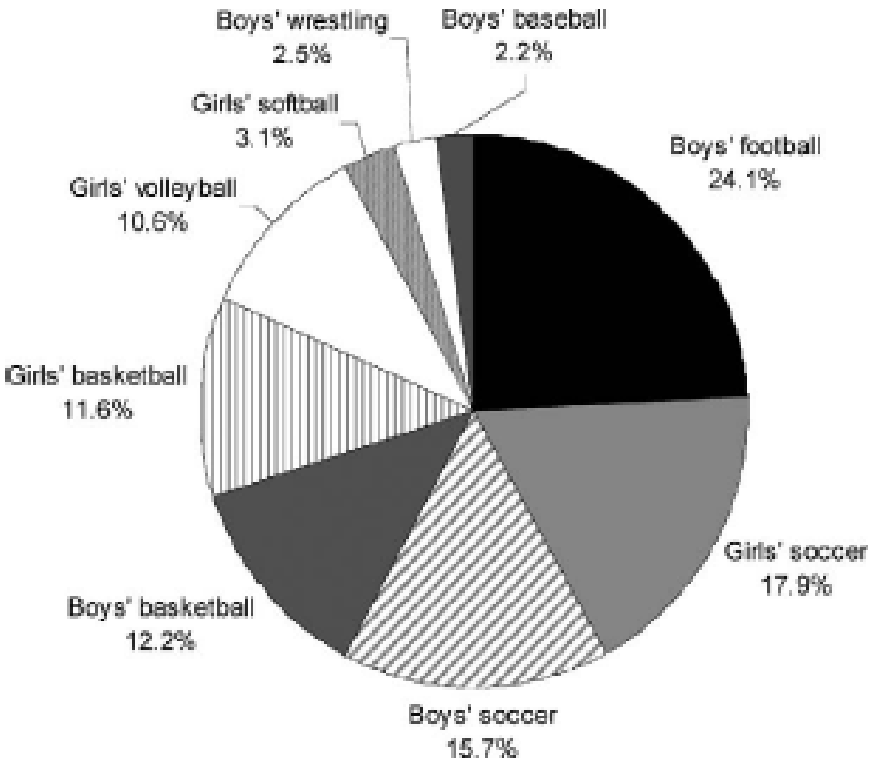
Ankle Sprain Facts

- One of most common F&A injuries
  - Lateral ankle sprains 85%
- 2 million acute ankle sprains per year in US
  - ~ 60% seek medical care
  - ~ $2 billion
- Peak Incidence: 15-19yo
  - 50/50 M/F
- 50% occur during athletic activity, 27% stairs
  - 30% of sports injuries = sprain



Waterman et al. JBJS. 2010.

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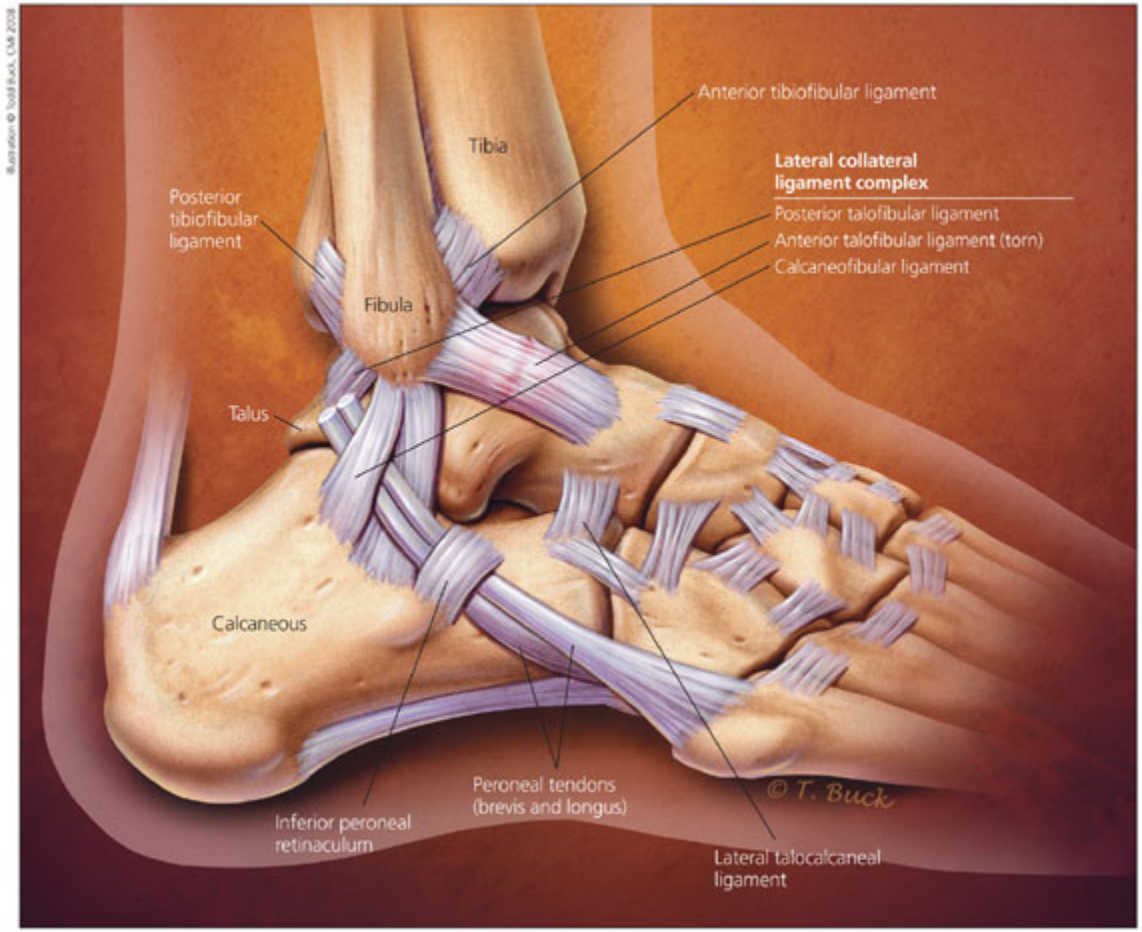
Anatomy



http://www.hss.edu/images/articles/ankle-anatomy-jmm.jpg

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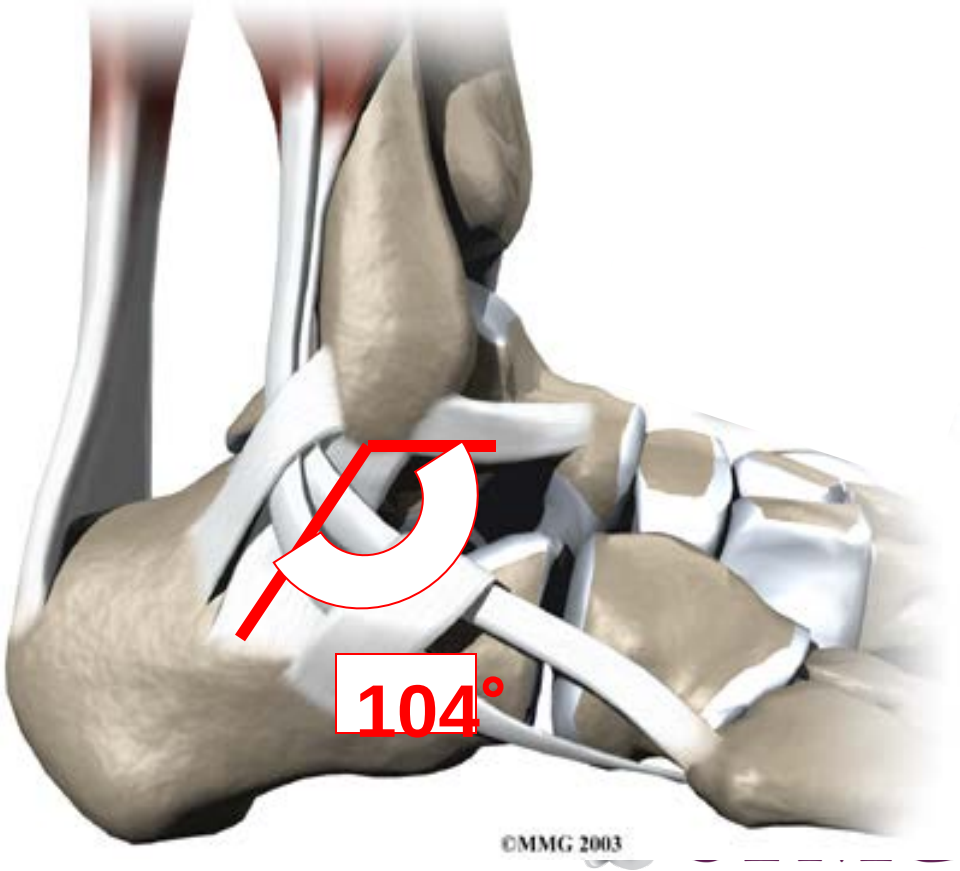
Anterior Talofibular Ligament

- Intracapsular
- Weakest
  - Primary stabilizer in PF

- Origin: 1cm proximal to distal tip of fibula
- Insertion: lateral talar neck

- 6-10 mm wide

- Restrains plantar flexion & internal rotation of the ankle
- Prevents anterior translation of talus



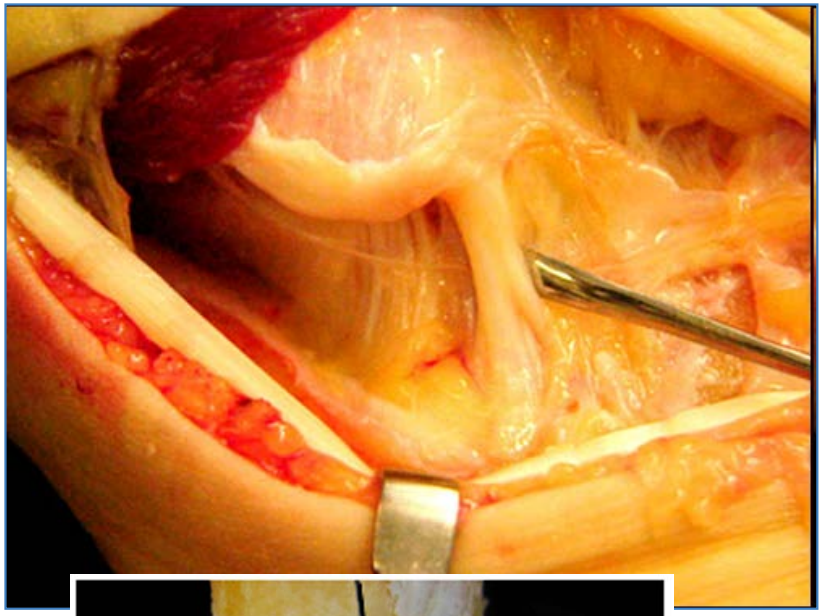
Calcaneofibular Ligament

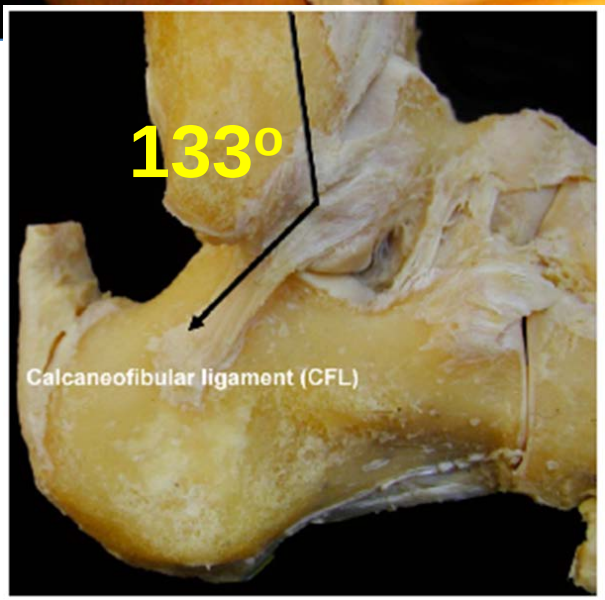
- Extra capsular
- Crosses AJ & STJ
- Critical for STJ stability

- Origin- distal tip fibula
- Insertion- calcaneus 13mm distal to STJ

- Forms floor of peroneal sheath

- Prevent excessive supination, inversion, internal rotation





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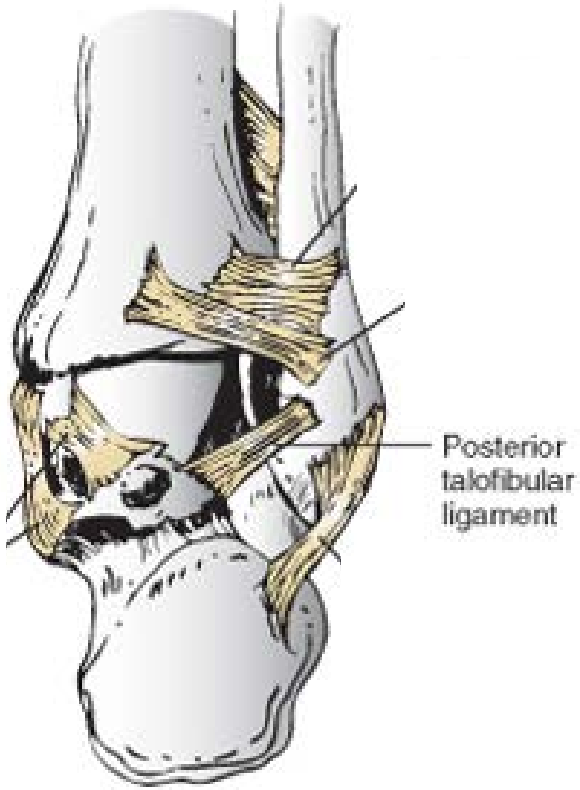
Posterior Talofibular Ligament

- Intracapsular
- Strongest

- Origin: 10mm prox to distal tip of fibula
- Broad insertion into posterior talus → FHL groove

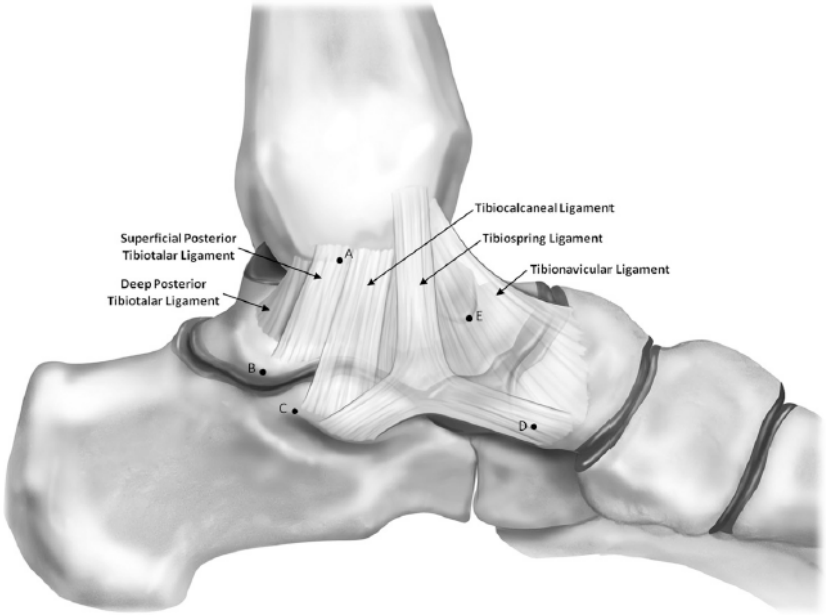
- Resist external rotation of talus

- Rarely injured?
- Rarely problematic in chronic ankle instability



Medial Ligaments

- Deltoid Ligaments
- Superficial vs Deep
- ~5% sprains tear deltoid ligaments
- More associated with PTTD?



The Ligament Anatomy of the Deltoid Complex of the Ankle: A Qualitative and Quantitative Anatomical Study

JBJS The Journal of Bone & Joint Surgery

Kevin J. Campbell, BS, Max P. Michalski, MSc, Katharine J. Wilson, MSc, Mary T. Goldsmith, MS, Coen A. Wijdicks, PhD, Robert F. LaPrade, PhD, MD, and Thomas O. Clanton, MD

- 14 cadavers
- Individuals ligament bands isolated
- All specimens with tibionavicular, tibiospring, and deep posterior tibiotalar
- Tibiocalcaneal, superifical posterior tibiotalar, deep anterior tibiotalar all variable
- Deep posterior tibiotalar largest band

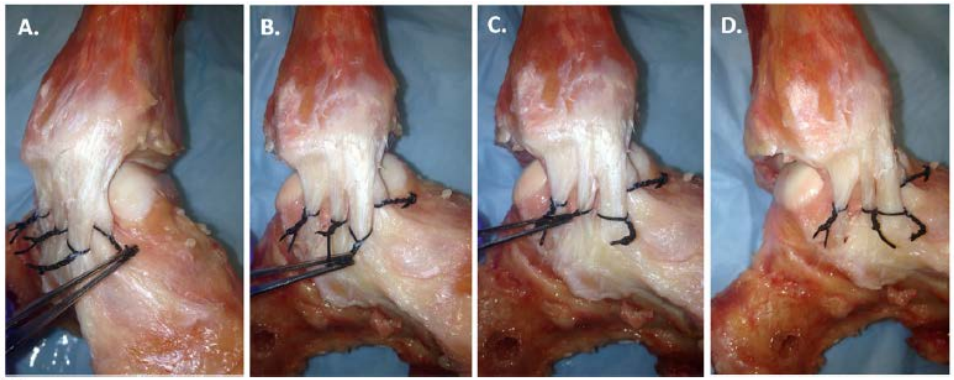


Fig. 1
Dissection photographs presenting the ligamentous bands (tagged with suture) of the superficial layer of the deltoid ligament in a left ankle. Four ligamentous bands composed the superficial layer of the deltoid ligament in this specimen and included the tibionavicular, tibiospring, tibiocalcaneal, and superficial posterior tibiotalar ligaments. **Fig.1-A** Anteromedial view of the deltoid ligament with the tibionavicular ligament grasped. **Fig.1-B** Medial view of the deltoid ligament with the tibiospring ligament grasped. **Fig.1-C** Medial view of the deltoid ligament with the tibiocalcaneal ligament grasped. **Fig. 1-D** Posteromedial view of the deltoid ligament with the superficial posterior tibiotalar ligament in view.

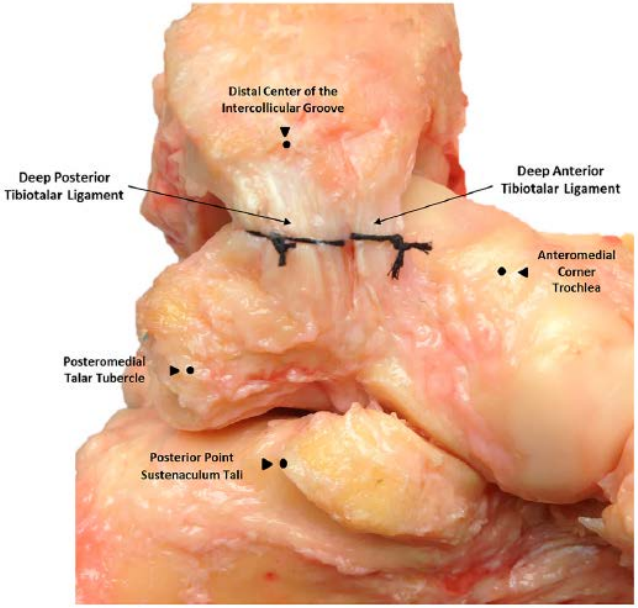
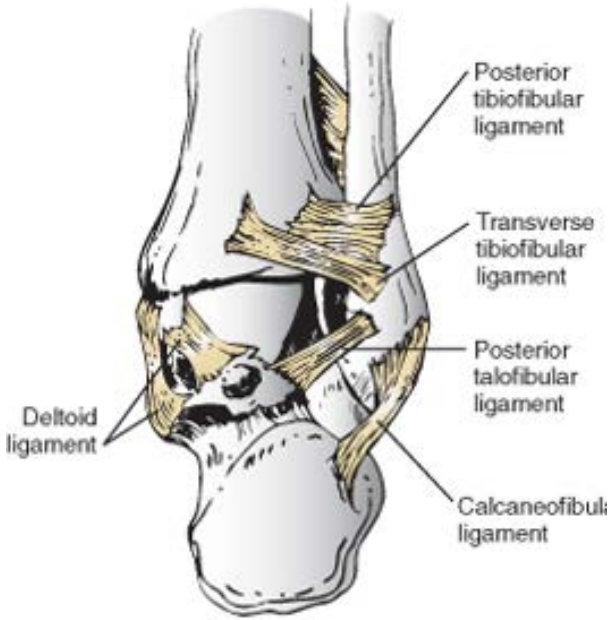
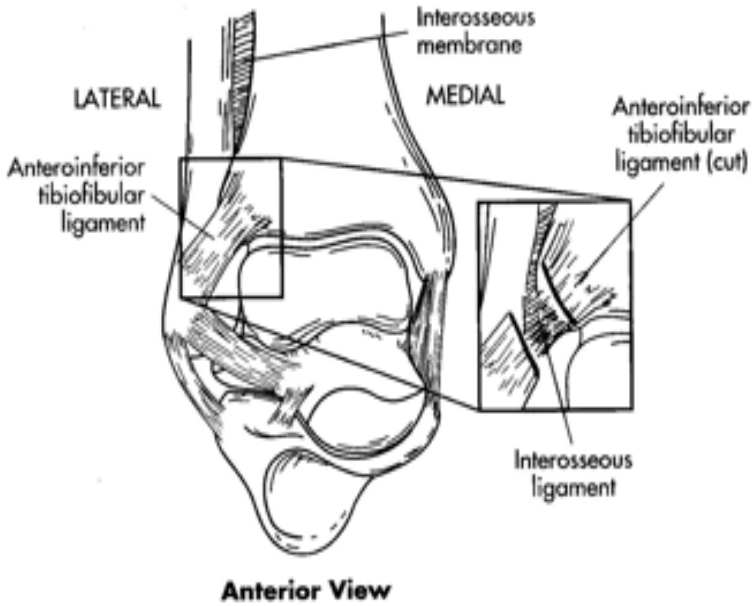


Fig. 2
Dissection photograph showing the deep layer of the deltoid ligament in a left ankle. Two ligamentous bands composed the deep layer in this specimen and included the deep anterior and posterior tibiotalar ligaments.

Syndesmotic Ligaments

- Syndesmotic injury associated with ankle sprain 1-11%
  - Hopkinson, FAI, 1990
- Anterior Inferior Tibiofibular
  - Bassett's
- Posterior Inferior Tibiofibular
  - Deep and SF
- Interosseous
  - Strongest





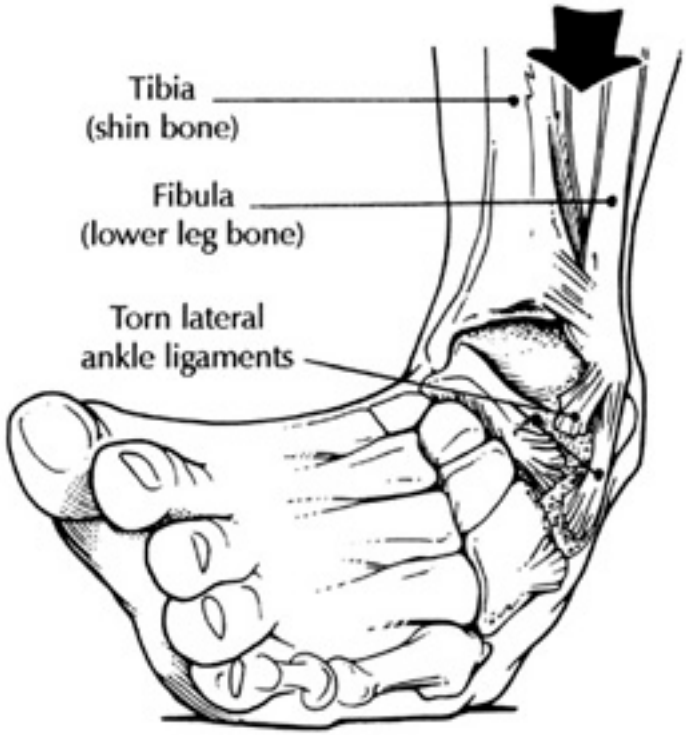
Injury Mechanism

- Lateral ligaments:
  - Injury mechanism
    - Combination of plantarflexion or dorsiflexion and inversion

ATFL

CFL

PTFL



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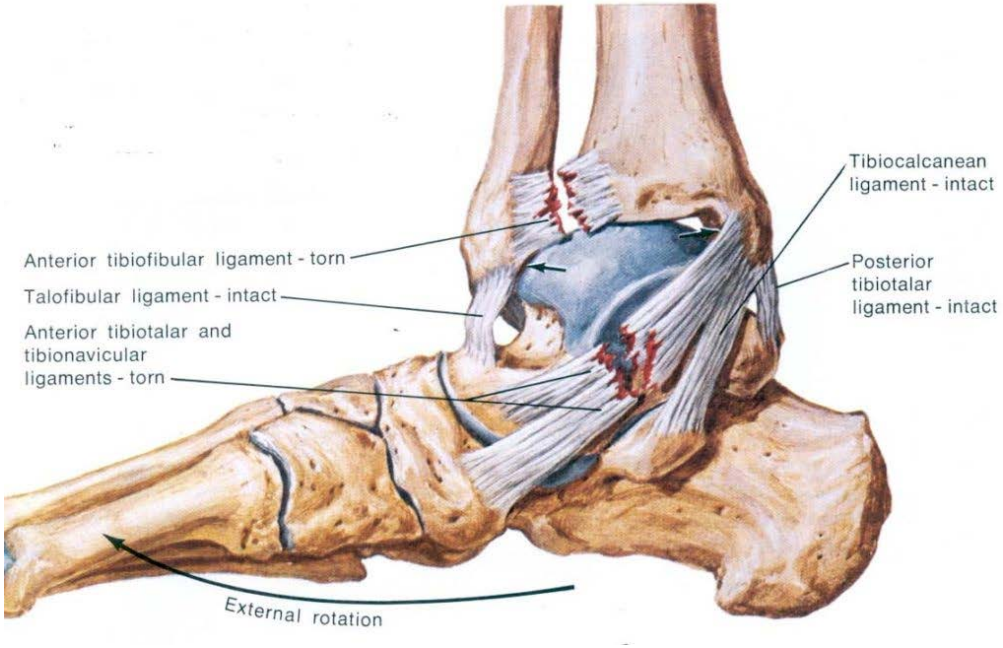
Injury Mechanism

- Medial Ligaments
  - Usually forced pronation, eversion
  - External rotation of foot/talus
  - Tend to be more problematic/longer to heal than lateral injuries
  - Chronic weakness/insufficiency associated with PTTD

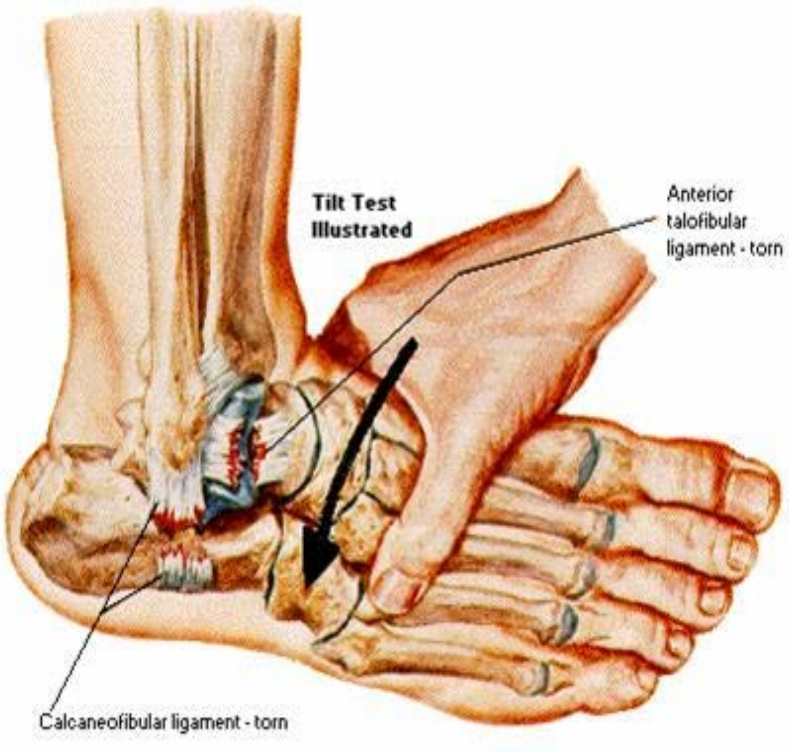


Injury Mechanism

- Syndesmosis
  - “High ankle sprain”
  - Most often from high energy contact sport
  - Forces disrupt the mortise can result in injury
    - External talar rotation
  - Isolated syndesmotic injuries rare
    - Chronic pain from untreated/not appropriately treated in associated injuries may result in chronic symptoms

Lateral Ankle Sprains

- Rupture Rates
  - ATFL
    - 75% ruptures
    - Stressed on PF and inversion
  - CFL:
    - 60% ruptures
    - Stressed on DF and inversion
  - PTFL
    - Rarely ruptures, 5%
    - Stressed on DF



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Classification of Acute Sprains

Grade	Ligament Injury	Clinical Findings
I	ATF stretched, partially torn	Mild swelling, point tenderness, mild restriction of ROM, difficulty WB, No laxity
II	ATF completely ruptured± partial tear of CFL	Moderate swelling, ecchymosis, localized tenderness, restricted ROM, difficulty WB, abnormal laxity
III	ATFL and CFL completely ruptured ± capsular tear ± PTFL tear	Diffuse swelling, ecchymosis, inability to WB

Ferran et al, Ankle Instability, *Sports Med Arthrosc Rev 2009; 17: 139-145*

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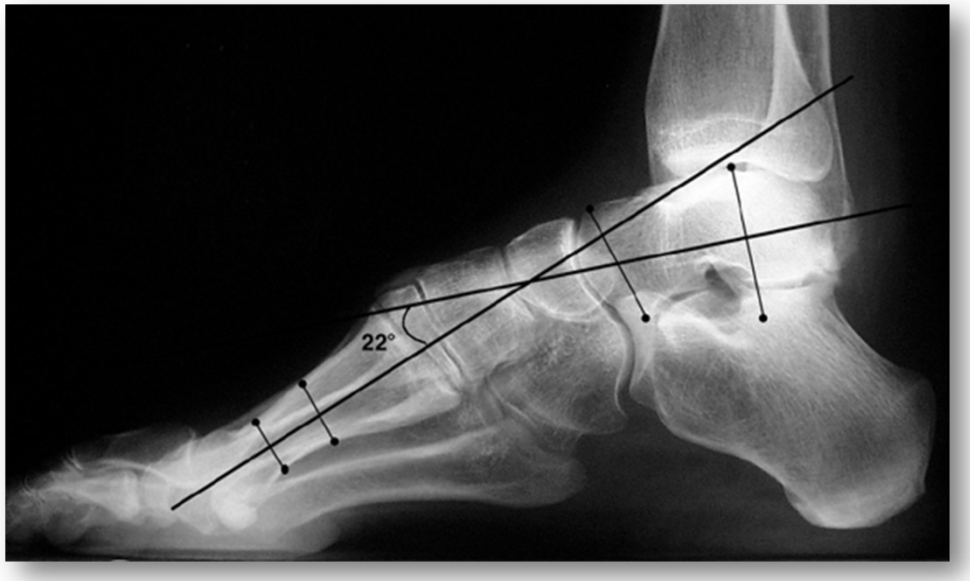
Predisposing Factors

- Cavus foot type
- Rigid PF 1st Ray
- Tibial/Calcaneal Varus
- Forefoot Valgus
- Peroneal muscle weakness
- Limb Length Discrepancy
- Ligamentous laxity
  - Marfans
  - Ehler's Danlos
  - Osteogenesis Imperfecta



Intrinsic Risk Factors for Inversion Ankle Sprains in Male Subjects

Tine Marieke Willems,*† PT, PhB, Erik Witvrouw,† PT, PhD, Kim Delbaere,† PT, PhB, Nele Mahieu,† PT, Ilse De Bourdeaudhuij,‡ PSY, PhD, and Dirk De Clercq,‡ PE, PhD
From the †Department of Rehabilitation Sciences and Physiotherapy, and the ‡Department of Movement and Sports Sciences, Ghent University, Ghent, Belgium

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- Methods
  - 241 male PE students
  - Initially evaluated at start of study
- Results
  - 44/241 (18%) sprained
  - Slower running speed, lower cardioresp endurance, decreased balance, less DF strength, less DF ROM, less coordination, faster reaction of TA and gastroc all at higher risk of sprain
- Conclusion
  - Above reflect persons at higher risk of inversion ankle injury

TABLE 1
Means and Standard Deviations for Demographic Data for Uninjured and Injured Subjects

	Uninjured Subjects	Injured Subjects	*P* (Cox Regression)[a]
Age, y	18.33 ± 1.18	18.35 ± 0.78	NS
Height, cm	179.88 ± 6.26	180.73 ± 5.71	NS
Mass, kg	69.24 ± 7.19	71.14 ± 5.94	NS
Body mass index	21.37 ± 1.66	21.81 ± 1.71	NS

[a]NS, not significant.

TABLE 2
Means and Standard Deviations for Functional Motor Performances for Uninjured and Injured Subjects

	Uninjured Subjects	Injured Subjects	*P* (Cox Regression)
Flamingo balance	7.57 ± 3.64	9.40 ± 4.95	.001[a]
Standing broad jump, cm	227.64 ± 21.62	225.92 ± 22.04	NS[b]
Shuttle run, s	19.10 ± 1.09	19.68 ± 1.12	.019[a]
Endurance shuttle run, min	12.06 ± 1.50	11.13 ± 1.49	.022[a]

[a]Significant difference between the 2 groups ($P < .05$).
[b]NS, not significant.

TABLE 3
Means and Standard Deviations for Isokinetic Concentric and Eccentric Eversion and Inversion Muscle Strength and Concentric Plantar Flexion and Dorsiflexion Muscle Strength at 30°/s and 120°/s Compared to Body Weight for Uninjured and Injured Subjects[a]

	Uninjured Subjects	Injured Subjects	*P* (Cox Regression)
EV 30°/s conc/BW	.43 ± .12	.45 ± .14	NS
EV 30°/s ecc/BW	.46 ± .10	.48 ± .14	NS
EV 120°/s conc/BW	.38 ± .10	.39 ± .12	NS
EV 120°/s ecc/BW	.47 ± .10	.49 ± .16	NS
INV 30°/s conc/BW	.54 ± .16	.51 ± .12	NS
INV 30°/s ecc/BW	.56 ± .18	.53 ± .13	NS
INV 120°/s conc/BW	.51 ± .19	.48 ± .17	NS
INV 120°/s ecc/BW	.55 ± .17	.56 ± .16	NS
DF 30°/s conc/BW	.73 ± .30	.54 ± .21	.036[b]
DF 120°/s conc/BW	.24 ± .09	.25 ± .17	NS
PF 30°/s conc/BW	1.47 ± .38	1.32 ± .36	NS
PF 120°/s conc/BW	.56 ± .26	.65 ± .30	NS

[a]Expressed in N·m/kg. EV, eversion; conc, isokinetic concentric; BW, body weight; NS, not significant; ecc, eccentric; INV, inversion; DF, dorsiflexion; PF, plantar flexion.
[b]Significant difference between the 2 groups ($P < .05$).

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TABLE 4
Means and Standard Deviations for Lower Leg Alignment Characteristics for Uninjured and Injured Subjects[a]

	Uninjured Subjects	Injured Subjects	P (Cox Regression)
Talocrural PF	52.39 ± 8.29	52.03 ± 8.64	NS
Talocrural DF (knee extended)	29.25 ± 7.38	25.88 ± 6.52	.013[b]
Talocrural DF (knee flexed)	34.85 ± 7.59	32.88 ± 6.06	.092
Subtalar INV	18.90 ± 6.49	19.41 ± 8.00	NS
Subtalar EV			NS
MTPIJ flexion			NS
MTPIJ extension			.052
Hip external rotation			NS
Hip internal rotation			NS
Position calc unloaded (ST			NS
Position calc WB (STJN)			NS
Position calc WB			NS

[a]Expressed in degrees. P
I joint; calc, calcaneus; ST
[b]Significant difference b

etatarsophalangeal
htbearing.

TABLE 6
Means and Standard Deviations for Muscle Reaction Time of the Peroneus Longus, Peroneus Brevis, Tibialis Anterior, and Gastrocnemius Muscles for Uninjured and Injured Subjects

	Uninjured Subjects	Injured Subjects	P (Cox Regression)
Peroneus longus	83.12 ± 14.12	75.99 ± 10.06	NS[a]
Peroneus brevis	80.40 ± 13.25	73.55 ± 10.90	NS[a]
Tibialis anterior	89.80 ± 11.50	78.67 ± 10.45	.048[b]
Gastrocnemius	90.31 ± 16.09	79.76 ± 10.66	.033[b]

[a]NS, not significant.
[b]Significant difference between the 2 groups ($P < .05$).

Means			Regression)
Weightbearing, % BW			NS
Bilat firm EO, °/s			NS
Bilat EC, °/s			NS
Bilat foam EO, °/s			NS
Bilat foam EC, °/s			NS
Unilat EO, °/s			NS
Unilat EC, °/s			NS
LOS reaction time, s	.65 ± .20	.60 ± .16	NS
LOS movement velocity, °/s	5.56 ± 1.57	5.61 ± 1.77	NS
LOS directional control, %	79.70 ± 5.57	77.85 ± 6.95	.037[b]
LOS endpoint excursion, %	80.47 ± 7.62	81.62 ± 9.17	NS
LOS max endpoint excursion, %	90.07 ± 5.04	91.50 ± 6.41	NS
FL distance, % BH	57.69 ± 6.05	57.73 ± 5.28	NS
FL contact time, s	.84 ± .22	.86 ± .21	NS
FL impact index, % BW	30.50 ± 9.67	31.99 ± 11.39	NS
FL force impulse, % BW	89.59 ± 22.22	91.69 ± 20.90	NS

[a]BW, body weight; NS, not significant; Bilat, bilateral stance; firm, firm surface; EO, eyes open; EC, eyes closed; foam, foam surface; unilat, unilateral stance; LOS, limits of stability; max, maximal; FL, forward lunge; BH, body height.
[b]Significant difference between the 2 groups ($P < .05$).

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Clinical Presentation

Acute Lateral Ankle Sprain

- Patient Presentation
  - Rolling
  - “pop/snap”
  - +/- WB
  - Ecchymosis
  - Swelling
  - Tenderness
  - h/o sprains or laxity

- ↑ time to examination = ↓ specificity of tenderness

Presentation

- History
  - Previous ankle sprains/injury
  - Relate instability, “giving out”, difficulty with activities, pain and tenderness to lateral ankle
    - May be asymptomatic between events

- Physical Exam
  - Anterior drawer
  - Talar tilt
  - POP
  - Pain with ROM

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Physical Exam

ATFL

Lateral ligaments

- ATFL
- CFL
- PTFL

CFL

Clinical Exam-Lateral Ankle

- Fibula
- 5th metatarsal base
- Navicular
- LisFranc complex
- Calcaneus
- Peroneals

5th metatarsal

Fibula

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Clinical Exam: Anterior Drawer

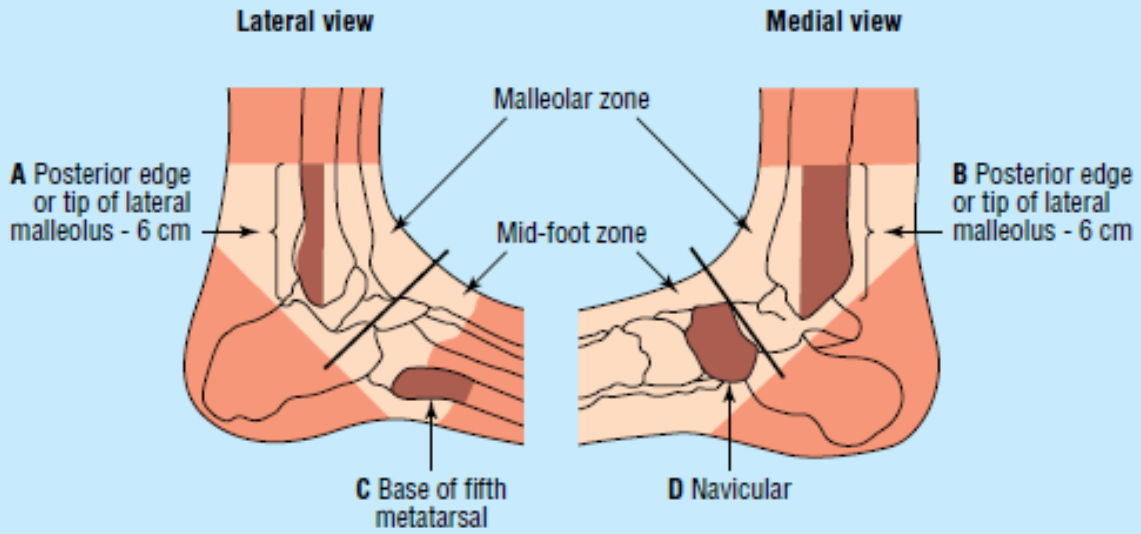
Anterior Drawer

Clinical Exam – Talar Tilt

Clinical Exam - Syndesmosis

Squeeze, external rotation, palpation of AITFL

Ottawa Ankle Rules



A series of ankle *x* ray films is required only if there is any pain in malleolar zone and any of these findings:

- Bone tenderness at **A**
- Bone tenderness at **B**
- Inability to bear weight both immediately and in emergency department

A series of ankle *x* ray films is required only if there is any pain in mid-foot zone and any of these findings:

- Bone tenderness at **C**
- Bone tenderness at **D**
- Inability to bear weight both immediately and in emergency department

Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: systematic review

Lucas M Bachmann, Esther Kolb, Michael T Koller, Johann Steurer, Gerben ter Riet

BMJ

- Methods
  - 32 studies, 15,581 patients
  - 27 studies included in meta-analysis
  - Evaluated sensitivities, negative likelihood ratios
- Results
  - Negative likelihood ratio 0.08 for midfoot and ankle fracture
  - Much more sensitive than specific
- Conclusion
  - Effective if used, often not in ED setting, per authors likely secondary to readily available x-ray

Category	Sensitivity (95% CI)	Median specificity (interquartile range)
All studies (n=39)	97.6 (96.4 to 98.9)	31.5 (23.8-44.4)
Type of assessment:		
Ankle (n=15)	98.0 (96.3 to 99.3)	39.8 (27.9-47.7)
Foot (n=10)	99.0 (97.3 to 100)	37.8 (24.7-70.1)
Combined (n=14)	96.4 (93.8 to 98.6)	26.3 (19.4-34.3)
Population:		
Children (n=7)	99.3 (98.3 to 100)	26.7 (23.8-35.6)
Adults (n=32)	97.3 (95.7 to 98.6)	36.6 (22.3-46.1)
Prevalence of fracture:		
<25th centile (n=7)	99.0 (98.3 to 100)	47.9 (42.3-77.1)
25th-75th centile (n=22)	97.7 (95.9 to 99.0)	30.1 (23.8-40.1)
>75th centile (n=10)	96.7 (94.2 to 99.2)	27.3 (15.5-40.0)
Time to referral (hours):		
≤48 (n=5)	99.6 (98.2 to 100)	27.9 (24.7-31.5)
>48 (n=34)	97.3 (95.9 to 98.5)	36.6 (19.9-46.8)

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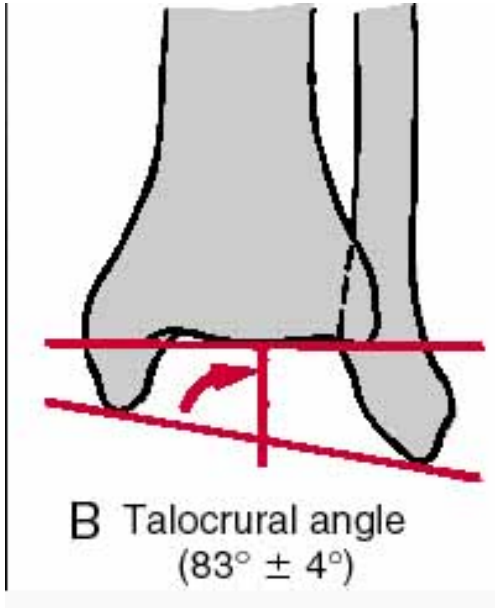
Imaging

- Plain XR
  - Ankle and foot
  - Tib/fib?
  - Concomitant pathology
- Stress XR
  - Drawer, tilt, external rotation
- Ultrasound
  - Dynamic evaluation
- MRI
  - Typically not in acute setting
  - Inflammation from injury

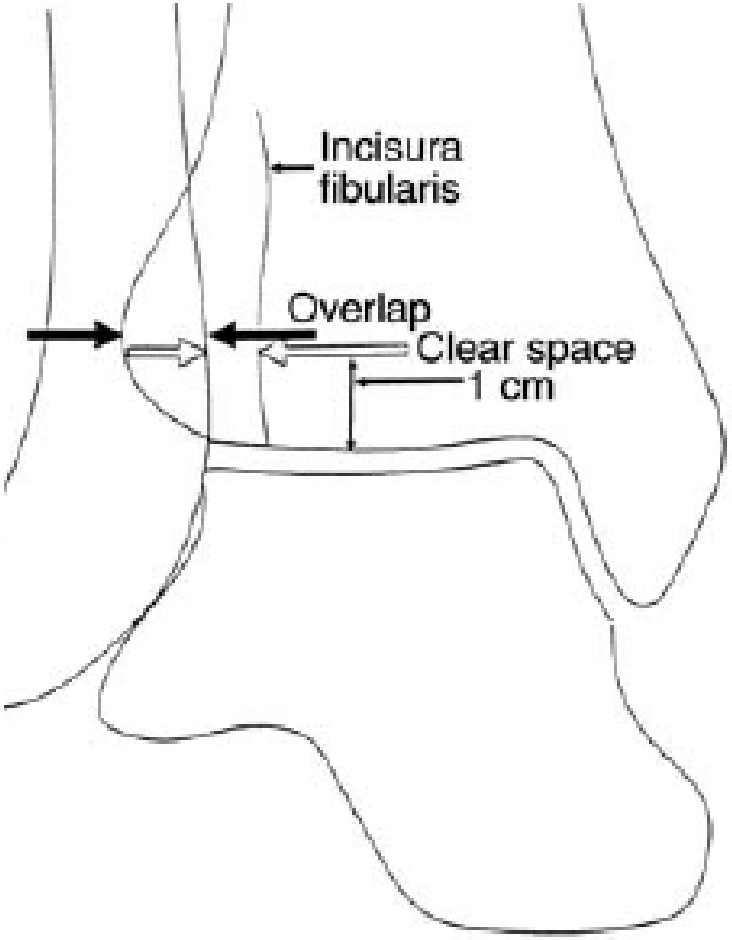
Imaging

- Talocrural angle
- Varus tilt
- Anterior drawer
- Medial clear space
- Tib fib overlap



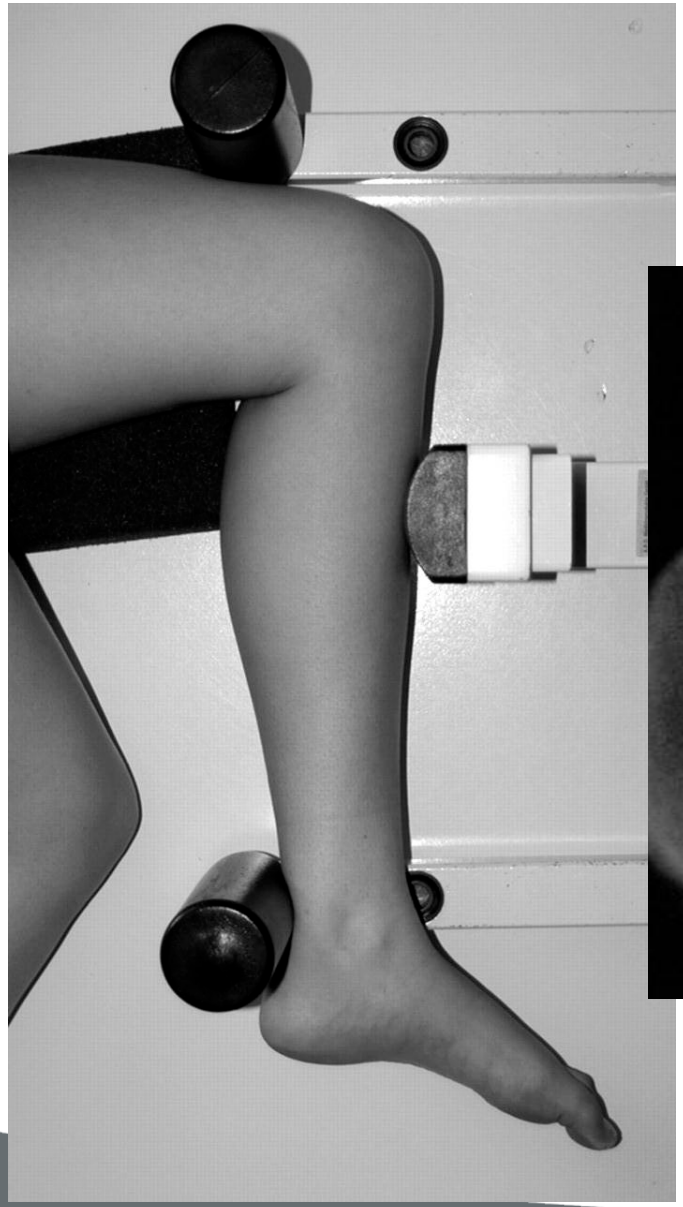
Imaging

- Mortise View
  - Tibia Fibula Overlap:
    - (AP= 5mm, 1/3 fibular width)
  - Tibia Fibula clear space
    - (AP <6mm)*
      - Most accurate
  - Symmetric Mortise



Imaging – Stress Radiographs

- Telos
- 150N



3-5mm> other side,
>10mm total

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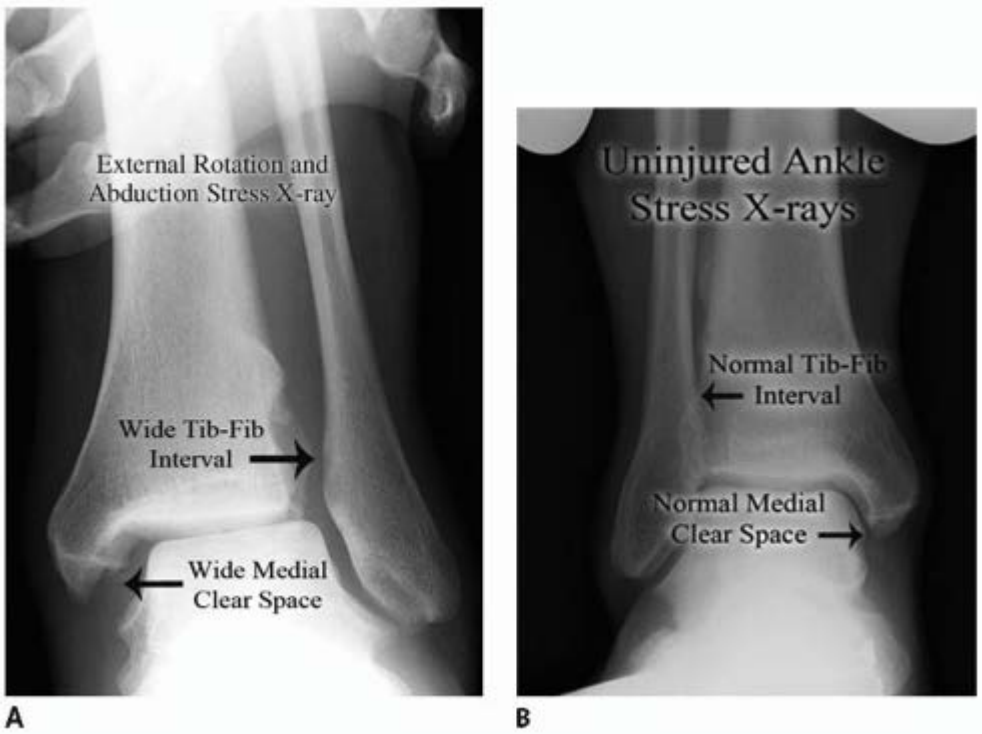
Imaging – Stress Radiographs

- Telos

- External rotation XR



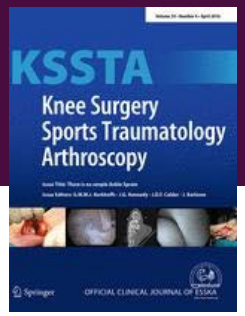
Treatment

Acute Surgical Repair

- Typically direct repair
- Becoming less common
  - Benefit in athletes?
- Seems to show equivocal outcomes when compared to functional treatment

Return to sport following acute lateral ligament repair of the ankle in professional athletes

W. James White[1] · Graham A. McCollum[1] · James D. F. Calder[1,2]



- Methods
  - 42 consecutive professional athletes, 2 yr follow up
  - Modified Brostrom for Grade III injury, clinically and radiographically
    - 30/42 had isolated ATFL and CFL rupture
    - 12/42 had concomitant OCD, deltoid injury
- Results
  - Faster return in isolated injury
  - Lower FOAS pain/symptom scores in combined injuries
  - No recurrent instability
- Conclusion
  - Effective for severe injuries, with return to sport around 10 wks

	All injuries	Isolated	Associated	p value isc
Median time to surgery in days (range)	7 (5–21)	7 (5–21)	6 (5–14)	(n.s.)
Median return to training in days (range)	63 (49–152)	57 (49–110)	86 (63–152)	$p < 0.001$
Median return to full sport in days (range)	77 (56–178)	72 (56–127)	105 (82–78)	$p < 0.001$
Median VAS pre-op (range)	4 (1–6)	4 (2–6)	4 (1–5)	(n.s.)
Median VAS post-op (range)	0 (0–3)	0 (0–2)	0 (0–3)	(n.s.)
Median FAOS pre-op (range)				
Pain	50 (22–83)	44 (22–64)	52 (28–83)	$p = 0.032$
Symptoms	43 (36–57)	43 (36–57)	43 (26–50)	(n.s.)
ADL	49 (41–82)	49 (41–82)	48 (41–66)	(n.s.)
Sport	10 (0–20)	10 (0–20)	15 (5–20)	(n.s.)
QOL	25 (6–31)	25 (6–31)	25 (13–31)	(n.s.)
Median FAOS post-op (range)				
Pain	100 (72–100)	100 (94–100)	97 (72–100)	$p = 0.027$
Symptoms	96 (75–100)	98 (89–100)	93 (75–100)	$p = 0.002$
ADL	100 (91–100)	100 (91–100)	100 (94–100)	(n.s.)
Sport	100 (90–100)	100 (90–100)	100 (90–100)	(n.s.)
QOL	100 (88–100)	100 (88–100)	100 (88–100)	(n.s.)

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Surgical Versus Functional Treatment for Acute Ruptures of the Lateral Ligament Complex of the Ankle in Young Men

A Randomized Controlled Trial

By Harri Pihlajamäki, MD, PhD, Kalevi Hietaniemi, MD, PhD, Mika Paavola, MD, PhD, Tuomo Visuri, MD, PhD, and Ville M. Mattila, MD, PhD

JBJS The Journal of Bone & Joint Surgery

- Methods
  - 51 males Grade III injury, 25 randomized to surgery (direct suture repair, WB cast x 6 weeks), 26 functional treatment (Aircast brace x 3 weeks)
  - 15 surgery and 18 functional follow up of 14 years
- Results
  - All at pre-injury functional level
  - Re-injury:
    - 1/15 surgical, 7/18 functional
    - No difference in ankle score outcomes
    - No difference in anterior drawer or talar tilt
    - Increased osteoarthritis in surgical group on f/u MRI
      - Unclear why?
- Conclusion
  - Similar functional outcomes, surgery may reduce rate of re-injury but increase OA

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Treatment for acute tears of the lateral ligaments of the ankle. Operation, cast, or early controlled mobilization

P Kannus and P Renstrom

JB&JS

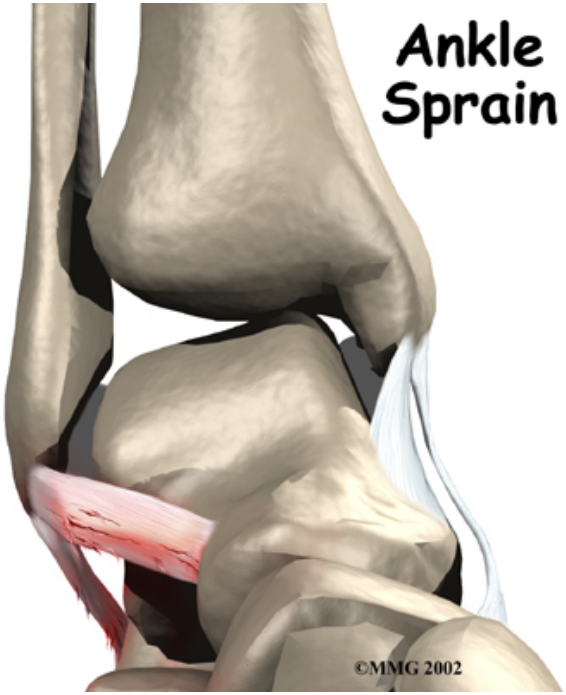
- Methods
  - 12 prospective, randomized studies
    - Acute repair, cast immobilization, early mobilization
    - f/u 6m-3.8yrs
    - Return to work and return to activity
- Results
  - Return to work 2-4x sooner after functional treatment vs surgery/cast
  - Return to activity sooner in 4 studies with functional, 3 with surgery, and same in 5
  - No difference in pain/swelling/stiffness
  - No difference in anterior drawer/tilt (5 studies)
  - Chronic instability not different (short follow ups)
- Conclusions
  - Functional preferred treatment
  - Less complications than surgery
  - Can perform secondary reconstruction at later date if needed with good results
  - Exceptions: medial and lateral damage, large avulsions

Chronic Instability

Symptoms of Chronic Instability

- 20% of Acute sprains → chronic instability
- 10-20% require surgical correction
- Recurrent inversion sprains
- "Giving out"
- Pain > 3 mo post injury
- Difficulty with uneven ground
  - Associated STJ pathology?

- "Lateral Ankle Triad"
  - Synovitis, instability, peroneal tear (Franson & Baravarian)



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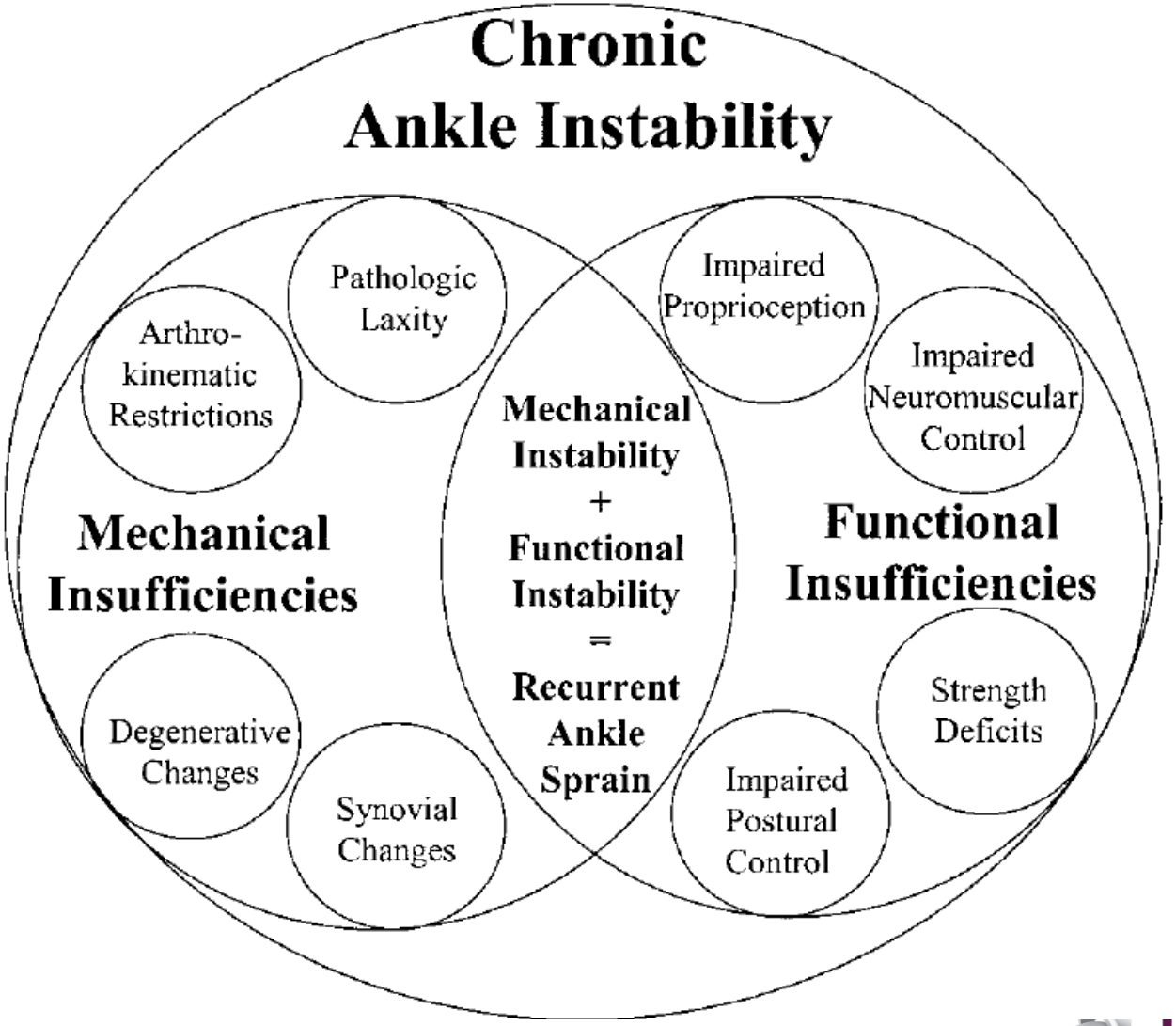
Development of Instability



Causes

- Decreased proprioception
  - Loss of mechanoreceptors
    - Joint capsule, ligaments, tendons
  - Nerve injury
- Decreased muscle strength
  - Peroneals
  - Eccentric weakness
- Ligamentous laxity

Lateral Ankle Instability

- Mechanical vs Functional Instability (Hertel, 2002)
  - Mechanical:
    - Pathologic laxity
    - Arthrokinematic restrictions
    - Synovial irritation
    - Degeneration of the joints
    - *Surgical treatment*
  - Functional:
    - Decreased proprioception
    - Decreased neuromuscular control
    - Decreased postural control
    - Decreased strength
    - *Non surgical management*

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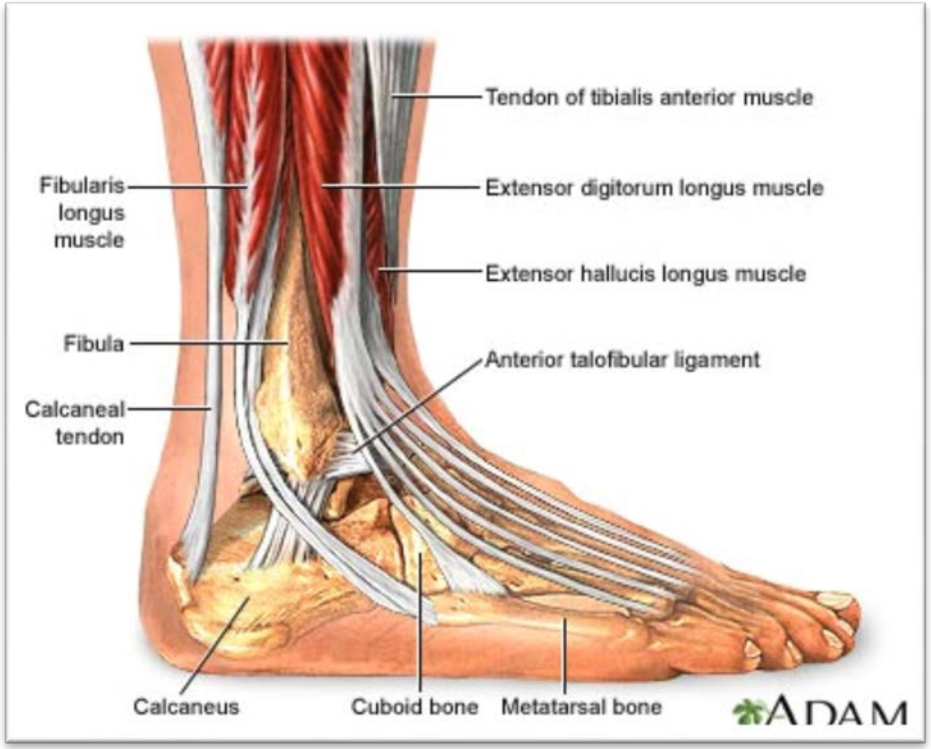
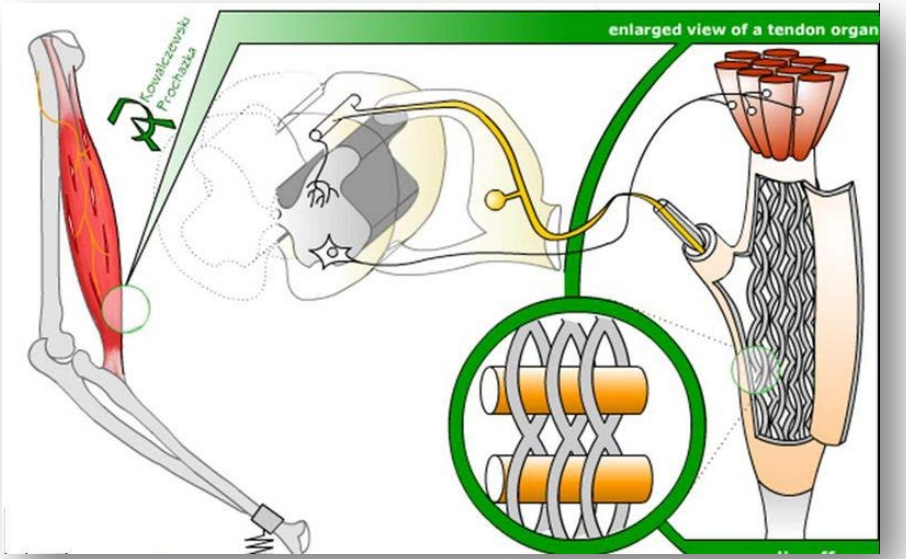
Functional Instability

- Dynamic and static restraints that work together
  - Dynamic = muscles
  - Static = ligaments
- Neuromuscular Control
  - Interaction between the nervous system and musculoskeletal system to produce a desired effect or response to a stimulus
- Open & Closed Loop Control



- Closed Loop Control
  - Reflex arc, mechanoreceptors
  - As ligaments are stretched an afferent signal → spinal cord → peroneals contract
  - Sprains cause damage to the proprioceptive feedback
  - Delayed reaction time to peroneal tendons
  - PT exercises
    - Balance boards
    - Proprioception training



- Open Loop Control
  - Anticipatory – before the stimulus
  - Sprains can cause reduced/delayed peroneal activation = ankle more inverted with landing
  - Training muscle activation, pre-activation
  - Visual and vestibular feedback
    - PT exercises
      - Altering jumping conditions
      - Evert ankle prior to landing

Proprioception and Muscle Strength in Subjects With a History of Ankle Sprains and Chronic Instability

Tine Willems*; Erik Witvrouw*; Jan Verstuyft†; Peter Vaes‡; Dirk De Clercq*

- Methods
  - 87 participants, 4 groups
  - Symptom free, chronic instability, sprain within 2 years w/o instability, sprain 3-5 years w/o instability
  - Proprioception and muscle strength

- Results
  - Decreased active position sense and eversion muscle strength in chronic instability group

Table 3. Exact Error on the Proprioception Test*

Variables	Control Group	Instability Group	Group 3	Group 4	*P* Value
Active joint-position sense					
Maximal active inversion minus 5°	−0.68 ± 3.21	−2.96 ± 2.96	0.10 ± 2.47	0.62 ± 2.79	.012†
15° of Inversion	−1.58 ± 3.64	−3.25 ± 3.18	−1.65 ± 4.21	−2.37 ± 4.90	.218
Passive joint-position sense					
Maximal active inversion minus 5°	−5.83 ± 5.93	−5.93 ± 6.68	−6.50 ± 4.67	−4.56 ± 3.63	.889
15° of Inversion	−7.27 ± 5.58	−7.18 ± 4.64	−7.97 ± 5.18	−7.87 ± 5.39	.857
Eversion (Nm/kg)					
30°·s⁻¹ Concentric/body weight	0.41 ± .01	0.31 ± .02	0.38 ± .02	0.48 ± .05	.015†[a]
30°·s⁻¹ Eccentric/body weight	0.44 ± .01	0.35 ± .02	0.40 ± .02	0.50 ± .04	.006†[b]
120°·s⁻¹ Concentric/body weight	0.38 ± .01	0.30 ± .02	0.36 ± .01	0.45 ± .05	.040†[c]
120°·s⁻¹ Eccentric/body weight	0.46 ± .01	0.36 ± .02	0.44 ± .01	0.47 ± .04	.021†[d]

Treatment-Chronic

- Non-surgical
  - RICE
  - Bracing
  - PT
  - Injections
    - Diagnostic vs therapeutic

- Surgical
  - Up to 50 different procedures described
    - Anatomic vs non-anatomic
  - More common are Brostrom and its variants
    - Modified Brostrom-Gould:
      - Direct anatomic repair of ATFL and CFL, reinforced with inferior extensor retinaculum
  - Most commonly open repairs, but arthroscopic and percutaneous described
  - Often concomitant procedures secondary to associated pathology

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Six Weeks of Balance Training Improves Sensorimotor Function in Individuals With Chronic Ankle Instability

JOELLEN M. SEFTON, PhD, ATC[1] • CEREN YARAR, PT, MS[1] • CHARLIE A. HICKS-LITTLE, PhD, ATC[2]
JACK W. BERRY, PhD[3] • MITCHELL L. CORDOVA, PhD, ATC[4]

Journal of Orthopaedic & Sports Physical Therapy
JOSPT

Methods:

- 12 pts with CAI; 9 healthy volunteers
  - CAI completed 6-wk balance training
  - Healthy controls with no training were compared at 0 and 6 wks

Results:

- CAI group who performed balance training demonstrated better performance than control participants on:
  - Baseline adjusted posttraining measures of dynamic balance in the anterior medial (P = .021), medial (P = .048), and posterior medial directions (P = .030)
  - Motoneuron pool excitability hmax/mmax ratio (P = .044)
  - Single-limb presynaptic inhibition (P = .012); and joint position sense inversion variable error (P = .017)

Conclusion:

- Results suggest that balance training may lead to a reduction in the incidence of repeated injury

FIGURE 1. Balance training set-up with H-reflex electrodes in place to allow for immediate data collection.

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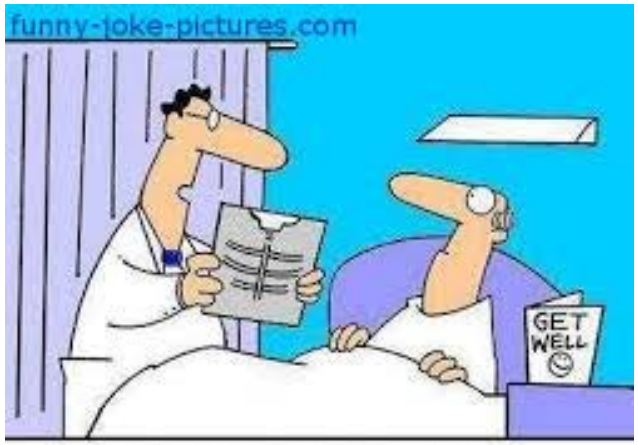
Imaging

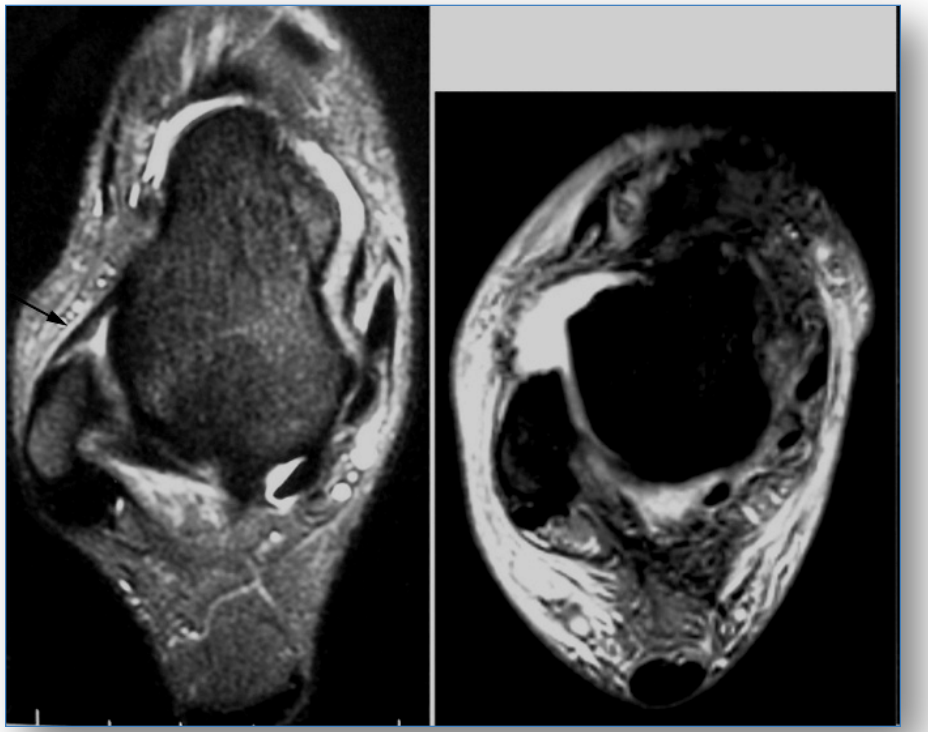
- Plain XR
  - Ankle and foot
  - Concomitant pathology
  - Predisposing pathologies
- Stress XR
  - Drawer, tilt, external rotation
- Ultrasound
  - Dynamic evaluation
- MRI
  - Associated pathology
  - Peroneal, OCD, deltoid, syndesmosis, STJ
  - Surgical planning



"Your x-ray showed a broken rib, but we fixed it with Photoshop."

Advanced Imaging-MRI

- If conservative treatment fails next step is MRI for surgical planning
- >80% accurate for diagnosis of OCD and peroneal tendon tears, syndesmotic injury
- 20-40% accurate for identifying ankle impingement and synovitis
  - Under-appreciated by musculoskeletal radiologist when compared to intra operative findings



Accuracy of MRI findings in chronic lateral ankle ligament injury: Comparison with surgical findings

H.-J. Park [a,b], S.-D. Cha [c], S.S. Kim [b], M.-H. Rho [a,*], H.-J. Kwag [a], N.-H. Park [d], S.-Y. Lee [a]

- Methods
  - 48 pts (25 men, 23 women)
    - MRI read/agreed upon by 2 MSK trained radiologists
    - No clinical information given
- Results
  - ATFL
    - Full tear: 75% sensitive and 86% specific
    - Partial tear: 75% sensitive and 78% specific
    - Sprain: 44% sensitive and 88% specific
  - CFL
    - Full tear: 50% sensitive and 98% specific
    - Partial tear: 83% sensitive and 93% specific
    - Sprain: 100% sensitive and 90% specific
- Conclusions
  - Assessment of ATFL more sensitive than CFL
  - CFL findings more specific than ATFL findings

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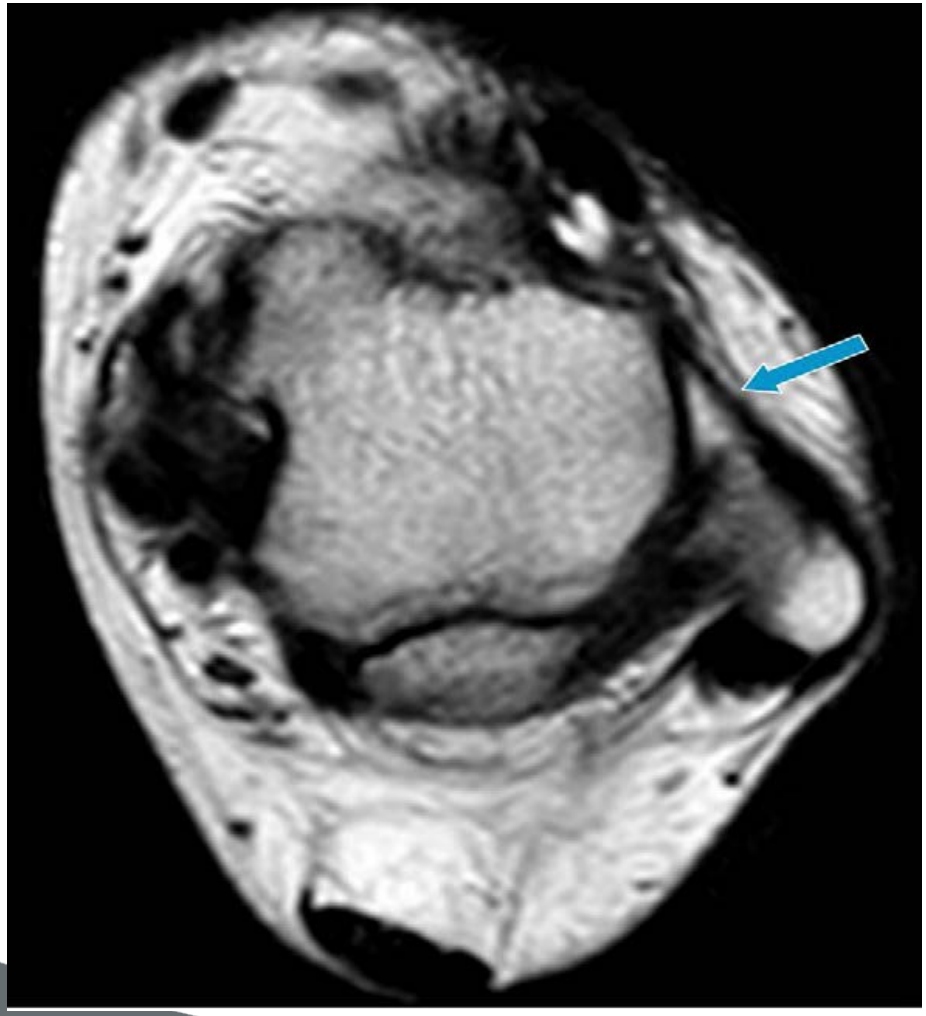
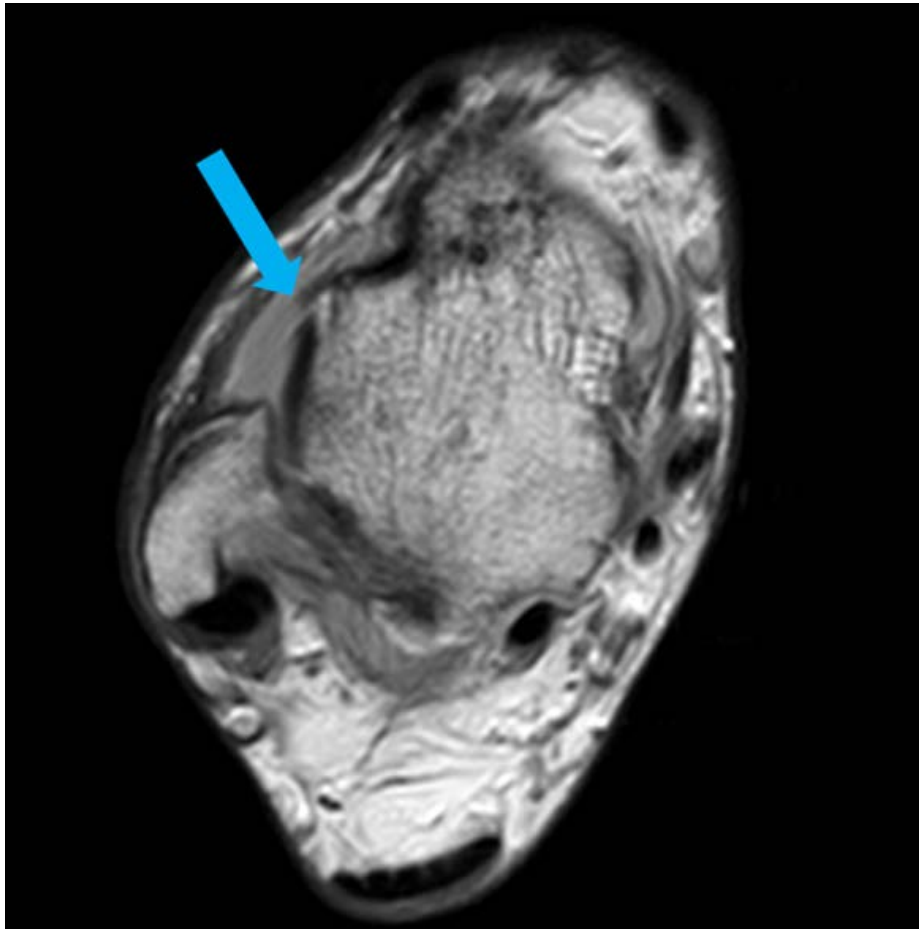
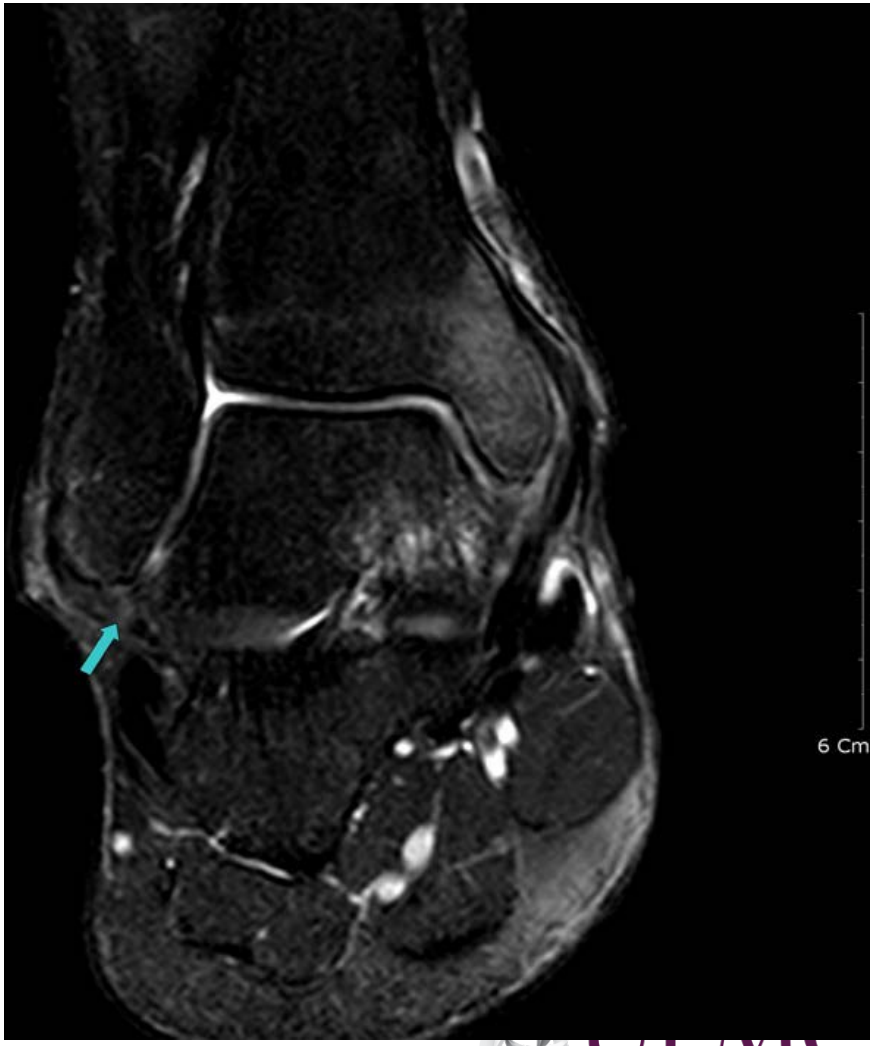
Normal MRI Anatomy



Abnormal MRI Anatomy





Associated injuries with Chronic Ankle Sprains/Instability

Soft Tissue

- Peroneal tenosynovitis
- Anterolateral ankle impingement
- Syndesmosis
- Talus OCD
- Medial ankle tenosynovitis
- Attenuated retinaculum/ peroneal subluxation
- STJ ligaments
- Peroneal Nerve

Osseous

- Lateral process talus
- 5th metatarsal base
- Fibula (proximal & distal)
- Anterior process of calcaneus
- Tibia (Volkmann's, Tillaux)
- Posterior Talus
- STJ synovitis

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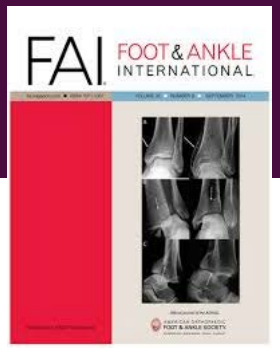
Associated Injuries Found in Chronic Lateral Ankle Instability

Benedict F. DiGiovanni, M.D., Carlos J. Fraga, M.D., Bruce E. Cohen, M.D., Michael J. Shereff, M.D.
Rochester, NY; Isla Verde, PR; Tallahassee, FL; Charleston, SC



- Methods
  - Retrospective, 61 pts
- Results
  - None with isolated lateral ankle injury
  - Peroneal, anterolateral impingement most common
- Conclusion
  - High frequency of associated injuries
  - Should have high index of suspicion to evaluate for concomitant injury in patient with chronic ankle instability

TABLE 1
Associated Injuries Noted At Surgery

Pathologic Structure	Number		Percentage
peroneal tenosynovitis	47/61		77 %
anterolateral impingement lesion	41/61		67 %
attenuated peroneal retinaculum	33/61		54 %
peroneal retinaculum avulsion		4	
ankle synovitis	30/61		49 %
intra-articular loose body	16/61		26 %
peroneus brevis longitudinal tear	15/61		25 %
peroneus brevis + longus tear		2	
talus osteochondral lesion	14/61		23 %
chondral flaps		12	
full thickness defect		2	
anterior talofibular ligament avulsion	7/61		11 %
accessory peroneus quatrus muscle[22,27]	5/61		08 %
medial ankle tendon tenosynovitis	3/61		05 %
FHL tenosynovitis		1	
FDL tenosynovitis		1	
PT tenosynovitis		1	
ankle capsular avulsion fracture	2/61		03 %

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Associated Intra-articular Ankle Pathologies in Patients With Chronic Lateral Ankle Instability: Arthroscopic Findings at the Time of Lateral Ankle Reconstruction

Foot&Ankle Specialist

Jake Lee, DPM,
Graham Hamilton, DPM, FACFAS,
and Lawrence Ford, DPM, FACFAS

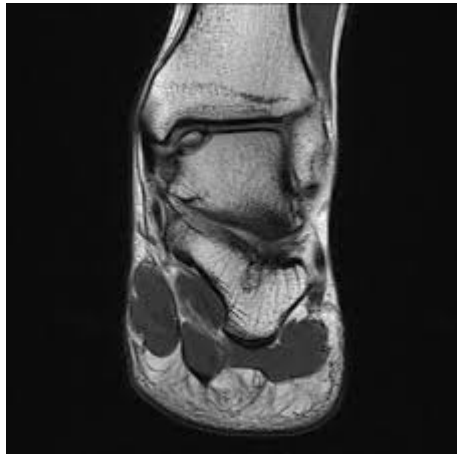
- Methods
  - 28 ankles, 28 pts
  - Modified Brostrom-Gould with arthroscopy
- Results
  - Every patient with intra-articular pathology
- Conclusion
  - High incidence of intra-articular pathology associated with chronic lateral ankle instability

Pathology Seen Arthroscopically	Frequency
Synovitis	100%
Talar osteochondral defect	7%
Talar fibrillation	25%
Talar chondral defect	14%
Loose bodies	11%
Bassett's lesion	7%
Anterolateral impingement	14%
Distal tibia osteophyte	14%

Characteristic	Comparison Groups		Statistical Test	P Value (2-sided)
	1 Pathology	> 1 Pathology		
Gender (%)				
Male	12.5	55.0		
Female	87.5	45.0	Fisher's exact test	.088
BMI				
<30	62.5	38.9		
≥30	37.5	61.1	Fisher's exact test	.40
Median	28.0	30.0	Wilcoxon Mann-Whitney	.38
Age				
Mean (SD)	34.38 (12.44)	39.45 (13.89)	*t* Test	.38

OLT

- Incidence of OLT in patients undergoing surgery for lateral ankle instability 17-63%
- Diagnosis
  - CT, MRI, Scope
- Treatment
  - Microfracture/subchondral drilling, allograft, autograft, ACI



McGahan, FAI 2010

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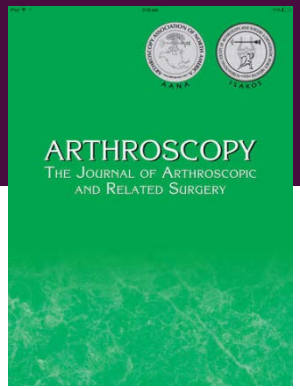
Combination of Modified Broström Procedure With Ankle Arthroscopy for Chronic Ankle Instability Accompanied by Intra-articular Symptoms

Yinghui Hua, M.D., Shiyi Chen, M.D., Ph.D., Yunxia Li, M.D., Jiwu Chen, M.D., and Hong Li, M.Med



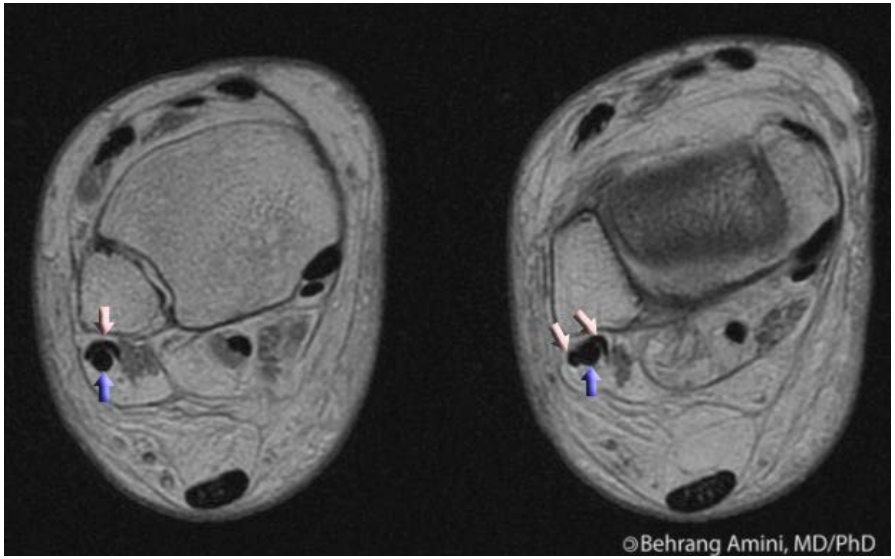
- Methods
  - 85 patients, 87 ankles
    - 79 patients at follow up
  - 58 male, 27 female
  - Arthroscopy and lateral ligament repair
  - AOFAS pre/post op
- Results
  - Chondral lesions significantly decreased post-op score
  - Other pathologies without significant difference
- Conclusion
  - Chondral lesions significantly decrease outcomes in patients with chronic lateral ankle instability

Intra-Articular Lesion	No. of Ankles With Intra-Articular Lesions
Synovitis/soft-tissue impingement	75 (86.2%)
Chondral injury	33 (37.9%)
Anterior tibial osteophyte	23 (26.4%)
Loose body	7 (8.0%)
Distal tibiofibular syndesmosis injury	6 (6.9%)

AOFAS Score	Group A: Ankles Without Chondral Injuries (n = 50)	Group B: Ankles With Chondral Injuries (n = 31)	*P* Value (Independent-Sample *t* Test)
Preoperative score	47.48 ± 7.39	45.29 ± 9.00	.237*
Postoperative score	89.76 ± 5.88	81.35 ± 7.18	<.05*
Improvement between preoperative and postoperative scores	42.28 ± 9.04	36.06 ± 11.85	.009*

Peroneal Tendon Injury

- Peroneal tendon synovitis - 75%
- Peroneal retinaculum attenuation – 50%
- Peroneal tendon Tears
  - Split tear in Peroneus Brevis 10%



DiGiovanni, FAI 2000

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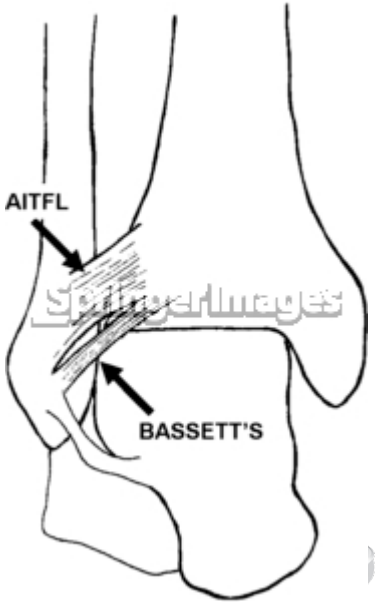
Ankle Impingement

- Bassett's ligament
  - Nikolopoulos 1st described 1982
  - Bassett 1st in English literature 1990

- Treatment with arthroscopy

- Kim et al JBJS 2000
  - 50% of patients with chronic ankle instability had anterior impingement



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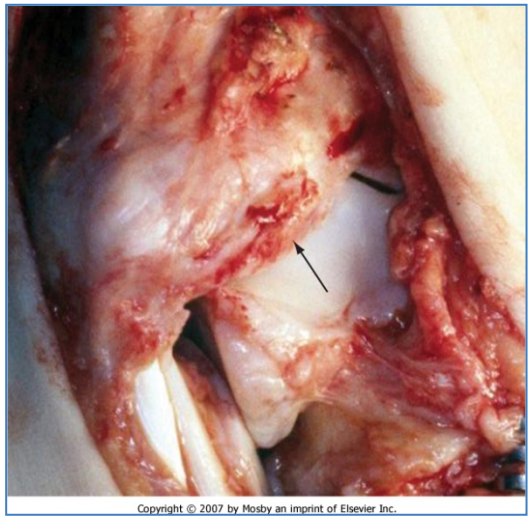
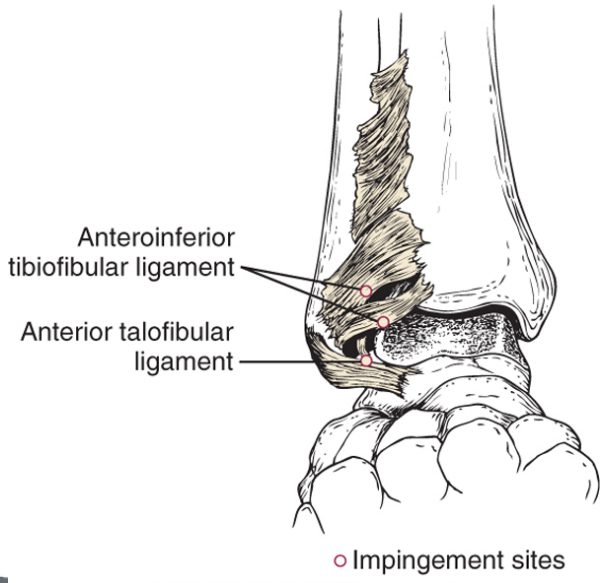
Ankle Impingement

- Bassett's fascicle
  - Present ~ 91% cadaver studies
  - Inferior/parallel to AITFL
  - Aggravated post-trauma
    - Tear ATFL
    - ↑ laxity of ATFL
    - Talar dome extrudes anterior on DF→Soft tissue impingement





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Syndesmosis Injury

- Chronic injury can mimic lateral ankle symptoms

- Due to external rotation of the talus on the fibula
- Longer recovery
- Ossification of syndesmosis
- Overlap
- Visualized with stress test
- If ruptured allows widening of tib-fib joint and lateral shift of the talus

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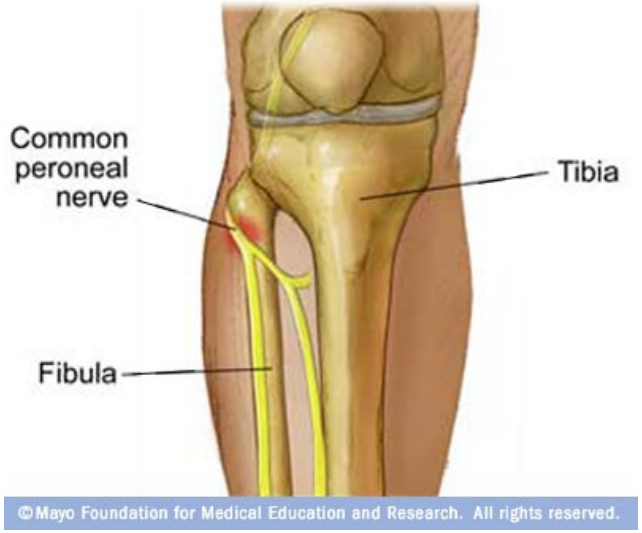
Peroneal Nerve Injury

- Traction Injury
- Potential cause of chronic morbidity
- Symptoms
  - Peroneal weakness, instability, paresthesias

- O'neill et al
  - Significant increase in excursion and strain on superficial peroneal nerve with ATFL transection in cadaver



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Nerve injury and Grades II and III ankle sprains

The American Orthopaedic Society for Sports Medicine

ARTHUR J. NITZ,* PhD, JOSEPH J. DOBNER,†‡ MD, AND DOUGLAS KERSEY,§ LTC, USA

- Methods
  - 66 consecutive Grade II/III (lateral/deltoid and lateral/deltoid/syndesmosis)
  - EMG at 2 weeks
- Results
  - Grade II
    - 17% injury to peroneal nerve
    - 10% injury to tibial nerve
  - Grade III
    - 86% injury to peroneal nerve
    - 83% injury to tibial nerve
- Conclusion
  - Severe injury (those with syndesmotic injury) more likely to have peroneal and tibial nerve injury
  - Likely contribute to functional instability

Electrophysiological data

	Normal[a]	Grade II[b]	Grade III[c]
No. of patients with denervation potentials			
Peroneal nerve	—	5 (17%)	31 (86%)
Posterior tibial nerve	—	3 (10%)	30 (83%)
Motor nerve conduction			
Peroneal nerve			
Distal latency (msec)	5.0 ± 0.6[d]	4.8 ± 0.4	5.1 ± 0.6
Conduction velocity (m/sec)			
Fibular head – ankle	48 ± 3.6	46 ± 2.7	48 ± 3.9
Across fibular head	48 ± 4.8	50 ± 4.1	51 ± 4.3
Midthigh–fibular head	54 ± 4.2	51 ± 5.0	53 ± 4.9
Posterior tibial nerve			
Distal latency (msec)	5.6 ± 0.8	5.7 ± 0.6	5.9 ± 0.8
Conduction velocity (m/sec)			
Popliteal fossa – ankle	49 ± 3.4	46 ± 2.4	47 ± 3.6
Midthigh – popliteal fossa	58 ± 4.3	56 ± 2.7	55 ± 4.0

TABLE 2

Clinical measurements—Grade II and Grade III ankle sprains

	Grade II[a]	Grade III[b]
AROM (degrees)		
Dorsiflexion	10 ± 4.1[c]	−2 ± 6.7[d]
Plantarflexion	35 ± 6.4	20 ± 7.4[d]
Eversion	15 ± 3.1	6 ± 4.6[d]
Inversion	27 ± 3.9	5 ± 5.2[d]
Heel walk 20 feet (weeks)	1.3 ± 0.4	5.1 ± 2.1[d]
Toe walk 20 feet (weeks)	1.5 ± 0.3	5.1 ± 2.2[d]
Time to full activity (weeks)	1.6 ± 0.4	5.3 ± 3.4[d]

[a] $N = 30$.
[b] $N = 36$.
[c] ± = SD.
[d] Significantly different than Grade II patients ($P < .01$).

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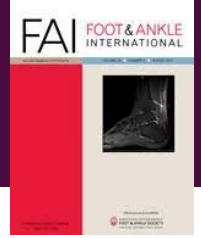
Deltoid Ligament Abnormalities in Chronic Lateral Ankle Instability

Julia R. Crim, MD; Timothy C. Beals, MD; Florian Nickisch, MD; Andrew Schannen, BS; Charles L. Saltzman, MD
Salt Lake City, UT



- Methods
  - 47 ankles, 46 pts
    - Reviewed MRI of those undergoing OR for chronic lateral ankle pathology
    - None complained of medial pain
- Results
  - 100% with ATFL, 91% with CFL, 49% with PTFL on MRI
  - Deltoid injury in 72% of studies
    - 23% superficial, 6% deep, 43% both
- Conclusion
  - Deltoid complex injuries relatively common in patients undergoing lateral ankle reconstruction without medial complaints
  - Clinical significance unclear

Table 1: Patterns of Ligament Instability in Patients With Chronic Ankle Instability

Lateral Ligaments Injured	Total number of ankles	Number of ankles with normal deltoid	Number of ankles with abnormal deltoid
ATFL	4	0 (0%)	4 (100%)
ATFL + CFL	20	8 (40%)	12 (60%)
ATFL + CFL + PTFL	23	5 (22%)	18 (78%)
Total	47	13 (28%)	34 (72%)

ATFL, anterior talofibular ligament; CFL, calcaneofibular ligament; PTFL, posterior talofibular ligament.

Table 2: Patterns of Deltoid Ligament Injury in Patients with Chronic Lateral Ankle Instability

Medial Ligaments Injured	Number of Ankles
No deltoid injury	13 (28%)
Any deltoid injury	34 (72%)
Superficial deltoid only injured	11 (23%)
Deep deltoid only injured	4 (6%)
Both components of deltoid ligament injured	20 (43%)

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Methods of Repair/Augmentation

Methods of Repair

- Direct repair
- Augmented direct repair
  - Bone anchors
  - Internal brace
- Non anatomic/tendon reconstruction
- Arthroscopic reconstruction

Methods of Repair

- Direct repair
- Augmented direct repair
  - Bone anchors
  - Internal brace
- Non anatomic/tendon reconstruction
- Arthroscopic reconstruction

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Direct Ligament Repair

- Brostrom 1966
- Gould modification 1980
  - Retinaculum
- Avoids sacrificing tendons
- 87-95% good to excellent results, large review of 460 pts (Peters, FAI)
  - Less postoperative pain, instability, and loss of inversion/eversion strength
  - Only 15-35% of patients continued to have pain and symptoms post op
  - Only 20% of intra-articular pathology seen with open lateral repair
- Addressing other pathology/intra articular?

Contraindications for Direct Repair

- Cavovarus foot types
- Obese patients
- Peroneal weakening
- Severe mechanical instability
- Poor soft tissues
- Isolated STJ instability

- As stand alone procedure

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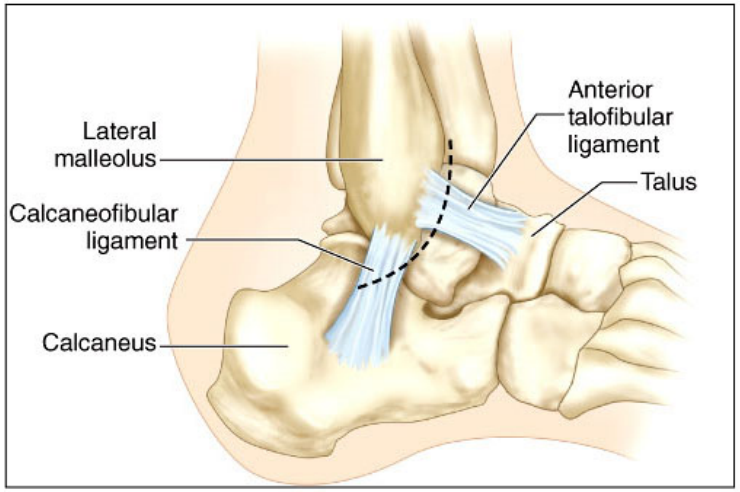
Technique – Brostrom Primary ligament repair

- Curvilinear incision anterior to fibula
- Pants over vest
- Small suture anchors
- Post op course: splint with ankle DF neutral in Eversion. NWB 2-3 wks, ankle brace for 3-6mo



B

A

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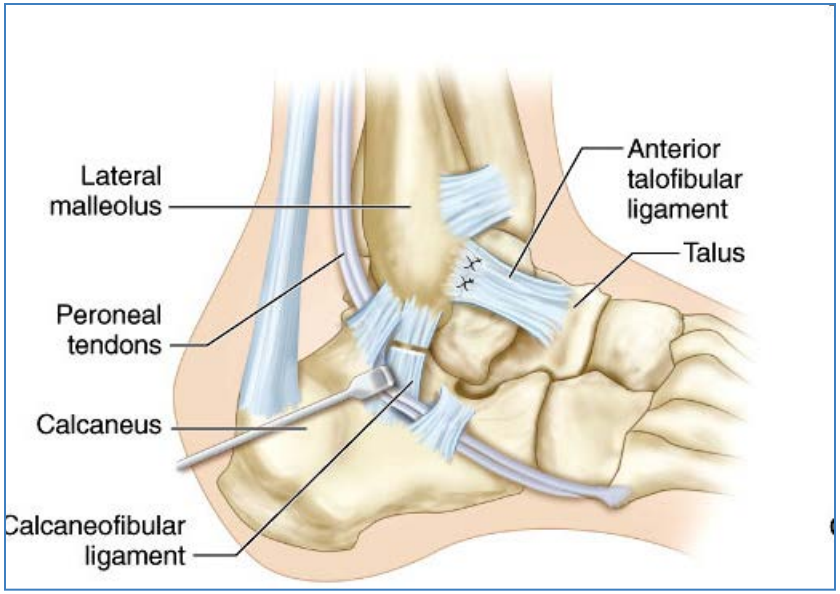
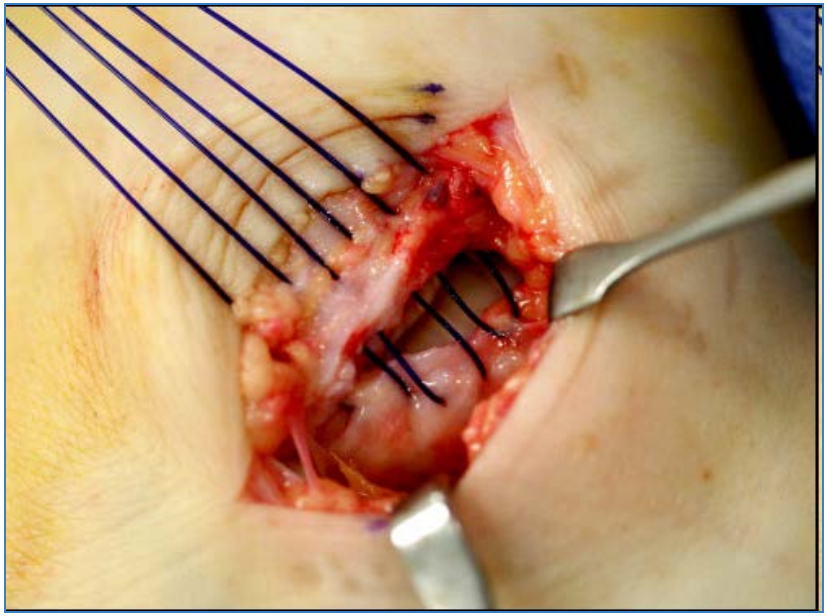
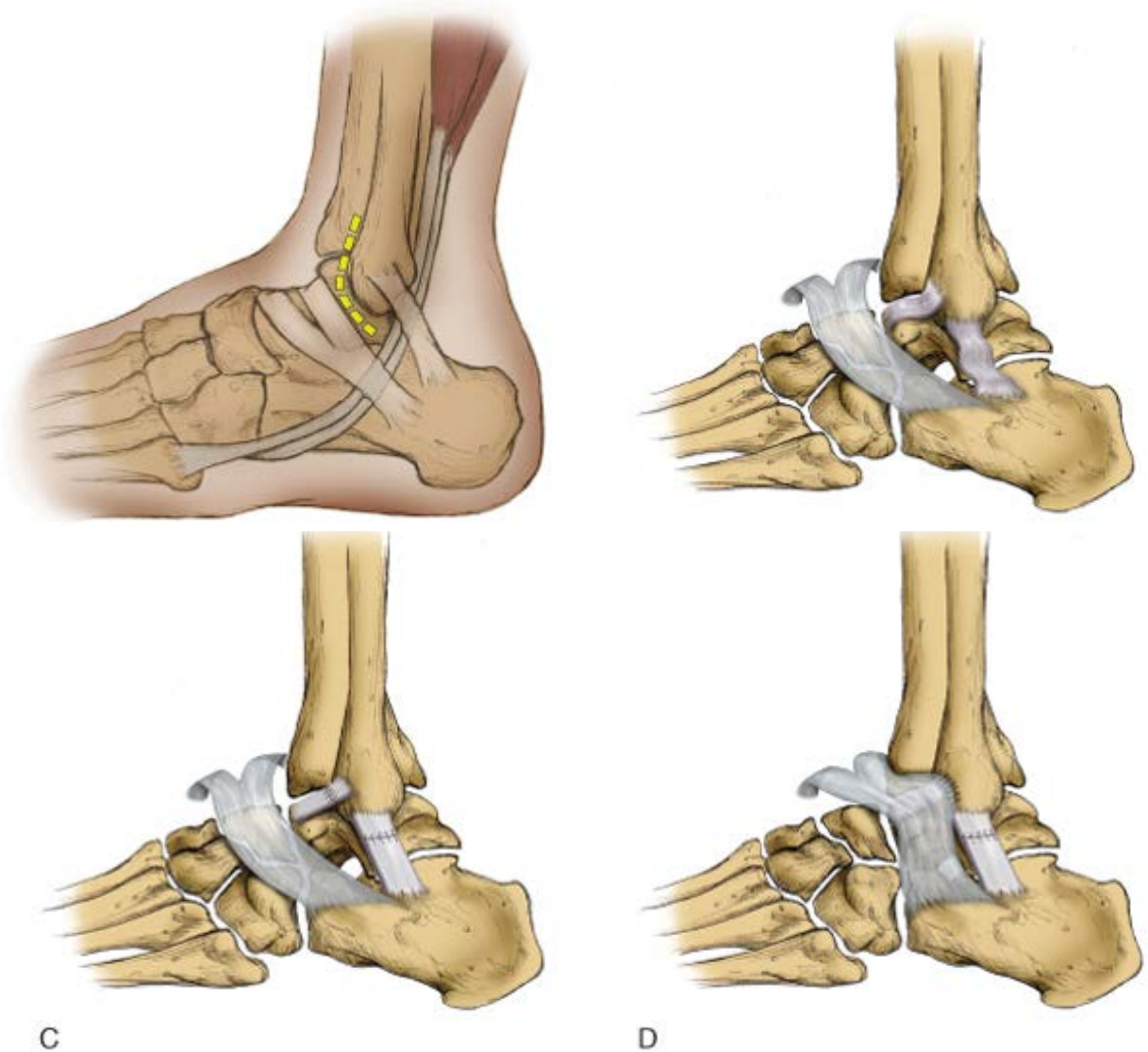
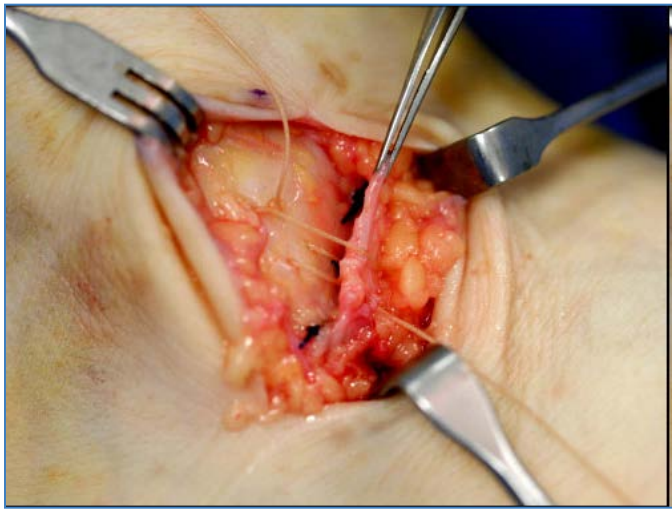
Brostrom


Lateral
malleolus
Peroneal
tendons
Calcaneus
Calcaneofibular
ligament
Anterior
talofibular
ligament
Talus



Brostrom Gould





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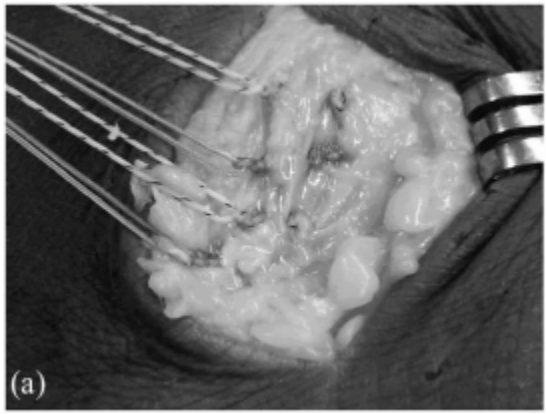
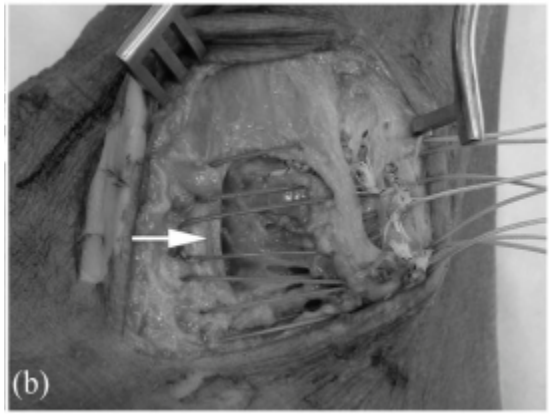
Biomechanical Analysis of Brostrom Versus Brostrom-Gould Lateral Ankle Instability Repairs

Steve B. Behrens, MD[1], Mark Drakos, MD[2], Byung J. Lee, MD[3], Dave Paller, MS[3], Eve Hoffman, BA[3], Sarath Koruprolu, BE[3], and Christopher W. DiGiovanni, MD[3]

Foot Ankle Int. 2013 Apr;34(4):587-92

- Methods
  - 10 cadaveric specimens, Telos ankle stress of 170N to simulate anterior drawer (AD) and talar tilt (TT)
  - Measured (1) intact, (2) sectioned (division of ATFL and CFL), (3) Brostrom repair, and (4) Gould modification states
- Results
  - Sectioned state demonstrated increased inversion and translation at all ankle positions during TT and AD testing
  - No significant difference between intact state and either of the repaired states
  - No difference in biomechanical stability between Brostrom repair and modified Brostrom-Gould procedure
- Conclusion
  - Additional reinforcement of lateral ankle ligament complex with inferior extensor retinaculum may be marginal at time of surgery





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Isolated Anterior Talofibular Ligament Broström Repair for Chronic Lateral Ankle Instability

9-Year Follow-up

Nicola Maffulli,*† MS, MD, PhD, FRCS (Orth), Angelo Del Buono,‡ MD, Gayle D. Maffulli,* MD, Francesco Oliva,§ MD, PhD, Vittorino Testa,‖ MD, Giovanni Capasso,¶ MD, and Vincenzo Denaro,‡ MD

The American Orthopaedic Society for Sports Medicine

- Methods
  - 42 athletes, 4 without follow up
  - Arthroscopy and ATFL direct repair
  - Average of 8.7 yr follow up

- Results
  - 22 (58%) at preinjury sport level, 6 (16%) at lower level, 10 (26%) no longer in sport, but still physically active
  - Outcomes:
    - AOFAS (51 → 90 at f/u)
    - Kaikkonen (45 → 90 at f/u)
  - Arthritis:
    - None pre-op: 30% with arthritis at f/u
    - 18% with existing had worsening

- Conclusion
  - Most (74%) return to some level of sport at long-term follow up
  - Many with development/progression of ankle arthritis

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Twenty-six-Year Results After Broström Procedure for Chronic Lateral Ankl

The American Journal of Sports Medicine

S. Josh E
and Jay S
From the
Center, A

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TABLE 2
Scores for the Patients With Long-term Follow-up[a]

Patient Number	Follow-up, y	SANE	Good et al Scale	Mean AOFAS Score	Comments
1					Lost to follow-up
2	27.9	80	3	93.2	
3	27.7	60	2	80.9	Fracture, excluded
4	27.9	65	1		Did not complete AOFAS
5	27.7	95	4	96.3	
6	27.6	100	4	98.9	
7	27.6	98	4	93.4	
7	27.4	98	4	93.4	Bilateral patient
8	27.1	100	4	97.8	
9	26.6	90	3	97.8	
10					Paraplegic after accident
11	26.4	95	4	100	
12	25.4	90	4	[illegible]	
13	26.3	95	4	[illegible]	
14	26.0	100	4	[illegible]	
15	26.0	90	3	[illegible]	
16	25.9	100	4	100	
17	25.9	100	4	100	
18	26.0	100	4	98.9	
19	25.6	80	4	86.9	
20	25.8	100	4	100	
21					Lost to follow-up
22	25.5	100	4	100	
23	25.4	90	4	92.3	
24	25.8	10	1	34.0	Fracture, excluded; reports similar symptoms on nonoperated side
25	25.4	70	1	47.4	
26	25.4	80	3	64.1	
27					Lost to follow-up
28					Torn peroneal tendons, surgical repair
29	24.7	95	4	97.2	
30	24.6	80	3	82.1	Multiple lower extremity fractures, excluded
31					Deceased

Fifteen patients sc[illegible] their a[illegible]s as grade 1 as described by Good; 5, as grade 2; and [illegible] grade 4. The mean functional outcome scores wer[illegible]ded into sections, as defined

[a]SANE, Single Assessment Numeric Evaluation; AOFAS, American Orthopaedic Foot and Ankle Society.

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Methods of Repair

- Direct repair
- Augmented direct repair
  - Bone anchors
  - Internal brace
- Non anatomic/tendon reconstruction
- Arthroscopic reconstruction

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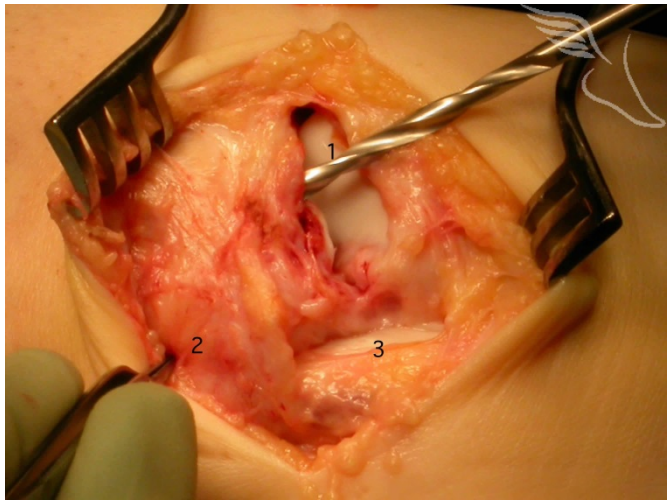
Fixation Options

- Bone tunnel
- Interference screw
- Suture anchor
  - Internal brace
  - SutureTak
  - FiberTak



http://www.footsurgeryatlas.com/media/augmented-graft-jacket-lateral-ligament-reconstruction-10.jpg

http://footandanklefixation.com/files/Biomet-Sports-Medicine-Rattler-Interference-Screw-System.jpg

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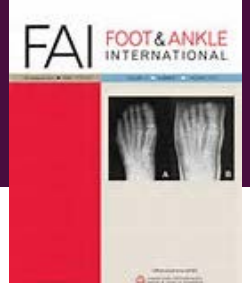
Comparison Between Suture Anchor and Transosseous Suture for the Modified-Broström Procedure

Byung-Ki Cho, MD; Yong-Min Kim, MD; Dong-Soo Kim, MD; Eui-Sung Choi, MD; Hyun-Chul Shon, MD; Kyoung-Jin Park, MD



- Methods
  - 40 pts
    - 20: Suture anchor (29.2m f/u); 20: Trans-osseous suture (28.4m f/u)
- Results
  - Karlsson score:
    - Anchor: 46.4 -> 90.8
    - Transosseous: 44.5 -> 89.2
  - No difference in talar tilt or anterior drawer
- Conclusion
  - No difference in outcomes between the groups, both reasonable for modified Brostrom fixation

Table 3: Comparison Between Transosseous Suture Group and Suture Anchor Group With Ankle Stress Radiographs (Mann-Whitney Test)

	Talar tilt angle (°)			Anterior talar translation (mm)		
	Transosseous	Suture anchor	*p* value	Transosseous	Suture anchor	*p* value
Preoperative	15.8 ± 5.1	17.2 ± 4.9	0.477	8.4 ± 2.3	8.2 ± 1.9	0.535
Postoperative (3 months)	4.7 ± 1.9	5.1 ± 2.1	0.528	3.5 ± 1.1	3.7 ± 1.3	0.621
Postoperative (1 year)	5.5 ± 2.2	5.8 ± 2.3	0.585	4.4 ± 1.4	4.5 ± 1.2	0.511
Final followup	5.4 ± 1.9	5.9 ± 2.5	0.251	4.1 ± 1.2	4.2 ± 1.1	0.447

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Comparison of Bone Tunnel and Suture Anchor Techniques in the Modified Broström Procedure for Chronic Lateral Ankle Instability

Chang-Yong Hu,* MD, Keun-Bae Lee,*† MD, PhD, Eun-Kyoo Song,* MD, PhD, Myung-Sun Kim,* MD, PhD, and Kyung-Soon Park,* MD, PhD

The American Orthopaedic Society for Sports Medicine

- Methods
  - 81 pts
    - 40: bone tunnel (34.2m f/u)
    - 41: suture anchor (32.8m f/u)
- Results
  - No significant difference between the two groups for AOFAS, Karlsson, anterior drawer, or talar tilt post-op
- Conclusion
  - Both techniques effective and reliable with comparable outcomes

Clinical Outcomes of the Bone Tunnel and Suture Anchor Groups[a]

	Bone Tunnel	Suture Anchor	*P* Value[b]
Karlsson score			
Preoperatively	57.0 (42-67)	59.9 (39-90)	.073
Final follow-up	94.9 (77-100)	96.4 (85-100)	.786
AOFAS score			
Preoperatively	64.2 (53-73)	70.3 (57-87)	.165
Final follow-up	97.8 (77-100)	97.4 (85-100)	.312

Ankle Stress Radiographic Measures of the Bone Tunnel and Suture Anchor Groups[a]

	Bone Tunnel	Suture Anchor	*P* Value[b]
Anterior talar translation, mm			
Preoperatively	9.0 (5.8-15.2)	9.2 (5.5-17.0)	.927
Final follow-up	6.5 (3.8-8.2)	6.8 (3.8-9.4)	.608
SSD preoperatively	5.0 (3.2-7.5)	5.1 (2.3-7.9)	.101
SSD at final follow-up	1.2 (0.3-2.4)	1.1 (0.1-4.0)	.608
Talar tilt, deg			
Preoperatively	12.0 (7.9-24.9)	12.5 (6.2-22.7)	.083
Final follow-up	8.8 (5.0-13.1)	8.8 (4.2-15.5)	.63
SSD preoperatively	7.2 (0.4-14.6)	7.0 (1.3-16.4)	.411
SSD at final follow-up	2.7 (0.4-6.9)	2.4 (0.1-7.2)	.774

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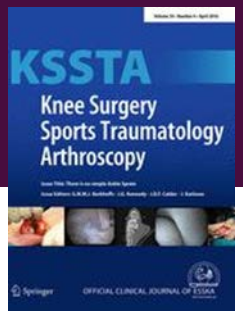
Internal Brace

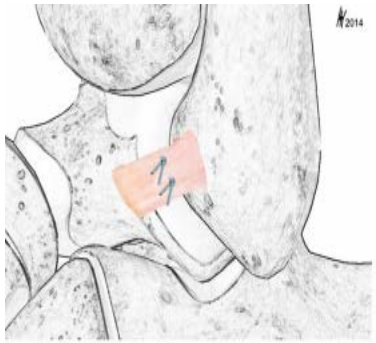
- Uses ankle and FiberTape to reconstruct ATFL
- Can be adjusted to repair ATFL and CFL
- Created hard stop point
  - Increased stiffness?

Comparison of Broström technique, suture anchor repair, and tape augmentation for reconstruction of the anterior talofibular ligament

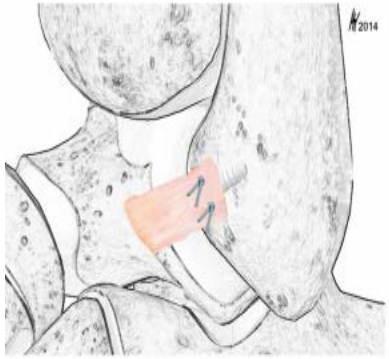
R. Schuh[1] · E. Benca[1] · M. Willegger[1] · L. Hirtler[2] · S. Zandieh[3] · J. Holinka[1] · R. Windhager[1]



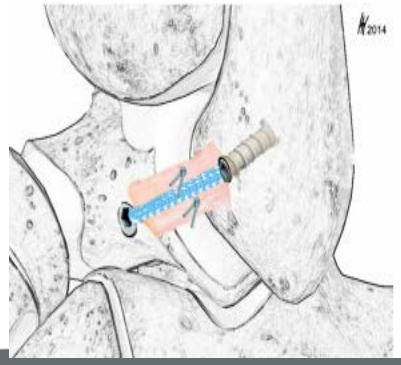
- Methods
  - 18 fresh-frozen human anatomic lower leg specimens were randomly assigned to three different groups:
    - Traditional Brostrom (TB) group
    - Sutures Anchor (SA) (SutureTak) group
    - Suture Anchor with Internal Brace (IB) augmentation group
  - Torque (Nm) to resist and rotary displacement were recorded



- Results
  - In TB group, ATFL reconstruction failed at an angle of 24.1˚
  - SA group failure occurred at 35.5˚
  - IB group it failed at 46.9˚ ($p = 0.02$)
  - Torque at failure reached 5.7 Nm for the TB repair, 8.0 Nm for the SA repair, and 11.2 Nm for the IB group ($p = 0.04$)
  - There was no correlation between angle at ATFL failure, torque at failure, and BMD for the SA or IB groups.



- Conclusion
  - Internal brace with significantly higher angle of failure and failure torque relative to SA and TB



JuggerKnot-Biomet

- They're Small
  - The volume of bone that is removed with a 3.0mm drill is equivalent to four 1.4mm anchor drill holes[4]
  - Reduces the amount of native bone removal
  - Allows for multiple points of fixation when repairing soft tissue to bone
  - Smaller diameter drill size reduces the likelihood of intersecting anchor tunnels when placing multiple anchors
- They're Strong
  - Strength is equal to or greater than some anchors two or three times larger[1]
  - High pullout strength ranging from 20-120 lbs., depending on size of anchor[2,3]
- They're All-Suture
  - Soft anchor deployment system with no rigid component
  - Eliminates the possibility of rigid material loose bodies in the joint
  - Allows blood to repair site

Biomechanical Comparison of an All-Soft Suture Anchor With a Modified Broström-Gould Suture Repair for Lateral Ligament Reconstruction

Christopher A. Brown,*† MD, Daniel Hurwit,‡ BA, Anthony Behn,‡ MS, and Kenneth J. Hunt,§ MD
Investigation performed at Stanford University, Redwood City, California,

Am J Sports Med. **2014 Feb;42(2):417-22**

Methods:

- Incised ATFL on 10 matched pairs of cadaveric ankles
  - Two 1.4-mm JuggerKnot all-soft suture anchors
  - Modified Brostrom-Gould technique using 2-0 FiberWire.
- Mounted to the testing machine in 20º of plantar flexion and 15º of internal rotation and loaded to failure after the repair.
- Stiffness, failure torque, and failure angle were recorded

Results:

- No significant difference in failure torque, failure angle, or stiffness.
- No anchors pulled out of bone. The primary mode of failure was pulling through the ATFL tissue, rather than knot failure or anchor pull-out

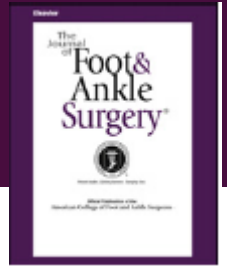
Biomechanical Testing Results for Suture and Anchor Repairs for All Specimens[a]

Repair Type	Failure Torque, N·m	Failure Angle, deg	Repaired Stiffness, N·mm/deg	Normalized Stiffness
Suture	5.7 ± 6.5	19.0 ± 5.8	315 ± 278	0.6 ± 0.2
Anchor	6.9 ± 5.9	21.7 ± 7.3	417 ± 301	0.8 ± 0.3

FiberTak

Outcomes of the Modified Brostrom Procedure Using Suture Anchors for Chronic Lateral Ankle Instability—A Prospective, Randomized Comparison between Single and Double Suture Anchors

Byung-Ki Cho, MD, Yong-Min Kim, MD, Dong-Soo Kim, MD, Eui-Sung Choi, MD, Hyun-Chul Shon, MD, Kyoung-Jin Park, MD



- Methods
  - 50 pts, follow up of at least 2 years
    - 25: one anchor (30.2m f/u)
    - 25: two anchor (29.8m f/u)
- Results
  - Similar clinical and functional outcomes, however better post op talar tilt in double anchor group
- Conclusion
  - Double suture anchors provide possibility of improved mechanical stability

Group	Karlsson Scale	
	Preoperative	Postoperative
Single suture anchor (n = 25)	46.2 ± 8.59	89.8 ± 5.86
Double suture anchor (n = 25)	47.4 ± 7.11	90.6 ± 6.04

Group	Mean Talar Tilt Angle* (°)			Mean Anterior Talar Translation† (mm)		
	Preoperative	Postoperative	Delta‡	Preoperative	Postoperative	Delta‡
Single anchor (n = 25)	14.8	5.72	9.08	9.8	4.6	5.2
Double anchor (n = 25)	15.72	4.48	11.24	9.52	4.26	5.26

Comparison between injured and uninjured side using ankle stress radiographs

Group	Mean Talar Tilt Angle (°)		Mean Anterior Talar Translation (mm)	
	Preoperative	Postoperative	Preoperative	Postoperative
Single anchor (n = 25)				
Injured side	14.8	5.72	9.8	4.6
Uninjured side	4.48	4.72	4.52	4.84
p value*	< .001	0.07	< .001	.496
Double anchor (n = 25)				
Injured side	15.72	4.48	9.52	4.26
Uninjured side	4.6	5.16	4.44	4.88
p value*	< .001	.072	< .001	.132

Sefton Grading System		Single Anchor Group (n = 25)	Double Anchor Group (n = 25)
Grade	Description		
Excellent	Full activity, including strenuous sports; no pain, swelling, or "giving way"	11	12
Good	Occasional aching only after strenuous exercise; no "giving way" or feeling of apprehension	12	10
Fair	No "giving way" but some remaining apprehension, especially on rough ground	2	3
Poor	Recurrent instability and "giving way" in normal activities, with episodes of pain and swelling	0	0

Complications – Primary Repair

- Poorer results if patients >250lbs
- CFL should be restored to prevent STJ laxity
- Must address underlying foot deformities
- Arthroscopy
    - 9% complications overall
    - 49% neurologic injury, distraction may increase risk
        - Most resolve by 6mo postop
    - Infection: 1.4% ankle scopes

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Methods of Repair

- Direct repair
- Augmented direct repair
  - Bone anchors
  - Internal brace
- Non anatomic/tendon reconstruction
- Arthroscopic reconstruction

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Graft/Reinforcement Materials

- Used in both anatomic and non-anatomic repairs

- Include:
  - Peroneal tendons
    - Elmslie 1934; Watson-Jones 1952
    - Evans 1953; Chrisman & Snook 1969
  - Achilles split tendon
  - Semitendinosis tendon
    - (Miller, 2013, FAI)
  - Palmaris longus tendon
    - (Okuda, 1999, FAI)
  - Gracillis tendon
    - (Ibrahim, 2011, JFAS)

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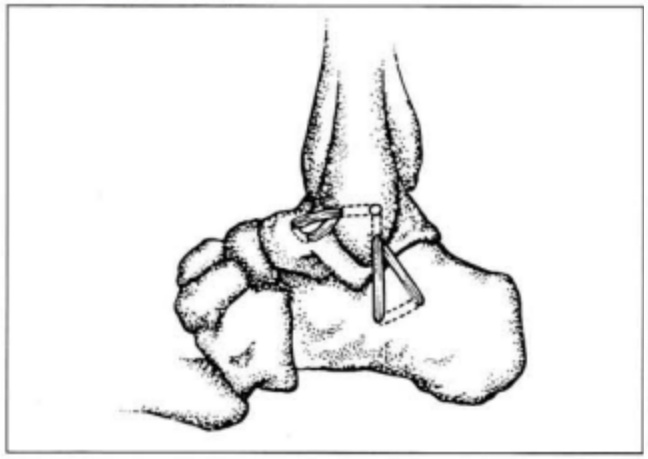

Figure 4. Elmslie double-ligament reconstruction.

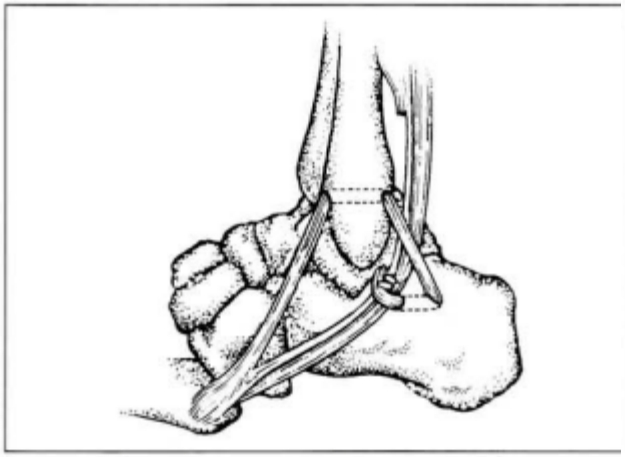

Figure 5. Christman and Shook lateral ankle stabilization.

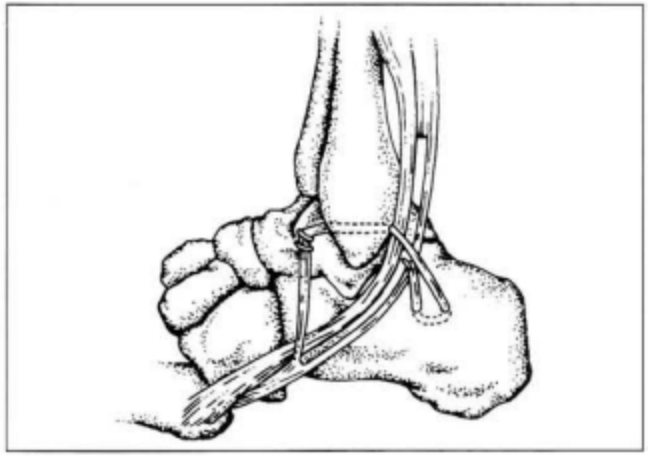

Figure 6. Hambly's lateral ligament reconstruction procedure.

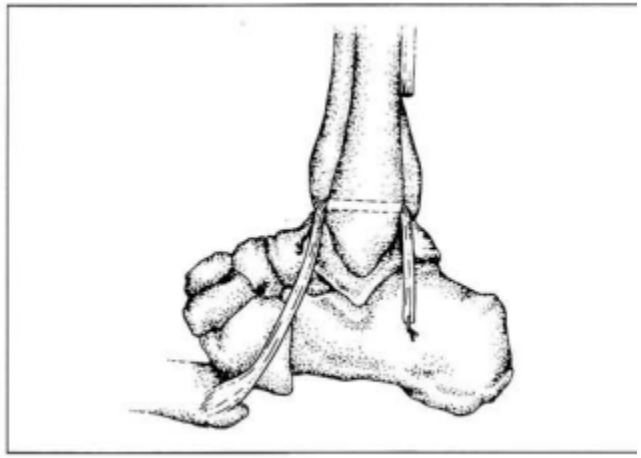

Figure 7. Whinfield double-ligament lateral ankle stabilization.

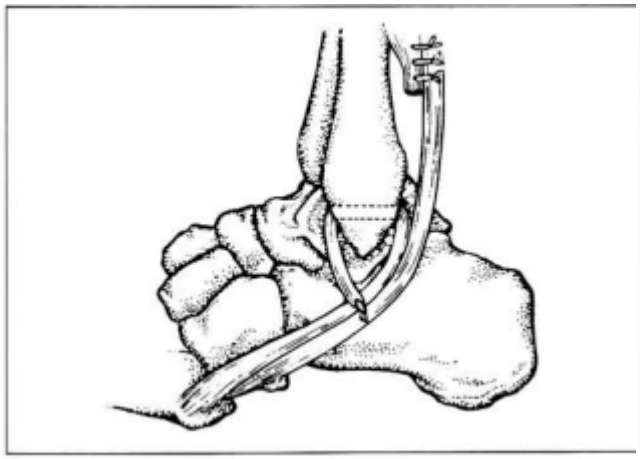

Figure 9. Lee lateral ankle stabilization.

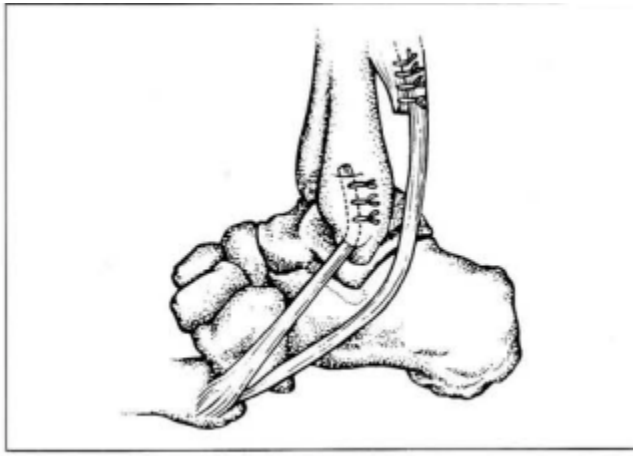

Figure 10. Nilsonne lateral ankle ligament repair.

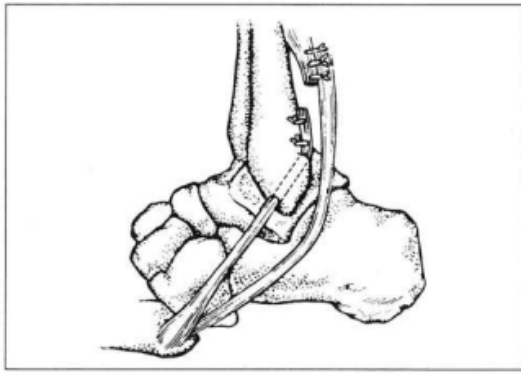

Figure 11. Evans lateral ankle stabilization.

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Biomechanical Properties of Commonly Used Autogenous Transplants in the Surgical Treatment of Chronic Lateral Ankle Instability

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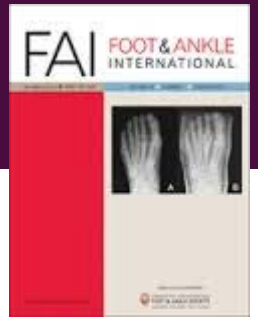

- Methods
  - 13 fresh anatomic specimens, mean age 43
    - Assessed the smallest cross-sectional area of each sample and biomechanical stability
- Results
  - Peroneus brevis, peroneus longus, and Achilles significantly higher biomechanically than other transplants

	peroneus longus	achilles split tendon	peroneus brevis	peroneus brevis split	fascia	corium	plantaris-tendon	periosteal flap	ant. talofib. ligament
crossectional	22.4	38.1	19.5	7.7	22.4	45.5	2.1	35.3	26.2
area (cm^2)	(±5.3)	(±34.6)	(±5.3)	(±1.8)	(±8.3)	(±14.2)	(±0.8)	(±15.7)	(±6)
stiffness	156.9	122	116.2	77	94.8	40.9	42.6	30.2	29.5
(N/mm)	(±21.4)	(±27.9)	(±15.2)	(±20)	(±31.9)	(±14.6)	(±12.9)	(±12.6)	(±16.2)
absorbed energy	79	58	37.4	15.6	29.3	40	6.4	3.5	9.6
(J)	(±13.2)	(±19.5)	(±11.2)	(±8.9)	(±24.7)	(±11)	(±3.9)	(±2.7)	(±7)
ultimate strain	49	62	41	40	66	68	28	42	225
(%)	(±14.7)	(±28.3)	(±11.7)	(±13.1)	(± 29.4)	(±21.1)	(±6.8)	(±11.5)	(±27.5)
modulus of elasticity (N/mm^2)	191.8 (±55)	105.6 (±55.8)	149.7 (±56.3)	171.5 (±33.3)	59.1 (±23)	22.5 (±6.3)	442.5 (±102.7)	10.3 (±6.7)	5.1 (±5.6)

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Methods of Repair

- Direct repair
- Augmented direct repair
  - Bone anchors
  - Internal brace
- Non anatomic/tendon reconstruction
- Arthroscopic reconstruction

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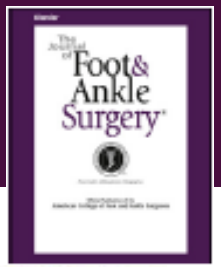
The "All-Inside" Arthroscopic Broström Procedure With Additional Suture Anchor Augmentation: A Prospective Study of 45 Consecutive Patients

James M. Cottom, DPM, FACFAS [1], Joseph S. Baker, DPM, AACFAS [2], Phillip E. Richardson, DPM [2]



- Methods
  - 45 consecutive patients
  - "Arthroscopic repair" with double suture anchors
- Results
  - Followed for avg 14 months
  - Wbing with crutches at 3.3 day avg, FWB 14.4 day avg, PT at avg 21.6 day avg, shoes with stirrup ankle brace at 28.7
  - AOFAS 48.7 → 95.4
  - VAS 8 → 0.6
- Conclusion
  - Good clinical and functional outcomes with this technique

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Methods of Repair

- Direct repair
- Augmented direct repair
  - Bone anchors
  - Internal brace
- Non anatomic/tendon reconstruction
- Arthroscopic reconstruction

- Does any of it restore mechanics?

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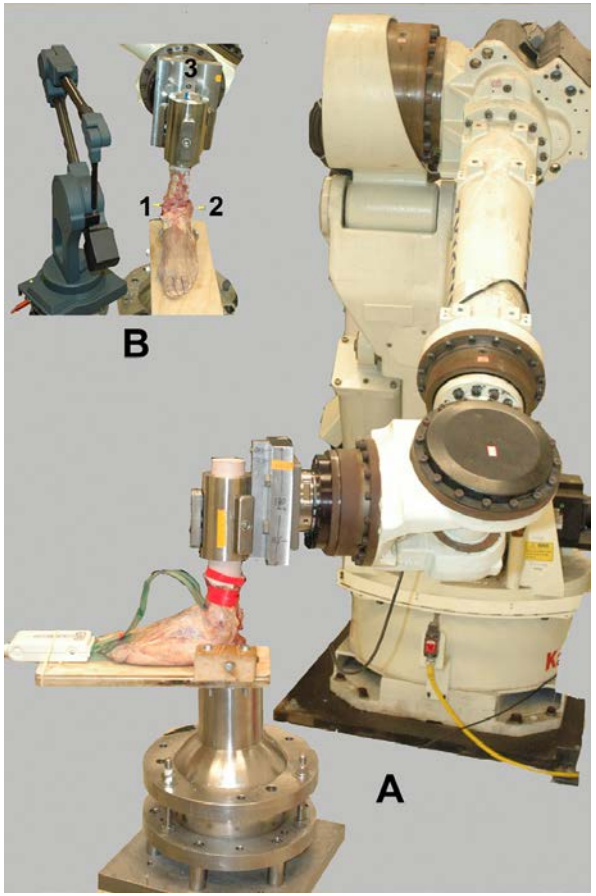
Lateral Ligament Repair and Reconstruction Restore Neither Contact Mechanics of the Ankle Joint nor Motion Patterns of the Hindfoot

Victor R. Prisk, MD, Carl W. Imhauser, PhD, Padhraig F. O'Loughlin, MD, and John G. Kennedy, MD, FRCS

JB&JS

- Methods
  - 8 cadavers for compression and inversion at 0 and 20 deg PF
  - Contact at ankle joint measured
  - Compared initial with:
    - Sectioned ATFL, sectioned CFL, Brostrom, Brostrom-Gould, graft reconstruction



- Results
  - Cut ligaments caused medial and anterior shift of center of pressure
  - No difference in inversion or axial rotation with inversion in intact vs Brostrom, but Brostrom with changed location of center of pressure
    - Brostrom Gould with higher control than intact ligaments
  - Graft more accurately restored motion, but altered center of pressure

- Conclusion
  - No ligament reconstruction completely restored contact mechanics of ankle joint and hindfoot motion patterns

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Post-op Management

ATFL Elongation after Brostrom Procedure: A Biomechanical Investigation

Kevin L. Kirk, MAJ, MC, USA; John T. Campbell, MD; Gregory P. Guyton, MD; Brent G. Parks, MSc; Lew C. Schon, MD

- Methods
  - Cadaver study
  - Prevented inversion, allowed for 30 deg plantarflexion and 10 deg dorsiflexion
  - 1000 cycles (20/day x 50 days)
- Results
  - No difference in elongated except for repaired, unprotected group
- Conclusion
  - Supports protected range of motion after ligament repair

Table 1: Percent elongation for protected intact, protected sectioned, protected repaired, and unprotected repaired ATFL at the initial and final stages (mean ± SEM) ($n = 6$)

	Elongation (%)		
Stage	**Initial**	**Final**	***p***
ATFL protected intact	3 ± 1	3 ± 1	0.61
ATFL protected sectioned	4 ± 1	3 ± 1	0.20
ATFL protected repaired	2 ± 1	3 ± 2	0.62
ATFL repaired unprotected	10 ± 1*	12 ± 1*	0.02†

*, Significantly different from all protected groups ($p \leq 0.05$).
† Statistically significant difference between initial and final ($p \leq 0.05$).

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Short- to Medium-term Outcomes After a Modified Broström Repair for Lateral Ankle Instability With Immediate Postoperative Weightbearing

Massimo Petrera, Tim Dwyer, John S. Theodoropoulos and Darrell J. Ogilvie-Harris

- Methods
  - 49 patients; 23 male, 26 female
  - Repair of ATFL and CFL with metallic suture anchors
  - FWB POD 1 in walking boot
  - 2 year follow up
- Results
  - Significant improvement in FOAS
  - No difference in motion relative to contralateral limb
  - Failure rate 6% (residual instability)
- Conclusion
  - Immediate weightbearing tolerated in lateral ankle reconstruction

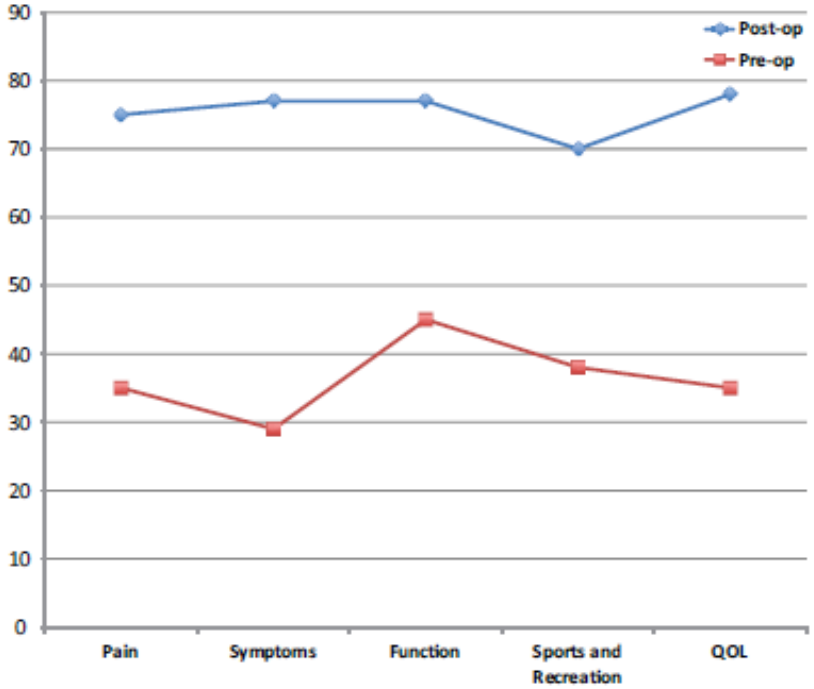

Figure 6. Diagram showing the trend in Foot and Ankle Outcome Score before and after surgery: the improvement in each subscale was significant ($P < .05$). QOL, quality of life.

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Accelerated Versus Traditional Rehabilitation After Anterior Talofibular Ligament Reconstruction for Chronic Lateral Instability of the Ankle in Athletes

Wataru Miyamoto,*† MD, Masato Takao,† MD, Kazuaki Yamada,† MD, and Takashi Matsushita,† MD

The American Orthopaedic Society for Sports Medicine

- Methods
  - 33 patients with ATFL recon. Using gracilis autograft
    - 15: 4 weeks WB cast, 4 weeks WB soft ankle orthosis (Group I)
    - 18: Accelerated rehab without immobilization—WBAT in soft ankle orthosis (Group A)
      - Motion at 2-3 days; Treadmill, sport specific drills, balance board at 6-7 wks

- Results
  - No difference in scores or radiology at 2 years
  - Accelerated rehab group returned to athletic activity 5 weeks earlier

- Conclusion
  - Accelerated rehab improves return to sport without sacrificing outcome

	Before Surgery	2 Years After Surgery	*P* Value
Group I			
Karlsson and Peterson score	62.3 ± 4.7 (54-72)	94.4 ± 7.1 (76-100)	<.0001
Talar tilt angle compared with contralateral side, deg	8.7 ± 2.6 (7-16)	3.8 ± 1.5 (1-6)	<.0001
Anterior displacement of the talus, mm	7.7 ± 1.8 (6-12)	4.0 ± 1.6 (2-8)	<.0001
Group A			
Karlsson and Peterson score	64.1 ± 4.8 (57-70)	91.7 ± 7.7 (74-100)	<.0001
Talar tilt angle compared with contralateral side, deg	10.5 ± 3.4 (6-15)	4.3 ± 1.8 (2-6)	<.0001
Anterior displacement of the talus, mm	8.7 ± 2.1 (6-13)	4.3 ± 1.2 (3-7)	<.0001

Conclusion

- Lateral ankle sprains are a very common pathology which can be treated non-surgically in the acute setting
- 20% of acute sprains lead to chronic lateral ankle instability, of which 10-20% require surgical intervention
- Consider pathology associated with chronic sprains/instability
- Advanced imaging (MRI) can assist with diagnoses with chronic instability and associated pathology
- Brostrom-type procedures are primary line in surgical intervention
- Autograft, allograft, labral tape/internal brace should be considered if failed Brostrom, generalized laxity, obesity, etc
- Increasing role for arthroscopy both treatment and diagnosis associated pathology

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Final thoughts

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