Calcaneal Fracture and Rehabilitation

Surgical Indications and Considerations

Anatomic Considerations: The calcaneus articulates with the talus superiorly at the subtalar joint. The three articulating surfaces of the subtalar joint are the: anterior, middle, and posterior facets, with the posterior facet representing the major weight-bearing surface. The subtalar joint is responsible for the majority of foot inversion/eversion (or pronation/supination). The interosseous ligament and medial, lateral, and posterior talocalcaneal ligaments provide additional support for the joint. The tibial artery, nerve, posterior tibial tendon, and flexor hallucis longus tendon are located medially to the calcaneus and are at risk for impingement with a calcaneal fracture, as are the peroneal tendons located on the lateral aspect of the calcaneus.

The calcaneus serves three major functions: 1) acts as a foundation and support for the body's weight, 2) supports the lateral column of the foot and acts as the main articulation for inversion/eversion, and 3) acts as a lever arm for the gastrocnemius muscle complex.

Pathogenesis: Fractures of the calcaneal body, anterior process, sustentaculum tali, and superior tuberosity are known as extra-articular fractures and usually occur as a result of blunt force or sudden twisting.

Fractures involving any of the three subtalar articulating surfaces are known as intra-articular fractures and are common results of: a fall from a height usually 6 feet or more, a motor vehicle accident (MVA), or an impact on a hard surface while running or jumping. Intra-articular fractures are commonly produced by axial loading; a combination of shearing and compression forces produce both the primary and secondary fracture lines.

Shearing forces are created by opposing, parallel forces, which in this case are often the upward-moving body of the calcaneus against the downward-driving subtalar articulation. Shearing forces often split the calcaneus into medial and lateral halves. The exact position of the hindfoot upon impact is partially responsible for the position of the fracture line—a hindfoot in the valgus position tends to move fractures more laterally, whereas a hindfoot in the varus position moves fractures medially.

Axial loading also produces a compression fracture line in a characteristic "Y" pattern, as seen from lateral and oblique radiographic views. The resulting fracture line often splits the middle subtalar facet and creates a superomedial fragment. As described by Essex-Lopresti, the "Y" pattern can extend more horizontally, as in a tongue-type fracture, or can extend more vertically, as in a joint-depression fracture.

Besides the descriptions of Essex-Lopresti, two other classification systems are most widely recognized and utilized in the evaluation of calcaneal fractures. Sanders, utilizing computerized tomography (CT) scanning, divides calcaneal fractures into four categories:

- Type I - Undisplaced
- Type II - Two parts (split)
- Type III - Three parts (or split/depression)

- Type IV - Comminuted

Crosby-Fitzgibbons also using CT scans divide calcaneal fractures into three categories:

- Type I - Small fracture segments which are slightly displaced or undisplaced
- Type II - Fracture segments which are displaced by 2mm or more
- Type III - Comminuted fracture

Epidemiology: Calcaneal fractures account for 2-3% of all fractures of the body, and 60% of all tarsal fractures. 75% of all calcaneal fractures are intra-articular and involve one or more of the three subtalar articulating facets. Intra-articular fractures have a poorer prognosis than extra-articular fractures. Calcaneal fractures are most often seen in young adult men. Compression fractures of the lumbar vertebrae occur in 10-15% of cases presenting with a calcaneal fracture.

Diagnosis: Patients with a fracture of the calcaneus may present with the following symptoms:

- Pain - Most importantly pressure pain, or pain elicited when providing pressure to the calcaneus by holding the heel of the patient's foot and gently squeezing
- Edema
- Ecchymosis - A hematoma or pattern of ecchymosis extending distally to the sole of the foot is specific for calcaneal fractures and is known as the Mondor sign
- Deformity of the heel or plantar arch - Widening or broadening of the heel is seen secondary to the displacement of the lateral calcaneal border outward and accompanying edema
- Inability to or difficulty weight-bearing on affected side
- Limited or absent inversion/eversion of the foot
- Decreased Bohler or "tuber-joint" angle - In normal anatomical alignment an angle of 25-40 degrees exists between the upper border of the calcaneal tuberosity and a line connecting the anterior and posterior articulating surfaces. With calcaneal fractures, this angle becomes smaller, straighter, and can even reverse.
- CT scan (both axial and coronal views) to classify the degree of injury to the posterior facet and lateral calcaneal wall
- X-rays or Radiographs:
    - Axial - Determines primary fracture line and displays the body, tuberosity, middle and posterior facets
    - Lateral - Determines Bohler angle
    - Oblique/Broden's view - Displays the degree of displacement of the primary fracture line

Nonoperative Versus Operative Management: Great debate remains as to what is the best course of treatment following a calcaneal fracture, especially following operative management of displaced or intraarticular fractures. Nonoperative management is preferable when there is no impingement of the peroneal tendons and the fracture segments are not displaced (or are displaced less than 2 mm). Nonoperative care is also recommended when, despite the presence of a fracture, proper weight-bearing alignment has been adequately maintained and articulating surfaces are not disturbed. Extra-articular fractures are generally treated conservatively.

Patients who are over the age of 50 years old or who have pre-existing health conditions, such as diabetes or peripheral vascular disease, are also commonly treated using nonoperative techniques. Patients receiving nonoperative management are 5.5 times more likely to require primary subtalar arthrodesis at some point in the future.

Surgical repair is recommended in calcaneal fractures which present with displaced fracture segments, impinged peroneal tendons, or entrapped medial compartments. Patients who are younger, female, have a light or moderate work load involving the foot, or who have a larger remaining Bohler angle have better results with operative care. A 16 percent incidence of wound complication is associated with operative management.

Using the classifications of Sanders and Crosby-Fitzgibbons, nonoperative and operative treatment courses are preferred for the following grades of calcaneal fracture:

- Type I (Sanders), Type I (Crosby-Fitzgibbons) - Nonoperative management of immobilization or early mobilization
- Type II (Crosby-Fitzgibbons) - Nonoperative management of immobilization or early mobilization, or operative management including closed reduction and fixation
- Type II/III (Sanders), Type III (Crosby-Fitzgibbons) - Operative management commonly including ORIF
- Type IV (Sanders) - Nonoperative management for non-salvageable comminuted fractures or operative management consisting of ORIF with primary arthrodesis

Surgical Procedure: The goals of operative management of a calcaneal fracture include: 1) restoration of normal heel height and length, 2.) realignment of the posterior facet of the subtalar joint, 3) restoration of the mechanical axis of the hindfoot. Surgical repair is often delayed 3-14 days after the fracture, especially in the presence of significant edema or fracture blister formation, to allow for some reduction of swelling.

There are various surgical techniques for the repair of a calcaneal fracture, including the least invasive, closed reduction with percutaneous fixation. Open reductions include the medial, lateral, or combined ORIF approach. The extensive lateral approach is the most popular and allows the surgeon to visualize the entire fracture area. However, this approach requires a full-thickness skin flap for closure. The lateral approach is indicated when: 1) the fracture occurred two to three weeks previous to the surgical repair, 2) the fracture is severely-comminuted, 3) the fracture fragment moves out laterally and positions itself near the talus, 4) a displaced fracture of the calcaneocuboid joint is present, and 5) the fracture is unable to be reduced using the medial approach. A variety of pins, plates and other fixation devices, such as the Gissane spike and Kirschner wires are used for stabilization during surgical repair.

Primary fusion, or arthrodesis, can be used for the surgical repair of Type IV (Sanders) or Type III (Crosby-Fitzgibbons) severely comminuted fractures, and is used in combination with an ORIF. Subtalar joint motion is limited after primary fusion and increases the patient's risk for development of arthritis secondary to increased rotational forces on the ankle during walking.

Preoperative Rehabilitation:

- Immediate elevation of involved extremity to decrease swelling
- Compression including: foot pump, intermittent compression devices, or compression wraps
- Ice
- Instruction in use of wheelchair, bedside transfers, or crutches to maintain strict non-weight bearing status
- Instruction in appropriate nonoperative or postoperative rehabilitation plan

NONOPERATIVE AND POSTOPERATIVE REHABILITATION

Note: Both the progression of nonoperative and postoperative management of calcaneal fractures include traditional immobilization and early motion rehabilitation protocols. In fact, the traditional immobilization protocols of nonoperative and postoperative management are similar, and are thereby combined in the progression below. Phases II and III of traditional and early motion rehabilitation protocols after nonoperative or postoperative care are comparable as well and are described together below. Much debate remains on the preferable management of calcaneal fractures after operative management. Bohler, Burdeaux, Palmer, and Parmer recommend traditional immobilization after surgical repair, while Buckley, Essex-Lopresti, Lance, Paley, and Wei advocate early mobilization beginning within 24-72 hours of surgical repair. Debate also exists on the preferable management of calcaneal fractures with nonoperative management. Barnard proposes the use of traditional immobilization in the form of a short leg cast, while Lance, Paley, and Parmer recommend early mobilization with nonoperative management.

Phase I for **Traditional Immobilization** and Rehabilitation following Nonoperative and Postoperative Management: Weeks 1-4

Goals: Control edema and pain
Prevent extension of fracture or loss of surgical stabilization
Minimize loss of function and cardiovascular endurance

Intervention:

- Cast with ankle in neutral and sometimes slight eversion,
- Elevation
- Ice
- After 2-4 days, instruct in non-weight bearing ambulation utilizing crutches or walker
- Instruct in wheelchair use with appropriate sitting schedule to limit time involved extremity spends in dependent-gravity position
- Instruct in comprehensive exercise and cardiovascular program utilizing upper extremities and uninvolved lower extremity

Phase I for **Early Motion** and Rehabilitation following Nonoperative and Postoperative Managment: Weeks 1-4

Goals: Control edema and pain
Prevent extension of fracture and loss of surgical stabilization
Prevent contracture and loss of motion at ankle/foot joints
Minimize loss of function and cardiovascular endurance

Intervention:

- Elevation of involved extremity with ankle maintained at 90 degree angle in relation to the lower leg (or tibia)
- Ice combined with compression wrap
- After 24-72 hours, active range-of-motion exercises in small amounts of movement begin at all joints of the foot and ankle, including: tibiotalar, subtalar, midtarsal, and toe joints, and are completed every hour
- After 2-4 days, instruct in non-weight bearing ambulation utilizing crutches or walker
- After 14 days, instruct in proper fitting and usage of prescribed surgical shoe or orthosis to prevent contracture
- Instruct in wheelchair use with appropriate sitting schedule to limit time involved extremity spends in dependent-gravity position
- Instruct in comprehensive exercise and cardiovascular program utilizing upper extremities and uninvolved lower extremity

Phase II for Traditional Immobilization/Early Mobilization and Rehabilitation following Nonoperative and Postoperative Management:
Weeks 5-8

Goals: Control remaining or residual edema and pain
Prevent re-injury or complication of fracture by progressing weight-bearing safely
Prevent contracture and regain motion at ankle/foot joints
Minimize loss of function and cardiovascular endurance

Intervention:

- Continued elevation, icing, and compression as needed for involved lower extremity
- After 6-8 weeks, instruct in partial-weight bearing ambulation utilizing crutches or walker
- Initiate vigorous exercise and range of motion to regain and maintain motion at all joints: tibiotalar, subtalar, midtarsal, and toe joints, including active range of motion in large amounts of movement and progressive isometric or resisted exercises
- Progress and monitor comprehensive upper extremity and cardiovascular program

Phase III for Traditional Immobilization/Early Mobilization and Rehabilitation following Nonoperative and Postoperative Management: Weeks 9-12

Goals: Progress weight-bearing status
Normal gait on all surfaces
Restore full range of motion
Restore full strength
Allow return to previous work status

Intervention:

- After 9-12 weeks, instruct in normal full-weight bearing ambulation with appropriate assistive device as needed
- Progress and monitor the subtalar joint's ability to adapt for ambulation on all surfaces, including graded and uneven surfaces
- Joint mobilization to all hypomobile joints including: tibiotalar, subtalar, midtarsal, and to toe joints
- Soft tissue mobilization to hypomobile tissues of the gastrocnemius complex, plantar fascia, or other appropriate tissues
- Progressive resisted strengthening of gastrocnemius complex through use of pulleys, weighted exercise, toe-walking ambulation, ascending/descending stairs, skipping or other plyometric exercise, pool exercises, and other climbing activites
- Work hardening program or activities to allow return to work between 13- 52 weeks

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