Evidenced-Based Ankle Evaluation

Casey Christy, MA, ATC, CSCS
Eastern High School, Voorhees NJ
Adjunct Instructor, Rowan University

What we'll cover

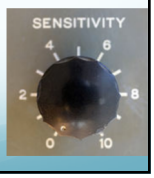
- Evidenced-Based Basics
  - Sensitivity, specificity, confidence intervals, P-value
- Ottawa Ankle Rules
- Syndesmosis Injuries
- Growth Plate Injuries

Statistics are no substitute for judgement.

- Henry Clay -

Evidenced-Based Basics

- Sensitivity
  - Proportion of patients with a condition correctly identified by a test (JAT ≥ 80%)
- Specificity
  - Proportion of patients without a condition correctly identified by a test (JAT ≥ 80%)



Evidenced-Based Basics

95% Confidence Interval (CI)

- 95% confident a true population difference exists between the range provided
- The more narrow the range the better
- (Sensitivity 88%, 95% CI 84 – 92)

Evidenced-Based Basics

- P value
  - Did the results happen by chance?
  - Significance
  - < .05
- Less than a 5 percent chance the findings happened by chance

EBP Basics

The Briles Test

	Positive Polygraph	Negative Polygraph
Positive Briles Test	50 (TP)	35 (FP)
Negative Briles Test	10 (FN)	45 (TN)
	50/60 = 83% Sensitivity	45/80 = 56% Specificity

Sensitivity 83% (95% CI 79 – 89%)

Specificity 56% (95% CI 34 – 76%)

Evidence-Based Basics

- Positive Likelihood Ratio
  - Closer to 10+ the better
- Negative Likelihood Ratio
  - Closer to 0 the better

"You realize one of us is not coming back"

Evidence-Based Basics

- Positive Likelihood Ratio
  - Shifts in probability
  - 1-2 small, rarely important shift
  - 2-5 small but sometimes important shifts (JAT ≥ 2.0)
  - 5-10 moderate shifts
  - 10+ large and often conclusive shifts
- Negative Likelihood Ratio
  - .5-1 small, rarely important shift
  - .2-.5 small but sometimes important shifts (JAT ≤ .50)
  - .1-.2 moderate shifts
  - < .1 large and often conclusive shifts

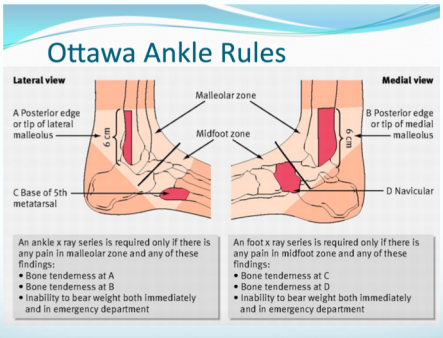
Learning Objectives

- Describe the OAR criteria that indicates radiography for a foot or ankle injury.
- Explain the OAR sensitivity and specificity in the adult and pediatric populations.
- Identify the most useful tests for diagnosing a syndesmosis injury.
- Discuss the accuracy of other ankle special tests and clinical decision rules.
- Review ankle physeal injuries and the risk of growth arrest.

Clinical Question

Are the Ottawa Ankle Rules (OAR) an effective tool to diagnose an ankle fracture in the pediatric population?

- Pediatric includes adolescents
- Diagnostic accuracy
  - Sensitivity and specificity



Weight bearing = 4 steps

44-55-66-PM

- Mnemonic better long-term recall
  - Unable to do **4** steps immediately
  - Unable to do **4** steps in the ER
  - Has pain at **5**th metatarsal base
  - Has pain at **S**caphoid (tarsal navicular)
  - Tenderness in **6**cm **P**osterior edge of medial **M**alleolus
  - Tenderness in **6**cm **P**osterior edge of lateral **M**alleolus
- 190 residents and medical students
  - Prior study 99% emergency physicians familiar, 30% correctly remember
- Mnemonic vs standard info sheet

Gravel J, Roy M, Carriere B, et al. 44-55-66-PM, a mnemonic that improves retention of the Ottawa Ankle and Foot Rules: a randomized controlled trial. 2010; *Acad Emerg Med.*17(8):850-864.

Early Ottawa Study in Adults

- JAMA 1993
- Emergency Depts, 2 hospitals
- 1485 adult patients
  - Excluded patients
    - Under 18 or pregnancy
    - Referred from outside the hospital
    - Injury occurred more than 10 days prior
    - Returned for re-evaluation

Stiell I, Greenberg G, McKnight D et al. Decision rules for the use of radiography in acute ankle injuries: Refinement and prospective validation. *JAMA*. 1993;269(9), 1127-1132.

Early Ottawa Study in Adults

- 100% sensitivity for ankle fx (95% CI 93–100%)
- 100% sensitivity for midfoot fx (95% CI 83–100%)
- 49% specificity for ankle fx (95% CI 44–54%)
- 79% specificity for foot fx (95% CI 75–83%)
- Estimated ankle xray reduction 30%

Stiell I, Greenberg G, McKnight D, et al. Decision rules for the use of radiography in acute ankle injuries: Refinement and prospective validation. *JAMA*. 1993;269(9):1127-1132.

Early Ottawa Study in Adults

ANKLE	Positive X-ray	Negative X-ray
Positive OAR	50	**205**
Negative OAR	**0**	198

FOOT	Positive X-ray	Negative X-ray
Positive OAR	19	**90**
Negative OAR	**0**	344

Stiell I, Greenberg G, McKnight D, et al. Decision rules for the use of radiography in acute ankle injuries: Refinement and prospective validation. *JAMA*. 1993;269(9):1127-1132.

Ottawa Implementation in Adults

- 2 hospitals (1 served as control)
- Adult patients
- 100% sensitivity ankle fx (95% CI 95–100%)
- 100% sensitivity foot fx (95% CI 82–100%)
- 50% specificity ankle fx (95% CI 46–55%)
- 77% specificity foot fx (95% 73–80%)

Stiell I, McKnight D, Greenberg G, et al. Implementation of the Ottawa Ankle Rules. *JAMA*. 1994;25(11):827-832.

Ottawa Implementation in Adults

ANKLE	Positive X-ray	Negative X-ray
Positive OAR	74	244
Negative OAR	0	247

FOOT	Positive X-ray	Negative X-ray
Positive OAR	19	125
Negative OAR	0	420

Stiell I, McKnight D, Greenberg G, et al. Implementation of the Ottawa Ankle Rules. *JAMA*. 1994;25(11):827-832.

Ottawa Implementation in Adults

- Reduced ankle x-rays by 28% at intervention hospital
  - Increased 2% at control hospital (p<.001)
- Reduced foot x-rays by 14% at intervention hospital
  - Increased 14% at control hospital
- For those not x-rayed
  - Lower costs ($62 vs $173, p<.001)
  - Less time in ER (80 min vs 116 min, p<.001)
  - No difference in patient satisfaction
- No missed fractures

Stiell I, McKnight D, Greenberg G, et al. Implementation of the Ottawa Ankle Rules. *JAMA*. 1994;25(11):827-832.

OAR HS and College Patients

- 21 secondary school ATs and 2 colleges
- 32 ATs
- Ankle evals within 1 hour of injury
- Used OAR and clinical judgment

David S, Gray K, Russell J, et al. Validation of the Ottawa Ankle Rules for acute foot and ankle injuries. *J Sport Rehab*. 2016;25:48-51.

OAR HS and College Patients

- 124 injured athletes (70% male, 30% female)
- 100 met OAR criteria for x-ray
- Only 38 obtained x-ray
  - ATs clinical judgment prevented x-rays of 62 others
  - 18% of those x-rayed had a fracture
- OAR missed one fracture
  - Orig dx was syndesmosis injury by physician
  - Failure to regain function
  - MRI revealed posterior tibial plafond fx

David S, Gray K, Russell J, et al. Validation of the Ottawa Ankle Rules for acute foot and ankle injuries. *J Sport Rehab*. 2016;25:48-51.

OAR HS and College Patients

	Positive X-ray	Negative X-ray
Positive OAR	7	31
Negative OAR	1	0

- Sensitivity 88% (95% CI 42–97%)
- Specificity 0 (95% CI 0.0–11.32%)
- Positive Likelihood Ratio .86 (95% CI .63–1.16)
- Negative Likelihood ratio not calculable

David S, Gray K, Russell J, et al. Validation of the Ottawa Ankle Rules for acute foot and ankle injuries. *J Sport Rehab*. 2016;25:48-51.

OAR HS and College Patients

- Study Conclusions
  - When OAR is negative, clinician can be confident there is no fracture
  - When OAR is positive, consider high chance of false positive
  - Combine OAR and clinical judgment
  - Low but possible risk of missing a fracture

David S, Gray K, Russell J, et al. Validation of the Ottawa Ankle Rules for acute foot and ankle injuries. *J Sport Rehab*. 2016;25:48-51.

Clinical Judgement

- Location of pain
- Inability to partially bear weight
- Gross edema, effusion
- Growth plates are of paramount consideration
- Ottawa is pretty good
- Pop/crack
- Feeling of instability
- Pain scale above a 7
- Inability to progress with rehab
- Carrying on, in extreme pain
- Deformity
- Depends when follow-up is feasible
- Athlete's age
- Special tests results
- Edema, ecchymosis
- Pre-existing medical conditions
- Previous injury
- Presence, location, severity of bony tenderness
- **Mom wants an x-ray**

OAR Children and Adolescents

- Systematic Review combining 12 studies
- 671 fractures
- Ages
  - Some studies < 18 years old
  - One study 6 – 16 years old
  - One study 5 – 19 years old
- 8 studies OAR applied retrospectively after xray

Dowling S, Spooner C, Liang Y, et al. Accuracy of Ottawa Ankle Rules to exclude fractures of the ankle and midfoot in children: A meta-analysis. *Acad Emerg Med*. 2009;16: 277-287.

OAR Children and Adolescents

- Pooled sensitivity 98.5 % (95% CI 97.3 – 99.2%)
- Specificities ranged 8 – 50% (not pooled)
- Pooled Negative Likelihood Ratio .11 (95% CI .05 –.26)
  - meaning OAR can be used to r/o fx
- Positive likelihood Ratio not pooled
- Missed fracture rate 1.2 % (95% CI .6 – 2.3%)
- 10 missed fractures
  - One SH-1, one SH-4, two 'insignificant fractures'
  - 6 not specified

Dowling S, Spooner C, Liang Y, et al. Accuracy of Ottawa Ankle Rules to exclude fractures of the ankle and midfoot in children: A meta-analysis. *Acad Emerg Med*. 2009;16: 277-287.

OAR Children and Adolescents

- Study Conclusions
  - Application of OAR is reliable for children > 5 years old
  - OAR application results in 24.8% reduction in xrays
  - Low but possible risk of missing a fracture

Dowling S, Spooner C, Liang Y, et al. Accuracy of Ottawa Ankle Rules to exclude fractures of the ankle and midfoot in children: A meta-analysis. *Acad Emerg Med*. 2009;16: 277-287.

More Ottawa Data

- Systematic Review with Meta-Analysis of OAR
- 66 studies, children and adults
  - 56 were prospective
- 22,273 patients
- 3,686 ankle/midfoot injuries
- Mean age range across studies 11– 47 yo

Beckencamp P, Lin C, Macaskill P, et al. Diagnostic accuracy of the Ottawa Ankle and Midfoot Rules: a systematic review with meta-analysis. *Br J Sports Med*. 2017;16:504-510.

More Ottawa Data

- Ankle Fx Sensitivity
  - Adults 99.4% (95% CI 97.9–99.8)
  - Children 97.9% (95% CI 94.9–99.1)
- Ankle Fx Specificity
  - Adults 35.8% (95% CI 28.8–42.3)
  - Children 21% (95% CI 13.1–31.9)

Beckencamp P, Lin C, Macaskill P, et al. Diagnostic accuracy of the Ottawa Ankle and Midfoot Rules: a systematic review with meta-analysis. *Br J Sports Med*. 2017;16:504-510.

More Ottawa Data

- Study Conclusions
  - OAR can reduce unnecessary xrays by 30%
  - Less accurate in children
  - High sensitivity
    - Sensitivity significantly higher in adults (99% vs 97%)
  - Poor specificity in adults and children

Beckencamp P, Lin C, Macaskill P, et al. Diagnostic accuracy of the Ottawa Ankle and Midfoot Rules: a systematic review with meta-analysis. *Br J Sports Med*. 2017;16:504-510.

Combining OAR & Tuning Fork

- 49 patients, 12–84 yo
- Inversion injuries
- Tuning Fork on "Ottawa Positive"
  - Distal tip lateral malleolus
  - Distal fibular shaft 5-10cm above max tender point

Dissman P, Han K. The tuning fork test – a useful tool for improving specficity in "Ottawa Positive" patients after ankle inversion injury *Emer Med J*. 2006;23:788-790.

Combining OAR & Tuning Fork

- Study exclusions
  - <12 yo
  - Non-traumatic ankle swelling
  - Non-inversion injuries
  - Extensive soft-tissue swelling
  - Diminished or altered sensation

Dissman P, Han K. The tuning fork test – a useful tool for improving specficity in "Ottawa Positive" patients after ankle inversion injury *Emer Med J*. 2006;23:788-790.

Combining OAR & Tuning Fork

- Ottawa alone 100% sensitivity, 32% specificity
- Ottawa and Tuning Fork
  - Lateral Malleolus specificity improved to 61% (CI 46-75%)
  - Distal fibula specificity improved to 95% (CI 83-99%)
  - No loss of sensitivity
- Combining OAR and Tuning Fork improves specificity 2–3 fold without reducing sensitivity

Dissman P, Han K. The tuning fork test – a useful tool for improving specficity in "Ottawa Positive" patients after ankle inversion injury *Emer Med J*. 2006;23:788-790.

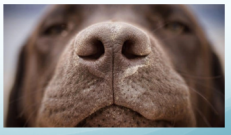
Clinical Question Answer

- OAR are clinically useful for children > 5 and adolescents; but not as accurate compared to adults
- OAR remain secondary to clinical judgement and common sense
- Risk of missing a fracture using OAR is small but possible
- OAR have high sensitivity, low specificity
- SnNout = If **sen**sitivity is high, a **n**egative test rules **out** the condition.

Evidenced-Based Basics

- SpPin
  - If **sp**ecificity is high, a **p**ositive test rules **in** the injury

- SnNout
  - If **sen**sitivity is high, a **n**egative test rules **out** the injury



Syndesmosis Injuries

- Clinical presentation
  - Pain out of proportion **Positive Test Rules In**
  - Single Leg Hop Test **Negative Test Rules Out**
  - Mx of Injury involving DF/ER
  - Inability to continue play or walk
- Clinical tests
  - DF w/ER test (Kleiger's) **Negative Test Rules Out**
  - Squeeze test Positive Test **Positive Test Rules In**
  - Local tenderness syndesmosis ligaments **Neg Rules Out**
  - Dorsiflexion lunge with compression test

Sman P, Hiller C, Rae K, et al. Diagnostic accuracy of clinical tests for ankle syndesmosis injury. *Br J Sports Med*. 2015;49:323-329.

Syndesmosis Injuries

- Clinical presentation, special tests compared to MRI
- Radiologist blinded to clinical assessment results
- 87 participants (ages 16 – 60 yo)
- Exclusions:
  - Suspected lower limb fx
  - Suspected isolated ATFL injury
  - If unable to get MRI within 2 wks of injury

Sman P, Hiller C, Rae K, et al. Diagnostic accuracy of clinical tests for ankle syndesmosis injury. *Br J Sports Med*. 2015;49:323-329.

Syndesmosis Injuries

- Clinical presentation
  - Pain out of proportion
    - Sensitivity 65% (CI 49 – 78%)
    - **Specificity 79%*** (CI 65 – 88%) **SpPin**
    - Positive Likelihood Ratio 3.05
  - Single Leg Hop Test
    - **Sensitivity 89%*** (CI 76– 96%) **SnNout**
    - Specificity 29% (CI 18 – 42%)

* Highest in study

Sman P, Hiller C, Rae K, et al. Diagnostic accuracy of clinical tests for ankle syndesmosis injury. *Br J Sports Med*. 2015;49:323-329.

Syndesmosis Injuries

- Clinical Tests
  - Squeeze Test
    - Sensitivity 26% (CI 15 – 42%)
    - **Specificity 88%*** (CI 76 – 94%) **SpPin**
    - Positive Likelihood Ratio 2.15 (CI .86 – 5.39)
  - Syndesmosis ligament tenderness
    - **Sensitivity 92%*** (CI 79 – 97%) **SnNout**
    - Specificity 29% (CI 18 – 42%)
  - DF w/ER (Kleiger's) Test
    - **Sensitivity 71%** (CI 55 – 83%) **SnNout**
    - Specificity 63% (CI 49 – 75%)

Syndesmosis Injuries

- Study Summary
- Good at Ruling In
  - Pain out of Proportion
  - Squeeze Test
- Good at Ruling Out
  - Single Leg Hop Test
  - Kleiger's Test
  - Syndesmosis Ligament Tenderness

Syndesmosis Injuries

- 60 Division I-A athletes
  - No frank diastasis or fx
- Days missed related to interosseous tenderness length
- Avg 13.4 days (range 5-24) P<.00001

Nussbaum E, Hiller C, Hosea T, et al. Prospective Evaluation of Syndesmotic Ankle Sprains Without Diastasis. *Amer J Sports Med*. 2001;29:1:31-35.

Syndesmosis Injuries

- Days missed = 5 + (0.93 X [tenderness length in centimeters]) +/– 3.72 days
- 23 of 60 described posterior ankle pain
- Avg tenderness length 8.5cm

Nussbaum E, Hiller C, Hosea T, et al. Prospective Evaluation of Syndesmotic Ankle Sprains Without Diastasis. *Amer J Sports Med*. 2001;29:1:31-35.

Syndesmosis Injuries

- Study conclusion
  - Days missed related to syndesmosis tenderness length (P=.0001) and positive squeeze test (P=.03)
- Management protocol outlined
- RTP: 15 single-leg hops off toes, pass functional test, mentally ready

Prospective Evaluation of Syndesmotic Ankle Sprains Without Diastasis*

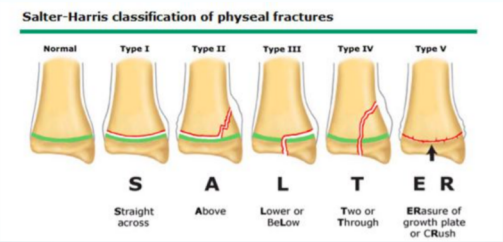
Eric D. Nussbaum,† MEd, ATC, Timothy M. Hosea,‡§ MD, Shawn D. Sieler,‡ MD, Brian R. Incremona,† MD, and Donald E. Kessler,† MEd, ATC

Physeal Injuries

- Weakest link
- Closure dates distal tibia and fibula growth plates
  - Girls 12-17
  - Boys 15-20
- Peak incidence
  - Girls 11 years old
  - Boys 14 years old

Hansman CF. Appearance and fusion of ossification centers in the human skeleton. *Am J Roentgenol Radium Ther Nucl Med.* 1962;88:476-82.
Ogden JA, McCarthy SM. Radiology of postnatal skeletal development. VIII. Distal tibia and fibula. *Skeletal Radiol.* 1983;10:209-20.

Salter-Harris Classification



A progressively increased chance of growth arrest occurs with higher classified fracture types.

Mallick A, Prem H. Physeal injuries in children. *Surg.* 2017; 35(1):10-17.
Salter R, Harris W. Injuries involving the epiphyseal plate. *J Bone Joint Surg Am.*1963;45A:587-622.

Lateral Ankle Sprain vs SH-1 Fracture

- Ankle inversion injuries
  - Salter-Harris I fracture "clinical diagnosis"
  - Up to 50% ages ≥ 6yo with negative x-ray have SH1 fx on MRI
- Less than thought?
  - Children 5-12 years old
  - Lateral ankle injury, swelling limited weight bearing
  - Tenderness distal fibular physis
  - Negative x-ray
  - 3% had SH1 fracture on MRI

Boutis, K, Komar L, Jaramillo, D, et al. Sensitivity of a clinical examination to predict need for radiography in children: a prospective study. *Lancet.* 2001;358(9299):2118-2121.
Stuart J, Boyd R, Derbyshire S, et al. Magnetic resonance assessment of inversion ankle injuries in children. *Injury.* 1998;29(1):29-30.

Lateral Ankle Sprain vs SH-1 Fracture

- Children with confirmed SHI fractures have similar functional recovery as those with ligamentous injury when treated with a removable brace and self-regulated return to activity.

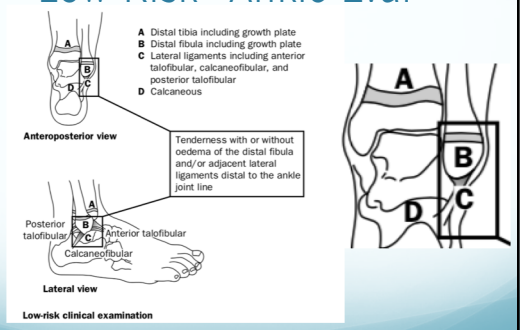
Boutis, K, Komar L, Jaramillo, D, et al. Sensitivity of a clinical examination to predict need for radiography in children: a prospective study. *Lancet.* 2001;358(9299):2118-2121.

"Low-Risk" Ankle Eval

- Ages 3-16
- Isolated pain, tenderness distal fibula below level of ankle joint
- Ligamentous tenderness
- With or without edema or ecchymosis

Boutis, K, Komar L, Jaramillo, D, et al. Sensitivity of a clinical examination to predict need for radiography in children: a prospective study. *Lancet.* 2001;358(9299):2118-2121.

”Low-Risk” Ankle Eval



Boutis, K, Komar L, Jaramillo, D, et al. Sensitivity of a clinical examination to predict need for radiography in children: a prospective study. *Lancet*. 2001;358(9299):2118-2121.

“Low Risk” Ankle Eval

- 100% sensitivity
- 63% reduction in X-rays
- 72% ligament sprain
- 23% Salter-Harris I fractures
- 5% radiographic visible fx
  - non-displaced SHII or and avulsion fx

Boutis, K, Komar L, Jaramillo, D, et al. Sensitivity of a clinical examination to predict need for radiography in children: a prospective study. *Lancet*. 2001;358(9299):2118-2121.

“Low-Risk” Ankle Eval

- Prospective cohort study pediatric ED
- 272 participants, ages 16 or younger
- Sensitivity 87% (95% CI 75-94%)
- Specificity 54% (95% CI 47-60%)
- X-Rays reduced 49%
- But missed 6 important fractures

Gravel J, Hedrei P, Grimard G, et al. Prospective validation and head-to-head comparison of 3 ankle rules in a pediatric population. *Ann Emerg Med*. 2009;54(4):534-540.

“Low-Risk” Ankle Eval

- The 6 missed fractures
  - SH II fibula
  - SH II fibula
  - Metaphysis fracture of fibula
  - Avulsion fracture fibula
  - SH II tibia
  - Tibia spiral fracture

Gravel J, Hedrei P, Grimard G, et al. Prospective validation and head-to-head comparison of 3 ankle rules in a pediatric population. *Ann Emerg Med*. 2009;54(4):534-540.

OAR vs Low-Risk

- Compared OAR vs Low-Risk Rules in a pediatric population
- Retrospective study
- 980 patients, ages 12 mos to 18 years old
- 28 high risk fractures
- High risk defined in Low-Risk Rules as:
  - Foot, distal tibia fx
  - Fibular fx proximal to distal physis
  - Syndesmosis injury
  - Ankle dislocation

Ellenbogen A, Rice A, Vyas P. Retrospective comparison of the Low Risk Ankle Rules and the Ottawa Ankle Rules in the pediatric population. *Am J Emerg Med*. 2017;35(9):1262-1265.

OAR vs Low-Risk

- Low-Risk Rules
  - Sensitivity 85.7% (95% CI 85.7-96)
  - Specificity 64.9% (95% CI 61.8-68)
  - Reduced x-rays by 63%
  - Missed 4 high risk fractures
- OAR
  - Sensitivity 100% (95%CI 87.7-100)
  - Specificity 33.1% (95% CI 30.1-36.2)
  - Would have reduced x-rays by 32%

Ellenbogen A, Rice A, Vyas P. Retrospective comparison of the Low Risk Ankle Rules and the Ottawa Ankle Rules in the pediatric population. *Am J Emerg Med*. 2017;35(9):1262-1265.

OAR vs Low-Risk

- Missed fractures
  - Spiral tibial fx
  - SH II, III, IV fx of tibia
- Authors: Low-Risk Ankle Eval not recommended for pediatric patients

Ellenbogen A, Rice A, Vyas P. Retrospective comparison of the Low Risk Ankle Rules and the Ottawa Ankle Rules in the pediatric population. *Am J Emerg Med*. 2017;35(9):1262-1265.

Malleolar Zone Algorithm

- Low risk for fracture if:
  - No bone tenderness at either malleolus, or region just proximal to the fibular malleolus
  - Bone tenderness at either malleolus but able to walk 4 steps in the ED, and no swelling at either malleolus
  - Sensitivity 94% (95% CI 83-98%)
  - Specificity 24% (95% CI 19-31%)

Gravel J, Hedrei P, Grimard G, et al. Prospective validation and head-to-head comparison of 3 ankle rules in a pediatric population. *Ann Emerg Med*. 2009;54(4):534-540.

Malleolar Zone Algorithm

- 3 missed fractures
  - Tibial epiphysis
    - Algorithm incorrectly used
  - Avulsion fx
    - Initially missed on xray
  - Tibial epiphysis
    - Algorithm correctly used

Gravel J, Hedrei P, Grimard G, et al. Prospective validation and head-to-head comparison of 3 ankle rules in a pediatric population. *Ann Emerg Med*. 2009;54(4):534-540.

Risk of Physeal Arrest

- Tibia
  - 12% (range 2-43%)
- Fibula
  - Low risk for limb-shortening, angular deformity, joint incongruity
- Displacement
  - Each mm displacement increases risk by 115% ages 4-17 with tibial physis injuries
- Reduction Attempts
  - Multiple attempts increase risk for premature tibial closure
    - One attempt 11%
    - Two attempts 24%
    - Three attempts 50%

Leary J, Handling M, Talerico M, et al. Physeal fractures of the distal tibia: predictive factors of premature physeal closure and growth arrest. *J Pediatr Orthop*. 2009;29:356-361.
Spiegel P, Cooperman D, Laros G. Epiphyseal fractures of the distal ends of the tibia and fibula: a retrospective study of two hundred and thirty-seven cases in children. *J Bone Joint Surg Am*. 60:1046–1050, 1978.
Barmada A, Gaynor T, Mubarak S. Premature physeal closure following distal tibia physeal injuries. *J Pediatr Orthop*. 2003;23:733–739.
Dugan G, Herndon W, McGuire R. Distal tibial physeal injuries in children: a different treatment concept. *J Orthop Trauma*. 1987;1:63–67.
Russo F, Moor M, Mubarak S, et al. Salter-Harris II fractures of the distal tibia: does surgical management reduce the risk of premature physeal closure? *J Pediatr Orthop*. 2013;33(5):524–529.

Risk of Physeal Arrest

- Fracture Type
  - High energy
  - Higher classification
- Interposed Perosteal Flap
  - Entrapped between metaphysis and epiphysis
- Intact Fibula
  - Lowers risk for tibial physis premature closure

Leary J, Handling M, Talerico M, et al. Physeal fractures of the distal tibia: predictive factors of premature physeal closure and growth arrest. *J Pediatr Orthop*. 2009;29:356-361.
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Dugan G, Herndon W, McGuire R. Distal tibial physeal injuries in children: a different treatment concept. *J Orthop Trauma*. 1987;1:63–67.
Russo F, Moor M, Mubarak S, et al. Salter-Harris II fractures of the distal tibia: does surgical management reduce the risk of premature physeal closure? *J Pediatr Orthop*. 2013;33(5):524–529.

Other Ankle Special Tests

- Systematic Review
- Anterior drawer test
  - 58% sensitivity (95% CI 29-84%)
  - 100% specificity (95% CI 60-100%)
  - SpPIN
- Thompson Test
  - 96% sensitivity (95% CI 91-99%)
  - 93% specificity (95% CI 75-99%)
    - Palpable Gap in Achilles
      - 73% sensitivity
      - 89% specificity

Schwieterman B, Haas D, Columber K, et al. Diagnostic accuracy of physical examination tests of the ankle/foot complex: a systematic review. *Int J Sports Phys Ther*. 2013;8(4).416-426.

Other Ankle Special Tests

- Lateral Talar Tilt Test
- 93 participants
  - Controls
    - No history of lateral ankle sprain
    - Cumberland Ankle Instability Tool (CAIT) score 29 or 30
  - Copers
    - ≤ 2 ankle sprains
    - CAIT ≥ 28
  - Chronic Ankle Instability
    - Hx moderate to severe ankle injury
    - CAIT ≤26
- Sensitivity 49%
- Specificity 78-88% SpPIN

Rosen A, Ko J, Brown C. Diagnostic accuracy of instrumented and manual talar tilt tests in chronic ankle instability populations. *Scan J Med Sci Sports*. 2015;25(2):e214-e221.

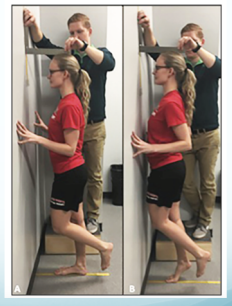
PROMs

- Patient Reported Outcome Measures
- Cumberland Ankle Instability Tool
  - 9-item pain and instability questions
- Foot and Ankle Ability Measure (FAAM)
  - 29 items
  - Difficulty with ADLs and sports activities
- Quick FAAM
  - Shortened version of the original FAAM
  - 12 items
  - Difficulty with activities (walking, running, landing, etc)
  - Validated, strong correlations to original FAAM (r = .95)

Hoch M, Hoch J, Houston M. Development of the Quick-FAAM: a preliminary shortened version of the Foot and Ankle Ability Measure for chronic ankle instability. *IJATT*. 2016;21(4):45-50.

Functional Heel-Rise Test

- Shows deficit in weight bearing plantarflexion ROM, strength
- Good to excellent intra and interrater reliability
  - Intraclass Correlation Coefficient .99
- Minimal Detectable Change 1.6-1.7 cm



Ness B, Sudhagoni, R, Tao H. The reliability of a novel heel-rise test versus goniometry to assess plantarflexion range of motion. *Int J Sports Phys Ther*. 2018 Feb;13(1):19-27

Clinical Bottom Line

- For best results, combine the OAR with both clinical judgment and the tuning fork to determine need to x-ray.
- Understand the OAR are less diagnostically accurate in the pediatric and adolescent populations compared to adults, but are still clinically useful.

Clinical Bottom Line

- Syndesmosis injuries – clinically useful:
  - Pain out of proportion
  - Squeeze test
  - Single leg hop test
  - Kleiger's test
  - Syndesmosis ligament tenderness

Clinical Bottom Line

- Physeal injuries
  - SH I clinical diagnosis
  - Growing children do get ligamentous injuries
  - Clinical decision rules may miss some fractures
  - Peak incidence 11 girls, 14 boys
  - Multiple risk factors for physeal arrest

Other Clinical Decision Rules

- Ottawa Knee Rules
- Bernese Ankle Rules
- Amsterdam Wrist Rules
- Pittsburgh Knee Rules
- Canadian C-Spine Rules
- Nexus C-Spine Rules

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Thank you!