CHAPTER **57**

INTRAARTICULAR CALCANEAL FRACTURES: Overview of Evaluation and Management

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Intraarticular fractures of the calcaneus are a significant and potentially devastating injury. Numerous studies demonstrate the incidence of long term sequelae including pain, disability, and inability to return to pre-injury function and/or employment. Although the management of intraarticular calcaneal fractures has improved dramatically over the last decade, controversies remain. These include philosophy of treatment of intraarticular fractures, outcomes comparing various treatment prognoses, and advantages/disadvantages of surgical treatment compared to non-surgical treatment. Few prospective outcome studies are available to define prognostic indicators and treatment. The evidence, based on the literature generally advocates surgical reduction of intraarticular calcaneal fractures. Specific to surgical treatment, several guiding principles of care are overviewed that provide a framework to optimize surgical reduction and restoration of calcaneal anatomy and intraarticular involvement. Appropriate post-operative management and functional rehabilitation is required to maximize potential for a satisfactory outcome.

ANATOMY, MECHANISM OF INJURY, AND CLASSIFICATION

The calcaneus is composed of four distinct articular facets and variable degrees of cortical and cancellous strength and density. The medial cortical thickness within the confines of the sustentaculum is most dense. The lateral wall of the calcaneus is relatively weak and thus generally requires buttressing when extensively involved. Because of the consistent bone quality of the sustenaculum fragment, provisional and final fixation constructs are aimed at reducing the anterior process, posterior facet, and calcaneal tuborosity of the sustenaculum or "constant" fragment.

Calcaneal fractures are generally closed injuries categorized into extraarticular (15-25%) and intraarticular fractures (75-85%). Those calcaneal fractures that are open injuries require familiarity of open fracture management principles. The vast majority of intraarticular fractures are closed injuries and comprise the focus of consideration.

Intraarticular calcaneal fractures occur as a result of transmitted energy from axially directed loads. Two primary fracture lines essentially divide the calcaneous. The first primary fracture line (shear fracture of Palmer) divides the posterior facet and may split the anterior calcaneal facet. This produces the medial sustentacular fragment. The second primary fracture line divides the calcaneus into anterior and posterior portions and produces the anterior lateral fragment at the angle of Gissanne. (crush fracture of Essex-Lopresti) From these primary fracture lines, the calcaneal tubor displaces axially (shortens) and translates into a varus malposition.

The lateral wall expands outward and is causative of peroneal tendon sheath disruption and/or impingement. Further directed forces can result in secondary fracture lines and comminution. Influences from positional changes of the hindfoot may alter fracture patterns.

The most common mechanism of injury includes a fall from a height, which produces an axial load transmitted through the hindfoot in a specific mechanism that remains controversial. Simulated loads in cadaveric models have suggested slightly different mechanisms of injury than previously reported. The suggestion of the lateral process of the talus acting as a wedge to splint the angle of Gissane and create a primary fracture line has been well described.

In addition to injuries occurring from falls, calcaneal fractures are commonly seen following impact occurring during a motor vehicle accident (MVA). Changes in legislation over the last decade and resultant improvements in restraint systems have ultimately improved survivorship and decreased mortality/morbidity from head and blunt trauma. The incidence of reported lower extremity injuries is still problematic and may be increasing, however. Several studies have suggested that further modifications of restraint systems are necessary to prevent increasing lower extremity traumatic injuries such as calcaneal fractures. Deceleration of the lower extremity via a protective mechanism may reduce the impact force and axial loading of the lower extremity resulting in forces consistent with those producing intraarticular calcaneal fractures.

INITIAL EVALUATION, EXAMINATION, AND MANAGEMENT

Intraarticular calcaneal fractures are often encountered in the polytraumatized patient. Approximately 10% of intraarticular calcaneal fragments are associated with a spine injury and 25% may be involved with other lower extremity fracture/dislocations. Care must be taken to ensure a thorough primary and secondary survey is completed by a qualified physician prior to initial evaluation and definitive treatment of intraarticular calcaneal fractures. Once a complete history, physical examination, and ancillary studies are complete, appropriate definitive fracture management is initiated.

Most patients with intraarticular calcaneal fractures will present to an acute care setting with pain, edema, and ecchymosis of variable degrees. Open calcaneal fractures are much less common and are accordingly assessed and managed as a surgical priority. Objectives include prevention of infection, stability of the local soft tissue environment and envelope, and fracture stabilization. Provisional external fixation or limited wire or "push screw" fixation is helpful to stabilize the osseous component of the injury initially, as appropriate. Definitive OPRIF is planned and provided once the soft tissue component is known to be supportive.

Neurovascular status of the involved extremity is assessed to determine peripheral arterial inflow, neurologic status and clinical evidence of current or potential (impending) compartment syndrome. Examination is undertaken to determine clinical evidence of any other associated fracture/dislocation as well.

Evaluation of peripheral pulses, digital perfusion and any comorbid state or compromise relative to arterial insufficiency and venous stasis is noted. Care is taken to differentiate acute neuritic pain versus an ischemic etiology. Pulselessness, pallor, parathesias, and uncontrollable pain recalcitrant to appropriate initial management may be suggestive of compartment syndrome. Objective measurement and quantification of compartment pressures is indicated if the clinical scenario suggests the possibility of ischemia. Ischemic changes are known to become irreversible within 24 hours and delays in appropriate management are to be avoided.

Typically edema, ecchymosis, and pain present as the initial complaints following an intraarticular calcaneal fracture. Inability to ambulate, and limitation of active range of motion about the ankle and hindfoot are likely. Clinical examination should focus initially on the neurovascular status of the affected extremity and the extent of soft tissue edema. Care is taken to note the extent and pattern of edema. Loss of visible relaxed skin tension lines are indicative of more significant soft tissue disruption. Inspection of the soft tissues will often reveal trauma blister formation. Care is taken to note the extent and location of serous versus hemorrhagic trauma blister involvement if present. Once the neurovascular status is determined to be intact and compartment syndrome is excluded, a Jones short leg dressing is applied to control edema. Other modalities may include sequential compressive devices to reduce the magnitude of acute edema and retard ischemia from increased vascular permeability and congestion within the confines of specific fascial planes. This modality is most appropriate if any concern of compartment syndrome exists.

Plain films are prerequisite to the definitive evaluation in determining calcaneal fracture involvement and extent. Films are to be obtained in as close to simulated functional position to ensure appropriate delineation of the fracture pattern. Anterior-posterior, lateral, oblique, calcaneal axial, (Harris-Beath view) as well as Broden's views are recommended initially. Ankle views may also be necessary to evaluate the ankle joint, fibula and tibial plafond. Contralateral extremity views including a lateral and calcaneal axial view may also helpful as comparison views and in preoperative planning and template preparation.

If intraarticular involvement is evident based upon plain film findings, a thin slice computed tomography (CT) is valuable to further delineate fracture patterns, degree of communition, malposition, and translation of the calcaneal tuberosity, and the position and degree of secondary fracture lines. Coronal and axial slices are ordered and further reconstruction can be helpful in operative planning in selective intraarticular fracture patterns.

A CT classification as described by Sanders divides the posterior facet of the calcaneus and talus into 2 lines and 3 columns from a representative axial CT slice of the widest portion of the talus (Figure 1). Although clearly useful, this classification scheme is not considered to be a prognostic indicator of treatment to outcome. Type 1-4 injuries are categorized by the number of fracture lines involving the articular surface of the posterior facet and the degree of displacement and communition. Greater than 2mm of displacement of the posterior facet is considered an indication for surgical intervention in combination with disruption of the normal anatomic configuration of the calcaneus.

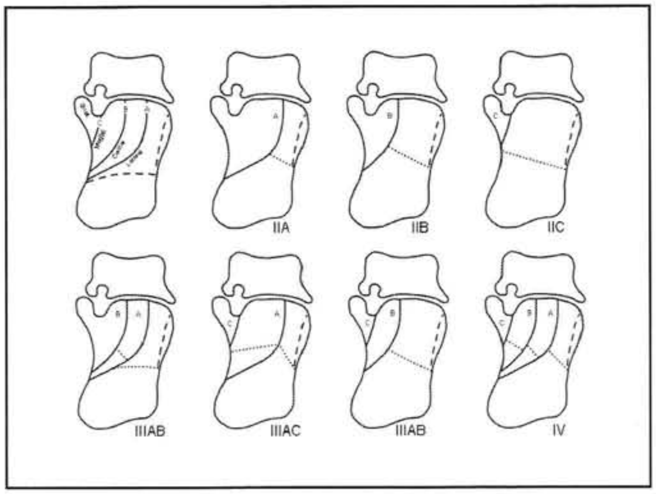

Figure 1. Sanders CT classification of intraarticular calcaneal fractures

SURGICAL MANAGEMENT

The primary objective of surgical intervention is to restore the normal anatomy (shape) of the calcaneus. Although anatomic reduction of the intraarticular nature of the deformity is a clear goal, restoration of normal or near normal height, width, and neutralization of the varus malposition of the calcaneal tuber are critical. Subsequent arthrosis of the posterior facet of the subtalar joint is not to be considered a surgical failure. Alignment and restoration of the periarticular relationships of the ankle and midtarsal joint are important to restore functional outcome.

Surgical intervention is generally delayed until adequate recovery of post-traumatic edema is resolved. Of importance is adequate restoration of the soft tissue envelope prior to surgical intervention. Care is maintained to reduce edema via application of a properly applied modified Jones compressive dressing and/or utilization of a sequential compressive pneumatic modality. Fracture blisters within the area of a planned surgical approach are managed appropriately and surgical intervention delayed until resolution of trauma blister formation.

Patient Positioning

A true lateral decubitus position is used to give access via a lateral extensile approach. Care is taken to secure leg and foot position, and all ipsalateral and contralateral sites of prominence are protected. A pneumatic tourniquet is used at the level of the thigh and secured. Available intra-operative fluoroscopy is used at various junctures to verify success in a sequential reduction of the fracture pattern.

Extensile Lateral Incision

A laterally-based extensile incision is preferred for adequate exposure to the intraarticular calcaneus fractures. Care is taken to adequately plan and perform the incision based upon the local arterial supply to the lateral hindfoot. Approriately placed, the incision will provide for predictable exposure and protection of the sural nerve and peroneal tendons. The apex of the incision must be carefully placed within the region of distribution of the lateral calcaneal artery. Proper incision placement and meticulous tissue handling will substantially reduce incisional wound complications. Potential full thickness tissue loss is an unfortunate complication that may ultimately lead to debridement and free tissue transfer for adequate soft tissue coverage.

Anatomic Dissection

Once an appropriate incision plan is mapped, a full thickness fasciocutaneous flap is anatomically dissected. The development of the apex of the extensile incision is carefully undertaken. Care is taken to create a perpendicular orientation to the skin margin. The sural nerve and peroneal tendons are protected within the confines of the extensile flap. Care is taken to utilize "stay" sutures that indirectly serve as a retraction force to complete the dissection technique. Once the incision and dissection are completed, care is taken to place a series of Kirschner-wires (K-wires) within the fibula, lateral process of the talus and distally if necessary to maintain position of the flap ("no-touch" technique) throughout the procedure.

Reduction of Fracture Components

A general approach to sequential reduction of the intraarticular calcaneal fracture begins with isolation and removal of the lateral wall "blow-out" fragment. The lateral wall "blow-out" fragment is manipulated and removed from the surgical wound. It is preserved in a saline soaked sponge and laid out on the back table in anatomic position for reapproximation. This provides visualization to the more medial fracture fragments, including the posterior facet fragment(s) and the fracture line separating the anterior calcaneal process at or near the angle of Gissane.

Attention is then directed to reduce the anterior fracture fragment. Care is taken to reduce the anterior calcaneal articular fragment and anatomically reduce the articular extension to the calcaneal cuboid joint if present. The anterior process is "brought down" or derotated from its extended position from the angle of Gissane, essentially plantarflexing the anterior process in congruency with the articulation of the calcaneocuboid joint. Provisional K-wire fixation is utilized to secure the anterior fracture fragment.

Attention is then directed to the depressed intraarticular posterior facet fragment(s) which is elevated superiorward from its impacted position within the the body of the calcaneus. Reduction of the varus malposition of the calcaneal tuberosity is then accomplished via an inserted Schanz pin, laterally applied within the calcaneal tubor. A corrective valgus moment and distal distraction force is utilized to reduce and simultaneously "lengthen" the impacted calcaneal tuborosity. Provisional fixation is directed from the plantar medial heel to the medial sustentaculum fragment to ensure adequate "axial" restoration and length of the heel.

The articular posterior facet fragment(s) is then reduced, working medially to laterally and regaining anatomic elevation while reducing any step-off defect across the posterior facet surface of the subtalar joint. Provisional fixation is applied from a lateral to medial direction to secure the posterior facet fragment(s) to the sustentaculum fragment as well.

Once provisional fixation is complete, fluoroscopic and/or radiographic confirmation is obtained. Care should be utilized to place all laterally applied provisional fixation in as superior an extent as possible to avoid loss of reduction. Planning of adequate provisional fixation is important as certain areas may require exchanging provisional for permanent fixation application. The lateral wall fragment is reapproximated in anatomic position as the last reduction maneuver and secured via laterally applied buttress plating.

Interfragmentary screw placement in combination with lateral buttress plating techniques are most useful in maintaining a rigid internal fixation construct. Reconstruction plates and various specially designed plates are available and specifically designed for calcaneal fracture application.

Bone grafting of intraarticular calcaneal fractures is generally not necessary, although selective injuries may reveal large defects once anatomic restoration is accomplished. Allogeneic bone graft materials and substitutes may be considered in select injury patterns with communition and loss of cancellous bone.

Care is taken to reapproximate and close the fasciocutaneus flap from the apex centrally. Interrupted over and over absorbable suture material is used to reapproximate the full thickness flap under minimal physiologic wound tension over a small closed

suction drain. Skin closure is performed in a combination of either vertical mattress, horizontal mattress and inclusion of a Donati type reapproximation of the apex of the extensile incision. A modified Jones short leg dressing is applied

POSTOPERATIVE CARE

Generally, upper extremity conditioning is prescribed on the first postoperative day. Minimal leg/foot dependency is allowed until gait training is begin on postoperative day 3. The drain is usually removed at postoperative day 3 and gentle protected range of motion exercises are initiated when the skin incision is well sealed (5-10 days).

Serial radiographs are evaluated and a functional rehabilitation program is outlined to prepare for full weight bearing at approximately postoperative week 12. Continued rehabilitation, strengthening and work hardening may continue up to postoperative week 24.

Intraarticular calcaneal fractures are potentially devastating injuries. Appropriate initial evaluation, reduction of edema, and carefully selected timing of surgical intervention are critical prior to definitive operative intervention. Intra-operative positioning, careful soft tissue handling and various reduction techniques assist in improving restoration of the anatomy of the calcaneus.

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