

Calcaneal Fractures

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Background: Calcaneal fractures have a varied appearance. Most often they are broken down into intra and extra-articular. Often extra-articular fractures are viewed as less serious and necessitating non-operative treatment. Though this is generally true, treatment of intra-articular fractures only in a surgical manner, may not be the best course of treatment. This article review will not only cover the gambit of calcaneal fractures, but will also focus on which intra-articular fractures always need, surgery, which fractures may need surgery, and which intra-articular fractures may be optimally managed non-surgically.

Key words: Calcaneus, Traumatic osteoarthritis,

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The calcaneus is a complex bone consisting of 4 articular surfaces. The triangular shaped calcanealcuboid articulation, the connected anterior, and middle facets, and finally the posterior facet which is separated from the anterior and middle facets by the calcaneal sulcus. The facets of the calcaneus are supported by a relatively thin cortex. The thalamic portion of the calcaneus made of compression trabeculae is 1cm in thickness and supports the posterior facet. The sustentaculum tali is thickened with compression trabeculae also and supports the middle facet. The anterior facet is supported by the anterior beak of the calcaneus. There are also traction trabeculae at the inferior aspect of the calcaneus. Between the compression trabeculae superior and along the facets, and the inferior traction trabeculae, lies the neutral triangle.¹

Calcaneal fractures are the most common type of tarsal fracture, and account for up to 2% of all fractures. 68 % of patient who undergo a calcaneal fracture are male. The mean injury severity score is 11.3 + or - 9.4. The most common mechanism of injury is MVA (49%) or fall from a height (43%). In addition 60 % of patients with calcaneal fractures

have an additional LE fracture (Most commonly foot or ankle). There is also a 23% chance that a patient with a calcaneal fracture will fracture their spine, with lumbar fractures being most common. In addition to all of these orthopedic complications, there is a 29% chance that a patient with a calcaneal fracture will have an additional nonorthopaedic injury. These injuries can be quite serious and include: head injuries, thoracic, and abdominal organ damage.²

Extra-articular Fractures

Extra-articular fractures are described as any fracture that does not involve the posterior facet, and account for anywhere between 25 and 30 percent of all calcaneal fractures. However, these fractures may involve other facets. These fractures are broken into 3 main groups: 1 Anterior process fractures 2 fractures of the middle calcaneus 3 fractures of the posterior calcaneus.¹

Anterior process fractures are the result of 1 of 3 mechanisms. The first being an inversion of the foot with a downward force placing tension on the bifurcate ligament, often resulting in an avulsion of

the calcaneus rather than injury to the ligament. The second being Forced abduction of the forefoot with a fixed calcaneus when there is exaggerated dorsiflexion of the foot. The third mechanism of anterior process fractures involves***³ Differential diagnosis of anterior process fractures of the calcaneus includes ankle sprains, and OS calcaneal secundarius. More often however patients are diagnosed with an ankle sprain, rather than an anterior process fracture leading to non-union of the anterior process fracture.⁴ For this reason, it is important to look for medial oblique foot films to be performed on patients with lateral ankle pain looking for anterior process fractures. However, once a perceived fracture is visualized on the medial oblique differentiation between it and OS calcaneal secundarius must be performed. This can be achieved with either a CT or MRI, although there have been articles arguing for the use of ultrasound.⁵ Once the presence of a fracture rather than OS calcaneal secundarius has been confirmed with advanced imaging, a course of treatment must be decided. If the fracture is greater than 25% of the anterior process, open reduction internal fixation (ORIF) has been advocated. If less than 25 % of the anterior process, conservative treatment consisting of a fracture boot and NWB has been advocated. These treatment protocols are widely agreed upon. Yet because anterior process fractures are often misdiagnosed as ankle fractures, many will go onto non-union. For these non-united fractures excision is often the treatment of choice, for relief, of painful symptoms. Excision of the non-united fragment has been classically achieved via open excision. However more recent literature has presented the alternative of arthroscopic excision. Potential benefits are decreased dissection, without disruption of the EDB, removal of the fat plug, or disruption of the ligaments of the sinus tarsi. Arthroscopic surgery on the other hand can increase the surgical time, which itself has its own risks. If either by open or arthroscopic removal excision of the fragment has been shown to reduce the symptoms of anterior process non-union.⁴

Fractures of the middle calcaneus are usually involved with other fractures, and may be involved with an intra-articular fracture, and may need CT to delineate if there is intra-articular involvement.⁶ Fractures of the middle calcaneus include: body fractures, sustentaculum tali fractures, peroneal tubercle fractures, lateral process of the calcaneus,

and medial process of the calcaneus fractures. Body fractures occur by the same mechanism as intra-articular fractures. However, because there is no articular involvement they are often treated conservatively, with a low non-union rate. 1 Sustentaculum tali injuries rarely occur in isolation, however when they do occur it is often due to direct trauma or axial loading and inversion. Again, surgical treatment is rarely necessitated. This is because of the strong ligamentous attachments to the sustentaculum talus which hold it in place. However, if there is delayed or non-union a single cortical screw has proven sufficient at reducing the fracture, and unlike anterior process fractures avulsion is never advocated.^{1,6,7} Peroneal tubercle fractures, occur because of the same mechanism as a peroneal retinaculum rupture, except in this case the retinaculum avulses the peroneal tubercle. Patients will present with a similar presentation of ankle popping with dorsiflexion and eversion. Treatment is often consistent with that of peroneal retinaculum tears consisting of: peroneal groove deepening, and direct repair of the avulsed peroneal tubercle. Fractures of the lateral process of the calcaneus are rare and are rarely mentioned in the literature.^{6,9} Fractures of the medial process of the calcaneus occur rarely in isolation, as they are often involved in complex injuries.⁶ When found in isolation it is often due to avulsion by the plantar fascia. ORIF with tension band wiring is often the treatment of choice.¹⁰

Fracture of the posterior calcaneus occur more frequently in isolation. Difficulty in their treatment often lies in the patient, as they are often found to be osteoporotic, which pre-disposes them to posterior calcaneus fractures. Most fractures of the posterior calcaneus are avulsion fractures except for the vertical fracture of the posterior calcaneus. Avulsion of the posterior tuberosity vary in size. Most commonly one will either see a beak fracture that is the result of avulsion from the deeper soleus muscles, or a larger avulsion from the insertion of the Achilles. Regardless of the size of these 2 avulsion fractures the treatment is the same. If there is minimal displacement, or if the patient is minimally active the patient is conservatively managed. If there is displacement the patient is treated with surgical management. Most often this is achieved with screw fixation or with tension band wiring, and after the surgery the patient is placed in a below the knee case

with the foot placed in a plantarflexed position for 4 weeks. When it comes to avulsion fractures there are many treatment options. Historically simple K-wire fixation, or suturing, and often a combination of the two were used for correction of avulsion injuries.^{11,12} In 1971 Lyngstadaas introduced the use of screws for the fixation of avulsion fractures. Screw fixation was the method of choice for fixation of larger avulsion fractures until 1997 when Levi published on a technique using K-wires and cerclage wire in a tension band technique to fix avulsion fractures. This method was thought to be superior as it was thought to work better in osteoporotic bone.¹³ Although tension band wiring as well as screw fixation remains popular, there are 3 more modern techniques, that although have less supporting literature are worth mentioning due to their novel approaches. 1st in 2005 Glanzmann developed the use of Mitek sutures for fixation of small avulsion fractures. Nothing that it could be used for small fragments and is less likely to cause skin irritation than prior constructs.¹⁴ Another more modern technique is use of a locking hook plate for fixation of Achilles avulsion type fractures. They noted that this fixation technique was less likely to cause soft tissue or skin irritation, and gave a more stable construct in osteoporotic bone.¹⁵ The final technique that like the prior was published in 2016 involves the use of suture as the primary technique. It is novel in that a bone hole is drilled through the calcaneus to the plantar aspect of the foot, and although this has previously been performed, with the use of the Krakow, suture with use of the side locking loop suture technique, one can be insured that there will be sufficient tension to withstand early WB. Further this technique is credited with a reduced tension on skin and soft tissue. The primary concern with this technique is the stress that this will put on the plantar skin beneath the knot at the plantar calcaneus.¹⁶

Intra-articular fractures

Intra-articular fractures only designate fractures that involve the posterior facet of the calcaneus. Although they can often be the more serious of the two definitive fracture groups. There is less consensus on when to treat these types of fractures, and there is little good literature on which treatments lead to results that are superior to that of conservative treatment. There are some patients that should always

receive conservative treatment. That is patients who have non-displaced intra-articular calcaneal fractures. There are additional indications for non-operative management. Patients who are greater than 60 years of age will more than likely benefit from non-operative management of their calcaneal fracture. A patient's activity level and physiological age may be more important and 60 should not be viewed as an absolute cut off.¹⁷ This concept also works in the opposite direction, patients who have less functional demands from their work and recreation would be better treated with non-operative management.¹⁸ Also patient who have medical co-morbidities that would preclude surgery, should also obviously undergo conservative management. Conservative treatment should consist of non-weight bearing to the fractured calcaneus for 6 weeks. During that time frame the patient should be performing ROM exercises of the subtalar joint starting with these exercises as early as 5 days after the initial injury.¹⁹ Aside from the considerations mentioned above all other patients would undergo some type of surgical procedure.

Surgical management of DIACF's can be broken into 3 categories: 1 ORIF 2 Minimally invasive surgery 3 ORIF with primary subtalar arthrodesis. Decisions about when to choose which fixation technique are multifactorial, and often clinical judgement must be used. Because of the multiple techniques, and the difficult clinical decision making required for such fractures. Much better outcomes have been noted in facilities that deal with such fractures on a regular basis.²⁰ ORIF can be performed through either the use of the extensile lateral L approach or using the sinus tarsi approach. The extensile L approach, has benefits of decreased peroneal tendonitis, decreased compromise of the anterior skin flap, preserves the sural nerve, and allows for good visualization of all the fracture fragments. The sinus tarsi approach is mainly noted for its decreased occurrence of wound healing complications. These studies, supporting decreased wound healing complications with the sinus tarsi approach, are limited in size, and have a short follow up. This small size makes the difference in wound healing difficult to assess with clinical significance, and the short follow up period, does not give the STJ's significant time to develop traumatic STJ arthritis.²¹ However, with the publication of a new

meta-analysis of medium to long term outcomes using the sinus tarsi approach, authors of the meta-analysis could conclude with statistical significance that the sinus tarsi approach does have decreased complication rates. All the while the authors were also able to conclude with statistical significance, that there was no difference in the level of anatomic reduction, or traumatic OA. ²² Regardless of the approach used reduction of calcaneal fractures remains consistent (except for some newer minimally invasive techniques.) First a Steinman pin is placed into the posterior tuberosity. This is used to joystick the calcaneus out to length and height. After doing so the posterior tuberosity is temporarily fixated to the constant fragment. Next attention is directed to the lateral anterior piece, or the lateral posterior facet. After it is elevated, or calcaneal height is restored it is fixated to the constant fragment. Pieces are fixated to the constant fragment due to its stable location, from numerous ligamentous attachments. After all of this is done, fixation is achieved with the instrument of choice, which could vary, from screws, to plates, to rods to cement depending on the type of procedure performed, ORIF or minimally invasive. More recent meta-analysis, and RCT point to the idea, that there is no difference between operative and non-operative treatment, in terms of patient pain and functional outcomes. ^{22,23,24} These studies go on to point out that there are very few RCT's and many have poor methods with high bias. They could conclude that there is an earlier return to work in operative patients, and that there may be a functional advantage however further investigation is needed. Despite these studies, there have been other authors that have tried to stratify, factors that can be used to determine the optimal treatment for each individual patient. The thought process is that when looking at the study groups as a whole, the patients who could benefit most from surgery are overlooked, as there is dilution of the studies, by patients who would not benefit from surgery, as well as selection bias, in the removal of patients who would most likely benefit from surgery. These authors advocate to put the baby back into the bath water, and make sure that patient populations that will most likely benefit from surgery to be further evaluated to look for confounding variables or overlooked factors. ²⁵ Age was found to be one of the factors affecting outcome. It was found that patients > 60 had no benefit from surgery, while patients < 30 more than likely have a benefit from

surgery. ²⁶ This has been labeled as a general guideline, as the level of physical demand on the job as well as with recreation may be more important, and it should be at least looked at in relation to age. As a patient age may be different from their physiological age. ²⁷ Another factor is sex. Male patients have been shown to more than likely benefit from surgery if less than 30. Women on the other hand have evidence of improved results if surgically treated at any age under 60. ²⁶ Bilateral fractures as well as fractures classified as a Sanders 3 or 4 are more than likely a high energy injury. For this reason, they are more likely to need surgical treatment. In addition, these patients are more likely to need ORIF with STJ arthrodesis. This is because high energy traumas are more likely to lead to STJ traumatic arthrodesis, and an initial fusion can prevent reoperation. ^{29,30} Mental state can play an important role in fracture treatment. This is because patients with mental illness were found to have better outcomes if they are treated with early weight bearing, as well as a single operation. For this reason, these patients are oft better treated with either a ORIF with STJ arthrodesis or non-operatively. Decision between these two should be based on the degree of mental disease, as well as confounding variables. Lastly comorbidities should be considered when determining the type of surgical intervention. Factors such as smoking, as well as diabetes control have been shown to increase the risk of wound healing complications. For this reason patients with such factors should be considered for minimally invasive surgery. Other comorbidities such as osteopenia or other factors that will impact bone healing should undergo fixation with a more stable construct. ⁵¹ For this reason patients with such factors should be considered for ORIF with an extensile lateral L approach. The final factor that will be mentioned necessitating consideration is Bohlers angle. Lower angles are associated with worse long term outcomes. Further better restoration of the angle with surgery has been shown to decrease rates of traumatic OA. Up to this point there has not been described a DIACF that necessitates fracture. However there are in fact 3 intra-articular fractures necessitating intervention. The first is open fracture. However in this case the focus of the surgery is to adequately wash out the wound, and provide good skin coverage. A second type of fracture necessitating surgery is a tongue type fracture with skin compromise. The posterior fracture when pulled proximally can put pressure on the skin, and if left

untreated can lead to skin breakdown. For the reasons described these 2 fracture types often require urgent or emergent surgery. The final fracture type that necessitates surgery is a locked in fracture type. This type of fracture involves dislocation of the posteriolateral tubercle laterally impacting the fibula. This fracture type is suspected when there is varus talar tilt noted on the AP radiograph. Definitive diagnosis is made on CT, visualizing impaction of the fibula by the calcaneus. This requires absolute surgical intervention, as the posteriolateral fragment is locked against the fibula, as there is interposition of the peroneals between this fragment and the rest of the calcaneus.²⁸ Except for the three fractures described, fracture fixation for DIACF's is difficult and many factors should be addressed.²⁰

Conclusion

Calcaneal fractures fall into 2 distinct categories intr and extra-articular. The differentiating factor is the involvement of the posterior facet. Many extra-articular fractures are treated conservatively, although there are specific guidelines for when surgery should be performed, regardless if there is RCT substantiating these treatments. Intra-articular fractures are difficult to treat as there is different opinions on the outcomes of surgical and non-surgical treatment in regards to RCT as well as meta-analysis. In addition, there are multiple treatment options. One can perform ORIF with an extensile L approach or a minimally invasive approach, one could perform an ORIF with STJ arthrodesis, or one could decide on non-operative treatment. Guidance as to whether one should perform surgical intervention, is based on factors such as: age, sex, level of activity, type of fracture, co-morbidities, and psychiatric status. These should be looked at and treatment should be determined based on all factors.

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