I. Historical
   A. Originally described by Sir Robert Jones in 1902
      i. 5th metatarsal found fractured about ¾ inch from its base
      ii. 4 fractures including his own, all healed conservative treatment
   B. Carp (1927), noted potential for delayed or nonunion, symptomatic nonunion rate approximately 20% in his 20 patients.
   C. Dameron (1975), 20 patients - 5 requiring sliding bone graft for union, initial treatment did not influence final results
   D. Kavanaugh (1978), 67% delayed union rate, advocated IM screw for young competitive athletes/selected recreational athlete/nonathletes with nonunions
   E. DeLee (1983), acute versus stress fracture, IM screw for stress fracture- average union 7.5 weeks and return to athletics 8.5 weeks.
   F. Torg (1984), role of intramedullary sclerosis in fracture chronicity, inlay bone graft for delayed or nonunions (especially athletes)
   G. Today’s definition of true Jones fracture
      a. Transverse fracture of the proximal diaphysis (or distal to the tuberosity) of the fifth metatarsal
         i. Significant confusion with fractures of the 5th metatarsal tuberosity
         ii. Best definition is a fracture of the metaphyseal-diaphyseal junction without extension to the 4/5 intermetatarsal articulation
         iii. Rarely displace due to ligament attachments

II. Anatomy/Osteology of 5th metatarsal
   A. Tuberosity - wide insertion of peroneus brevis
   B. Diaphysis with distal 1/3rd lateral curve
      a. Dorsal-plantar cortex thinner than medial-lateral (Ebraheim et al)
   C. Blood supply - “watershed” area at proximal diaphysis (Smith)
   D. Apophysis
      a. May persist in large number of patients
      b. Usually symmetric
      c. Differentiate from fracture/nonunion
         i. Smooth rounded edges
         ii. Symmetric presentation

III. Classification of 5th metatarsal fractures
   A. Multiple schemes described
      a. Zones of vascular anatomy
      b. Location of fracture
      c. Acute vs. chronic
      d. Incomplete (stress) vs. complete fracture
   B. Torg: (diaphyseal fx) based partially on presence and amount of intramedullary sclerosis
      a. Acute - sclerosis absent, sharp margins
      b. Delayed union - evidence for sclerosis
      c. Nonunion - sclerosis completely obliterating canal
   C. DeLee
      a. Acute - secondary to single traumatic event
      b. Stress - prodromal symptoms, lack of significant acute injury, x-ray findings including periosteal reaction and sclerosis
D. Preferred – 3 zone concept
   a. Zone I
      i. most proximal
      ii. cancellous 5th MT tuberosity
      iii. peroneus brevis insertion
      iv. may enter 5th MT- cuboid articulation
   b. Zone II
      i. metaphyseal-diaphyseal junction
   c. Zone III
      i. distal to 4/5 intermetatarsal ligaments and extends distally into the tubular portion of diaphysis for 1.5 cm

d. No reason to differentiate between zones II and III with respect to treatment and prognosis (Chuckpaiwong CORR 2008)

IV. Incidence – 5th metatarsal fractures
   A. Dameron (JAAOS, 1994)
      a. 237 5th MT fx from 1988-1992
         i. 38% male, 62% female
         ii. <30 y/o higher male predominance, >30 y/o female
         iii. Location
              1. 93% zone I: avulsion
              2. 4% zone II: Jones fx
              3. 3% zone III: diaphyseal (stress) fx

V. Physical exam
   A. Lateral foot pain
   B. Tenderness over 5th metatarsal – variable
   C. Usually little swelling/erythema
      a. Peroneal tendon weakness (strong / spastic peroneus longus?)
      b. Plantarflexed first ray?
      c. Heel varus / Metatarsus adductus?
   E. Hindfoot ROM (Kaufman)
   E. Pedobarography can assess for lateral overload
VI. Radiographic evaluation of zone II/III fractures
   A. Plain views: AP, lateral, oblique, hindfoot alignment (Saltzman)
      a. Chronicity of fracture: periosteal reaction, intramedullary sclerosis
      b. Postural changes: cavus, adductus, skew
   B. Bone scan or MRI if suspicion high and x-rays normal
   C. CT helpful to assess degree of healing and determine return to full activity

VII. Consider Metabolic Work UP: Labs / Dexascan

VIII. Epidemiology/Etiology
   A. Industrial workers, recreational/competitive athletes (especially basketball)
   B. Mechanism
      a. Acute - inability of plantar flexed foot to go into inversion (Kavanaugh)
      b. Stress
         1. Lateral overload from cavovarus foot posture, metatarsus adductus
         2. Increased stress created by prolonged running, poor training, poor
            shoeare, etc
      c. Nutrition, hormonal status, bone density, lack of neuro feedback

IX. Nonoperative treatment (zone II and III)
   Correct any nutritional, hormonal imbalances
   A. Acute “traumatic” fractures
      a. Nondisplaced
         i. 4 weeks NWB cast and 4 weeks WB cast
         ii. Older/less demanding patients can be treated in WB orthosis
         iii. Non-union rate up to 44% (Mologne, Clapper)
      b. Displaced
         i. Require ORIF, screw preferable to plate due to prominent hardware
   B. Acute “stress” fractures
      a. May require prolonged period of casting/NWB
         i. 50-75% heal within 5 months (Josefsson 1994; Clapper 1995
            Fernandez Fairen 1999)
         b. High risk of refracture (33% - Quill, 1995)
         c. 50% either do not heal or refracture (Quill, 1995)

X. Operative treatment options
   A. IM screw (DeLee)
   B. Inlay cortical cancellous graft (Torg)
   C. Combination screw + grafting

XI. Screw fixation
   A. Biomechanical issues – what is the best screw?
      a. Ebraheim et al. (F/A 21, 2000)
         i. Curved bone
         ii. Dorsal-plantar cortex thinner than medial-lateral
      b. Shah et al. (F/A 22, 2001)
         i. 4.5 mm screw diameter is adequate for fixation
         ii. 5.5 mm screw diameter does not improve 3-point bending failure
             load strength
c. Kelly et al. (F/A 22, 2001)
   i. 5th MT can accommodate a 6.5 mm screw
   ii. 6.5 mm screw affords greater pull-out strength than smaller diameter screw
   iii. Larger diameter screw may be more appropriate in operative management given indirect mechanism of injury
   iv. Shorter screw OK as long as threads cross fracture site
   v. Longer screw not necessary and may be detrimental
      1. Straight screw does not pass down curved bone
      2. May gap fracture
d. Manoli (F/A 22, 2001)
   i. Proper lag screw technique
   ii. Intentionally penetrate medial diaphysis to gain cortical purchase (stress riser?)
e. Pietropaoli (F/A 20, 1999)
   i. 3-point bending model
   ii. Choice of screw (4.5 malleolar vs. 4.5 cannulated partially threaded) no difference in resistance to 3-point bending

B. Indications for screw fixation
   1. Controversial
      a. Acute fracture in athlete (all levels?)
      b. Stress fracture/delayed or nonunion
      c. Refracture
      d. Failure of conservative treatment
      e. Cavovarus posture = lateral overload

C. Contraindications - all relative?
   1. Obliterated canal/sclerosis
      a. Requires open treatment?
   2. Acute fracture
   3. Non athlete

D. Goals
   1. Expedite healing/union
   2. Quicker recovery/return to athletics
   3. Decrease refracture rate

E. Essentials of technique

Limited open
   1. Ankle block feasible
   2. Supine, bump under hip
   3. Longitudinal incision (1 cm) extending proximal from tuberosity and parallel to plantar surface of foot
   4. Dissect around sural nerve branches and peroneus brevis tendon
   5. Fracture site not exposed unless malunion or malaligned nonunion (see below)
   6. 0.45 inch K-wire entered into canal from tuberosity; “high and inside” position preferred, check position on multiple fluoroscopic views
7. Mark skin along K-wire to set direction for drill/screw insertion or use 2.8-3.2mm cannulated drill set (beware of cutting off guide wire – use only to enter canal)
8. 3.2mm drill into canal, avoid distal curve, countersink

9. Select largest solid screw that fits canal!
   a. Smaller canal/woman: 4.5mm malleolar screw, make certain threads cross fracture site, avoid distal curve; keep thread-shaft junction as far from fracture site as possible (to avoid screw fatigue)
   b. Larger individual: 6.5mm partially threaded screw (16 mm thread length)
10. Insert screw, check multiple fluoroscopic views to r/o perforation
11. Suture skin

from DeLee, 1983
In event of significant intramedullary sclerosis/resorption with large diastasis/ refracture/nonunion/broken hardware:

1. Expose fracture site
   a. Longitudinal incision over lateral aspect 5th metatarsal
   b. Avoid sural nerve
      i. 2-3 mm from screw head (Donley et al)

2. Remove hardware
   a. May require creating a slot in lateral cortex of 5th MT
   b. Broken screw set (Synthes)

3. Insert new screw in combination with bone graft
   a. Prepare canal
      i. Shingle/drill cortices at level of fracture
      ii. Remove areas of partial union (usually dorsal)
   b. Insert largest screw possible
      i. Usually a 50-60 mm 6.5 mm solid screw
   c. Autogenous bone graft
      i. Best harvested percutaneously/mini-invasive from the iliac crest

E. Postoperative Management
1. Splint, NWB x 2 weeks
2. Osteostimulator – especially if revision surgery
3. Suture removal at 2 weeks, cast boot or wooden shoe and progress to full weight bearing as tolerated
   i. If revision: 4-6 weeks NWB
4. Eight week follow up - check x-ray, if nontender and without radiographic change then initiate running activity
   a. Pool therapy helpful
   b. If revision: wait additional 2-4 weeks
5. Full practice is allowed once the patient can run and cut without pain, with return to competition usually 2 weeks after full practice has started
6. Orthotic device helpful - cushion, relieve pressure at site of screw entry and under fifth metatarsal head, more rigid sole/flex steel insert helpful, consider lateral heel wedge and forefoot posting in flexible cavovarus foot (Raikin 2008)
6. Leave screw indefinitely
a. Definitely leave for duration of athlete’s career
   i. High incidence of refracture after screw removal (Josefsson, 1994)

F. Pitfalls and Complications
1. Reported up to 45 percent
2. Infection
3. Wrong screw selection
   a. 4.0mm - too small, lacks compression, threads cross fracture site
   b. 6.5mm - too large in some patients, shatter/split or torque/twist distal fragment
   c. Cannulated – anecdotal reports of bending
      i. Herbert - head buried but less compression forces
      ii. Accutrak – difficult to remove
4. Distal bone penetration
   a. Too long of screw – straight screw in curved bone
5. Prominent screw head
   a. Failure to enter “high and inside” or placed on angle
6. Peroneal tendinitis
7. Sural nerve injury
8. Bent/broken screw – with nonunion
9. Failure of revision surgery
   a. Reassess for hindfoot varus/lateral overload
      i. Consider dorsiflexion 1st MT or Dwyer osteotomy

XII. Results/Prognosis
A. Kavanaugh (1978) - union in all surgically treated fractures, complications in 6/13
B. DeLee (1983) - union in 10/10 patients with stress fractures, 3 patients with tenderness over screw head, 5 patients with plantar fifth MT head pain, 4/5 required metatarsal pad and 7/10 required shoe modification, no refractures, shorter union time and return to activity than bone grafting technique
C. Clapper (1995) – 100% union rate for nonunions managed with screw, ½ time to heal compared to cast management
D. Glasgow (1996) – using screw other than 4.5 mm malleolar correlated with failure
E. Wright (2000) – 6 refractures after screw fixation, recommended use of larger diameter screw and postop orthosis
F. Portland et al (2000, AOFAS, Orlando) – 22 patients, 100% union, type I acute fx healed at avg. 6.7 weeks, type II stress fx healed at avg. 8.8 weeks

XIII. Refracture Risk Factors:
   Cavus foot (idiopathic or neuromuscular) (Raikin 2008)
   Small screw, (Wright)
   Too early return to activity (Larson)

XII. The future?
A. Surgeons will become more aggressive with recommendation for immediate screw fixation
   in zone II/III fractures, regardless of athletic involvement/level
B. Artificial bone substitutes with osteoinductive properties injected at fracture site to assist with percutaneous screw fixation
C. Medications (Bisphosphonates, RANKL) (Stewart)
D. Discontinue eponym “Jones” – confusing term
REFERENCES


