Treatment of Intra-articular Comminuted Os Calcis Fractures

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Despite numerous published studies, the management of displaced intra-articular calcaneal fractures remains controversial. Treatment options include conservative management,\textsuperscript{1,3} closed reduction and stabilization with percutaneous Kirschner-wires,\textsuperscript{4,5} open reduction and internal fixation,\textsuperscript{6,22} and primary subtalar arthrodesis.\textsuperscript{23,24} Although, a number of classification systems and different evaluation criteria are used, it is not always easy to compare results and draw meaningful conclusions.

In severely comminuted intra-articular os calcis fractures, conservative management does not seem to be an acceptable option, as it often results in a poor outcome or even in permanent disability.\textsuperscript{4,14,21} However, treating a severely comminuted calcaneal fracture with open reduction and internal fixation using a plate and screws often requires extensive soft-tissue stripping and the use of autologous bone grafts from the iliac crest.\textsuperscript{6,9,10,12,15,18,21}

This study analyzes the outcome of a new technique for the surgical management of comminuted intra-articular os calcis fractures, consisting of open reduction through a small skin incision, stabilization with percutaneous K-wires and augmentation with remodelable cancellous bone cement.\textsuperscript{25}

**Figure 1:** Preoperative radiograph of type C fracture in a 57-year-old man.

**Figure 2:** Preoperative radiograph of type C fracture in 40-year-old woman.

**MATERIALS AND METHODS**

From August 1998 to May 2002, 17 patients with 22 comminuted intra-articular os calcis fractures were treated in our department. In all patients the mechanism of injury was fall from a height. Sixteen patients sustained a unilateral or bilateral calcaneal fracture alone (Figures 1 and 2), while one had a concomitant ipsilateral bimalleolar fracture.

Thirteen men and four women, with an average age of 46.2 years (range: 21-64 years), were followed up for a minimum of 18 months (range: 18-63 months; average: 32.8 months).

Anteroposterior and lateral radiographs of the foot and ankle were performed in all patients on admission. Axial views and a computed tomography scan were not obtained.

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This technique for the management of comminuted intra-articular os calcis fractures minimizes the amount of implants used, obviates autologous bone graft, and allows for early mobilization and return to work.
regularly. Based on lateral plain radiographs and the number and exact location of secondary fracture lines, the modification of fracture classifications by Essex-Lopresti and Soeur and Remy, as described by Paley and Hall, was used. There were six tongue type fractures (all were type fractures) and 16 central depression type fractures (9 C1 and 7 C2 type fractures).

Operative Technique
All patients underwent surgery within 2 to 10 days (average: 5.6 days) from injury, as soon as swelling had subsided. A tourniquet was applied and a lateral incision of approximately 5 cm in length was made, beginning 1 cm below the tip of the lateral malleolus and progressing forward, parallel to the subtalar joint and crossing the peroneal tendons (Figure 3A). Peroneal tendons were retracted distally and posteriorly and the sinus tarsi was exposed (Figures 3B and 3C). After blood clots, fat, ligamentous debris and small pieces of bone were removed, the subtalar joint was visualized and reduction was attempted as close to the anatomical position as possible. Care was taken to accurately restore the articular surface and height of the os calcis. Reduction was held with two or three percutaneous K-wires and, if intraoperative radiographs were satisfactory (Figure 4), the osseous defect left in the subchondral bone was filled with 5-10 mL of Norian SRS remodelable cancellous bone cement (Norian, Cupertino, Calif) (Figures 5 and 6). The cement was mixed according to the manufacturer’s specifications and was injected from the deepest to the most superficial part of the osseous defect. At the end of the procedure, before soft-tissue closure, the subtalar joint was carefully inspected to ensure that calcium phosphate cement extrusion in the subtalar joint had been avoided. The wound was closed in layers and a below knee back-slab was applied over adequate padding.

Postoperative Regime
Intravenous antibiotics were administered for 48 hours. The operated leg was kept elevated for the swelling to subside. The back-slab was removed intermittently starting from the early postoperative period and active mobilization of the ankle joint and the subtalar joint was commenced as soon as pain allowed. Sutures were removed 15 days postoperatively. The back-slab and the K-wires were removed and patients were encouraged to partially bear weight at the end of the third postoperative week in the unilateral fractures, and at the end of the fourth postoperative week in the bilateral.
fractures. Full weight bearing commenced 6 weeks postoperatively. Patients were followed both clinically and radiologically at 3, 6, 12, 26, and 52 weeks and yearly thereafter.

**Clinical and Radiographic Evaluation**

All patients were evaluated with the scoring system used by Paley and Hall, based on both subjective (pain, daily activities, sports and recreational activities, and walking [70 points]) and objective (range of motion of the subtalar and ankle joints and the presence of a limp [30 points]) criteria. A total score of 90 to 100 points was considered excellent, 72 to 89 points good, 41 to 71 points fair, and <40 points poor.

Anteroposterior and lateral radiographs of the foot and ankle were obtained postoperatively, on removal of K-wires, on regular follow-up appointments, and at final follow-up (Figures 7 and 8).

Böhler’s angle, height of the calcaneus, and osteoarthritic changes of the subtalar joint were evaluated preoperatively, postoperatively, and on final follow-up. Osteoarthritic changes of the subtalar joint were graded: Grade 0 when the joint space was normal with no evidence of degenerative cysts or subchondral sclerosis; Grade 1 when osteophytes, subchondral sclerosis, and cysts were present without joint space narrowing; Grade 2 when joint space narrowing was present, and Grade 3 when there was complete loss of joint space.

**RESULTS**

At final follow-up, 20 of 22 cases either were pain free or had only occasional mild pain, and 2 had moderate pain necessitating occasional use of medication. With regard to activities of daily living, they were not modified or slightly modified in 20 of 22 cases, while sporting and recreational activities were not modified or slightly modified without difficulty in 21 of 22 cases. All 17 patients were fully weight bearing by the end of the second postoperative month. They returned to their previous occupation within 3-6 months from the initial injury.

Full or almost full range of motion in the ankle joint was achieved in 21 of 22 cases, while full or almost full range of motion in the subtalar joint was achieved in 19 of 22 cases. There was no limp at all in 13 of 22 cases, while only a slight limp was recorded in the remaining 9 cases.

According to the scoring system used by Paley and Hall, there were 6 excellent, 15 good, and 1 fair result. This brings the satisfactory (excellent or good) results to 21 (95.5%) in our group of patients, while the average Paley and Hall score was 81.1 points. No significant differences were found in the results with regard to the fracture type (tongue or central depression).

The height of the calcaneus was significantly reduced and Böhler angle was substantially flattened preoperatively. They both were corrected postoperatively very close to normal and virtually all the correction was retained on final follow-up. No or minimal subtalar osteoarthrosis (grade 0 or 1) was seen in 16 of 22 cases, while more substantial osteoarthritic changes (grade 2 and 3) were seen in the remaining 6 cases. However, no patient required a secondary procedure.

No major complications, such as deep wound infection, osteomyelitis, wound dehiscence, or skin necrosis were noted. The only complication recorded was a case of hypoesthesia in the distribution of the sural nerve.

**DISCUSSION**

Displaced intra-articular os calcis fractures, especially when some degree of comminution is present, are a difficult problem for the orthopedic surgeon. Anatomic reconstruction of the articular surface seems to be of great importance; thus, operative reduction and inter-
nal fixation of the fracture with a special plate and screws, or a combination of screws and K-wires, is the treatment of choice for most surgeons.

In comminuted fractures, anatomic reduction and internal fixation with a special plate and screws is a demanding procedure that often requires an extensive approach and soft-tissue stripping, as well as the use of allograft or autologous bone graft from the iliac crest, to fill the defect often left in the subchondral bone. The need for an extensive approach and soft-tissue stripping, could well be the reason for the main complications of this fixation method, namely wound dehiscence, infection, loss of sensation, or formation of a painful neuroma. Additionally, the use of a special plate and screws has been shown to cause peroneal tendinitis in up to 18% of patients, frequently necessitating early metalwork removal. The overall complication rate ranges from 7.4% to 23% in the literature. Donor site morbidity for bone graft harvesting from the iliac crest includes considerable blood loss, formation of hematomas, wound breakdown, and postoperative pain. This may lead to prolonged hospital stay and difficulty in early mobilization. Furthermore, with this method, weight bearing often is delayed for up to 3 months until the operative construct gains adequate stability with the progression of the fracture healing process.

Ebraheim et al. reduced the fracture using a sinus tarsi approach and fixed it with K-wires without the use of bone grafts or any other means of augmentation. Their results were satisfactory in 75.5% of cases, but patients had to be restricted to nonweight bearing for 10 weeks.

The remodelable cancellous bone cement used in this series of patients has recently been developed for the fracture treatment. This calcium phosphate cement hardens under physiological conditions into a carbonated apatite in a nonexothermic fashion through a crystallization process. Its compressive strength of 55 MPa is reached within 24 hours and is higher than the compressive strength of cancellous bone. Although it provides satisfactory initial compressive strength, it does not behave equally well under tensile or shear loads. Early clinical studies as well as biomechanical testing suggest that it does not degrade mechanically with time. It has already been shown in cadaveric feet that augmentation with injectable calcium phosphate cement largely increases the stability and compressive strength of the fixation of a calcaneal fracture construct.

Histological animal studies as well as histological evaluation of SRS in humans have strongly suggested that it is osteoconductive, biocompatible and follows a normal healing pattern. Extensive bone apposition occurs from as early as 2 weeks postoperatively, followed by gradual vascular penetration associated with resorption and new-bone formation in a process resembling normal bone remodelling.

This process is evident 18 months postoperatively, lead-
ing to almost full restoration of trabecular bone and marrow space. 29

With the proposed technique, reduction is achieved through a small incision and held with K-wires inserted percutaneously. The defect left in the subchondral bone is filled with remoldable cancellous bone cement, instead of allograft or autograft. Due to the excellent compressive strength SRS achieves within the first day, weight bearing is allowed quickly with a very good degree of safety with regard to stability of the operative construct. 25,29

This technique allows for minimalization of metalwork used, and early mobilization and return to work with a good degree of safety. It also obviates the need for autologous bone graft, leading to complication reduction.

Although the proposed technique was used in a relatively small group of patients, the results show that it is a reliable option for treatment of intra-articular comminuted calcaneal fractures.

REFERENCES


