Percutaneous Treatment of Displaced Intra-Articular Calcaneal Fractures: Indications, Technique and Limitations

Indications

The ideal choice of treatment for displaced intra-articular calcaneal fractures has generated controversy for more than a century [19, 21]. There is evidence from numerous clinical studies with greater patient cohorts that anatomical restoration of the calcaneal shape and joint congruity are important prognostic factors in the treatment of these injuries [1, 3, 11, 12, 15, 16, 22, 27, 33]. In the majority of cases this goal is best achieved with open reduction and internal fixation via an extended lateral approach. However, the development of minor and major wound complications remains a major concern because of the thin and vulnerable skin over the lateral calcaneal wall which is exposed during surgery with reported rates of wound edge necrosis between 2 and 11 % and soft tissue infections between 1.3 and 7 % after plate osteosynthesis via an extended lateral approach [1, 10, 16, 22, 33]. The cumulative rate of wound complications has approached 25 percent of patients with 21 % of patients requiring further surgery in a cohort of 190 patients [6].

Numerous authors have proposed closed reduction and minimally-invasive osteosynthesis in order to minimize soft tissue problems in the treatment of calcaneal fractures since more than 150 years [9]. Many of them included some kind of continuous skeletal traction and external fixation. In particular, the method of closed reduction with percutaneous pin leverage and subsequent plaster immobilization, which was introduced by the German surgeon Westhues in 1934 [31], has later been modified and popularized by Gissane and Essex-Lopresti in the English-speaking literature. This method has found reappraisal in the 1990s for closed reduction of tongue-type fractures with the posterior calcaneal facet to the subtalar joint being displaced as a whole [29]. When being supplemented with subtalar arthroscopy, this method can be used for simple (Sanders Type II) intra-articular fracture patterns [18].

External fixation, supplemented by percutaneous K-wire fixation if necessary, has a role in emergency treatment of complex foot trauma, open calcaneal fractures or closed fractures with severe soft tissue compromise like skin necrosis due to pressure from grossly displaced bone fragments. In these cases, three-point distraction and subsequent external fixation is carried out from medial to allow secondary (staged) open reduction and internal fixation via an extended lateral approach [17, 19].
Limited approaches are generally indicated in patients who are in a systematically critical condition, like polytraumatized and multiply injured patients, in order to minimize the time for surgery. Percutaneous fixation is also a treatment option for patients with contraindications to open surgery, such as those with severe, poorly controlled diabetes, heavy smokers, and immunodeficiency, or those with critical local soft-tissue conditions that preclude extensive approaches, like blistering, superficially contaminated wounds, and severe vascular compromise [19].

**Authors’ Preferred Technique**

In our practice, percutaneous reduction is attempted in extraarticular and in less severe (selected Sanders type II) intra-articular fractures [18, 20]. Patients are placed in a lateral decubitus position. A 6.5 mm Schanz screw with T-handle was introduced via stab incision centrally into the main portion of the tongue fragment parallel to the superior border of the calcaneal body. The screw is directed towards the most distal aspect of the displaced posterior facet. Loosening of the fragments and gross reduction of the tuberosity is achieved with leverage at the handle under fluoroscopic guidance. In Sanders type IIC fractures with the posterior facet being displaced as a whole, exact restoration of the calcaneal height and correction of any varus or valgus malalignment was controlled fluoroscopically with lateral, axial and Brodén views, and followed by percutaneous screw fixation. In Sanders type IIA and B fractures the quality of the reduction of the posterior facet is judged with a small-diameter arthroscope (2.7 mm, 30°) via the standard anterolateral or posterolateral portals to the subtalar joint. The joint and the fracture site are cleared from loose fragments, debris or clots. If a residual step-off is detected after gross reduction with screw leverage, fine corrections can be carried out under direct vision. The joint bearing fragments can be realigned with an additional Kirschner wire, pestle, smooth or sharp elevator introduced percutaneously. Reduction of the overall anatomical shape of the calcaneus is controlled fluoroscopically. The main fragments are fixed via stab incisions with 3.5 or 4.5 mm screws and controlled fluoroscopically. 3D fluoroscopy is most helpful for percutaneous reduction [8]

If anatomic reduction of the joint cannot be achieved percutaneously because of deep impaction of the lateral joint fragment, interposition of debris or further fragmentation with manipulation, open joint reduction via a direct anterolateral approach to the subtalar joint (modified Palmer approach), ideally including the arthroscopic portals, is carried out and a screw or plate osteosynthesis is performed.

In the author’s practice, percutaneous reduction and screw fixation has been performed in 61 patients with less severe (Sanders type II) calcaneal fractures over a course of ten years [20]. In 33 patients with displaced intra-articular fractures (Sanders IIA and IIB) anatomic reduction of the subtalar joint was controlled arthroscopically. No wound complications and no infections were seen. No compartment syndrome or any other negative effects attributable to subtalar arthroscopy like fluid extravasation have been observed. In two patients one prominent screw was removed after 1 and 3 years, respectively. In one patient, arthroscopic arthrolysis was performed one year after the index procedure. 24 patients could be followed at a mean of 26 months. Subjectively, 23 of 24 patients had good or excellent clinical results. The average AOFAS ankle/hindfoot score was 92.1 (range 80 to 100). When comparing these results to a matched cohort of 20 patients treated with open reduction and internal fixation via a standard extended lateral approach for Sanders Type II calcaneal fractures, no significant differences were seen with respect to the AOFAS scores and the radiographic parameters of reduction after one year. However, the patients from the percutaneous treatment group had significantly less time off from work and a significantly better range of hindfoot motion in the coronal plane at follow-up [20].
Similarly, Tornetta [29] reported on good to excellent results with the Maryland Foot Score in 85 per cent of 46 patients with 41 closed reductions of mostly Sanders type IIC tongue type fractures followed for an average of 3.4 years. After first having been using percutaneous Steinmann pins for definite fixation, he later changed to percutaneous screw placement because of complaints related to shoe wear and drainage from the pin sites. More recently, other groups from the US and Singapore have reported good to excellent results with percutaneous reduction of Sanders type II fractures under arthroscopic and fluoroscopic control [25, 32].

**Limitations**

Several authors have reported on percutaneous reduction and fixation of displaced intra-articular calcaneal fractures regardless of the type of fracture. Methods include external fixation with a three-point distractor [4, 13, 14, 24], Steinmann pin and K-wire fixation [2, 26, 30] or screw fixation [5, 28]. Some of them report good to excellent results in a high percentage of cases, however, almost all of the authors use their own follow-up scores which makes it difficult to draw any general conclusions. The use of external fixators or K-wire fixation with the wires extruding through the skin invariably leads to pin track infections that may develop into deep infections in up to 3.5% of cases [2, 26]. Historically, K-wire fixation resulted in residual articular step-off's in plain radiographs in 37% and some loss of reduction in 71% of cases [17]. These numbers could be reduced in more recent series although no CT was employed to determine joint reduction in most of these studies [24, 26, 30]. While the numbers of soft tissue complications could be substantially reduced, percutaneous reduction of severely displaced and more complex intra-articular calcaneal fractures carries the considerable risk of residual joint incongruity (which can be seen in the figures of some of the above cited papers) with inferior functional results [4].

As biomechanical and clinical studies have consistently shown, even minor step-off's in the joint surface of 1-2 mm lead to significant load redistribution within the posterior joint facet of the calcaneus [23] and inferior clinical results [1, 3, 11, 12, 16, 22, 33]. In our experience, anatomic reduction cannot be achieved with percutaneous methods alone in the majority of calcaneal fractures due to the impaction of the posterior facet fragment into the calcaneal body, multiple fragmentation and interposition of debris and small fragments. We therefore limit percutaneous reduction and fixation to less severe fractures with either one displaced fracture line in the posterior facet of the subtalar joint or the facet being displaced as a whole [17, 20].

When applying these criteria, percutaneous reduction could not be achieved with percutaneous methods alone in 5 of 31 patients with Sanders IIA and IIB fractures [20]. In four of them, open reduction could be carried out within the same surgery using a modified direct lateral approach to the subtalar joint. In one patient open reduction was postponed because of the soft tissue swelling after percutaneous reduction attempts and arthroscopy. Therefore, one should not be overly zealous to achieve closed reduction by any means. After three unsuccessful trials of percutaneous reduction surgery should be converted to open reduction. In any case, patients should be made aware not only of possible conversion but also the need of a second surgery in case of severe soft tissue swelling. Generally, reduction is best achieved shortly after the injury and surgery should be ideally performed within 3-5 days.

In summary, percutaneous reduction and screw fixation of displaced calcaneal fractures yields good to excellent results in patients with less severe fracture patterns (Sanders type II with moderate displacement). Percutaneous treatment minimizes soft-tissue complications and postoperative scar formation and therefore appears preferable to open reduction and plate fixation via an extended lateral approach in properly selected cases. The quality of joint reduction should be visualised arthroscopically or with 3D fluoroscopy in all displaced intra-articular fractures. A uniform
application of percutaneous reduction and fixation methods to all types of calcaneal fractures is not encouraged because it carries a considerable risk of inadequate joint reconstruction and redislocation.

References

14. McGarvey WC, Burris MW, Clanton TO, Melissinos EG. Calcaneal fractures: indirect reduction and external fixation. Foot Ankle Int. 2006;27:494-499