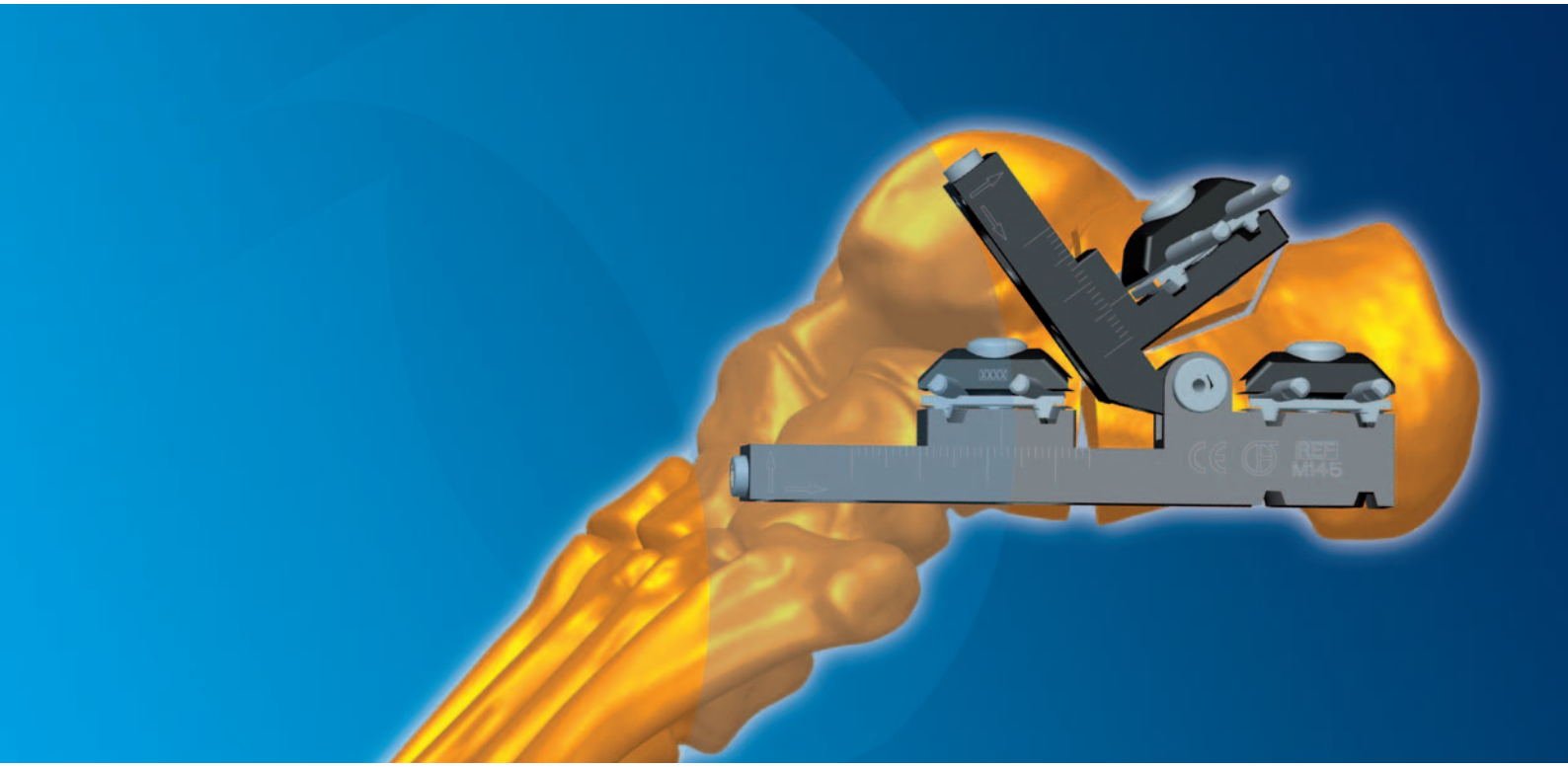
OPERATIVE TECHNIQUE



Orthofix Calcaneal External Fixator

ORTHOFIX®

Orthofix wishes to thank
the following surgeons for their contribution
to the development of the technique:

GREG GRABOWSKI D.P.M.
BRUNO MAGNAN M.D.

INTRODUCTION

As reported in the literature [1, 2] calcaneal fractures involving the joints are disabling injuries which can jeopardize work and day-to-day activities[3].
The anatomy and biomechanics of the hindfoot account for the difficulties in treating this type of fracture, since the calcaneus is constantly subjected to compression forces, operates as a sesamoid bone in the Achilles-calcaneal-plantar system and has articular surfaces that form two complex joints: Chopart's and subtalar joint.
Despite several comparative studies between the conservative and surgical methods, the management of intra-articular calcaneal fractures remains controversial.
There are a number of reasons for this:

- difficulty in obtaining reduction using conservative methods, often leading to considerable sequelae, such as pain, hindfoot deformity, impingement, and disturbed gait;
- difficulty in reduction and fixation, even with an open surgical approach;
- the high risk of major complications related to open surgery[4]

Although open reduction and internal fixation is currently considered the treatment of choice for Sanders types II, III and IV fractures[5,6], uncertainty remains about the comparative final results of surgical and conservative treatment[7], since neither method provides good results without the risk of considerable early and delayed complications.
The main goal for treatment of articular displaced heel fractures should be the restoration of the three dimensional structure of the os calcis, emphasising correct alignment in the coronal and axial planes and the height of the calcaneal body[8,9], rather than anatomical reconstruction of the congruency of the subtalar articular fragments[6,10,8]. The use of external fixation to treat displaced articular fractures of the heel appears suitable for obtaining such goals, and is therefore as good rationale for the technique, which allows stable fixation and a reduced risk of major complications.
Anatomical restoration of the subtalar joint facet is very difficult to obtain, particularly with percutaneous reduction and external fixation using two single pins stabilizing the articular fragments, as demostrated by CT evaluation at follow up. Some degree of stiffness and degenerative arthritis of the sub-talar joint following a displaced articular fracture[11] is usually unavoidable whatever the chosen treatment[12,13,14,15], due to the severe damage to the articular cartilage which almost always sustains high energy axial load[16]. The results of our series indicate that neither the subtalar mobility nor the clinical outcome seem to be significantly affected by obtaining congruency of the subtalar facet, when compared with the results reported with open forms of treatment, which specifically aim to reduce the articular fragments anatomically, but correlate more with the results following early post-operative mobilization and the restoration of Boehler's angle[12,10].

Percutaneous reduction and external fixation proved to be a reliable technique for obtaining stable reconstruction of fractures of the os calcis. The clinical results appear to be comparable to those obtained with open reduction and internal fixation.
The added advantages of minimally invasive procedures are considerably shortened operating and hospitalization time, and reduced risk of complications related to surgical exposure.

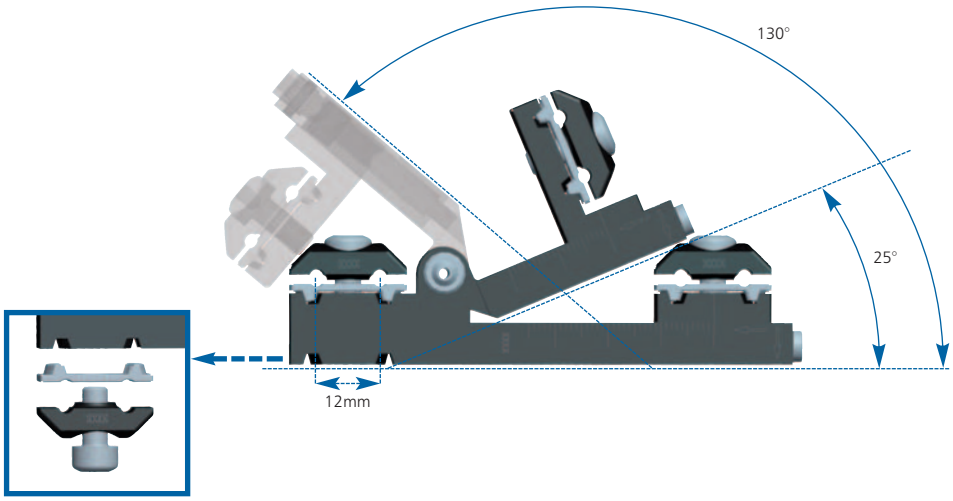
References

1.Magnan B et al. G.I.O.T., 2006; 32 (suppl.1), S322-S326.
2.Magnan B et al. J Bone Joint Surg, 2006; 88 B, 1474-9
3.Cotton FJ, Wilson LT. Fractures of the os calcis. Boston Medical Journal, 1908; 159, 559-565.
4.Howard JL, Buckley R, McCormack R, Pate G, Leighton R, Petrie D, Galpin R. Complications following management of displaced intra-articular calcaneal fractures: a prospective randomized trial comparing open reduction internal fixation with nonoperative management. Journal of Orthopaedic Trauma, 2003; 4, 241-249.
5.Rajkumar P, Henderson AA. Surgical treatment of displaced intra-articular fractures of the os-calcis. Foot and Ankle, 2003; 9, 3-6.
6.Sanders R, Fortin P, DiPasquale T, Walling A. Operative treatment in 120 displaced intraarticular calcaneal fractures. Results using a prognostic computed tomography scan classification. Clinical Orthopaedics and Related Researches, 1993; 290, 87-95.
7.Randle JA, Kreder HJ, Stephen D, Williams J, Jaglal S, Hu R. Should calcaneal fractures be treated surgically? A meta-analysis. Clinical Orthopaedics and Related Researches, 2000; 377, 217-27.
8.Richardson ML, Van Vu M, Vincent LM, Sangeorzan BJ, Benirschke SK. CT measurement of the calcaneal varus angle in the normal and fractured hindfoot. Journal of Computer Assisted Tomography, 1992; 16, 261-264.
9.Rosenberg ZS, Feldman F, Singson RD. Intra-articular calcaneal fractures: computed tomographic analysis. Skeletal Radiology, 1987; 16,105-113.
10.Magnan B, Montanari M, Bragantini A, Bartolozzi P. A system of prognostic evaluation of CT imaging of heel fractures: the Score Analysis Verona (SAVE). Foot Disease, 1995; 1, 19-25.
11.Csizy M, Buckley R, Tough S, Leighton R, Smith J, McCormack R, Pate G, Petrie D, Galpin R. Displaced intra-articular calcaneal fractures: variables predicting late subtalar fusion. Journal of Orthopaedic Trauma,. 2003; 2, 106-112.
12.Sanders R.: Displaced intra-articular fractures of the calcaneus. Journal of Bone and Joint Surgery American Volume, 2000; 82, 225-250.
13.Coughlin MJ. Calcaneal fractures in industrial patients. Foot Ankle International, 2000; 21 (11): 896-905.
14.Myerson M, Quill GE Jr. Late complications of fractures of the calcaneus. Journal of Bone and Joint Surgery American Volume, 1993; 3, 331-341.
15.Paley D, Hall H. Intra-articular fractures of the calcaneus. A critical analysis of results and prognostic factors. Journal of Bone and Joint Surgery American Volume, 1993; 3, 342-354.
16.Borelli J Jr, Torzilli P. Effect of impact load on articular cartilage: development of an intra-articular fracture model. Journal of Orthopaedic Trauma, 1997; 11, 319.

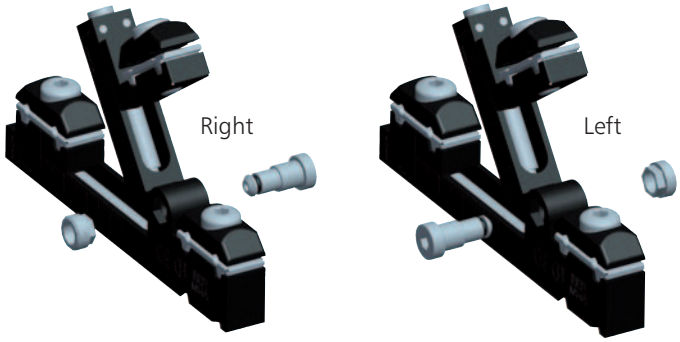
INDICATIONS

1) Articular Fractures of the Calcaneus
   - Sander's CT classification I, II, III, IV
   - Rowe's X-ray classification IV
2) Oblique or Coronal Calcaneal Body Fractures not involving the Subtalar joint
   - Rowe's X-ray classification III

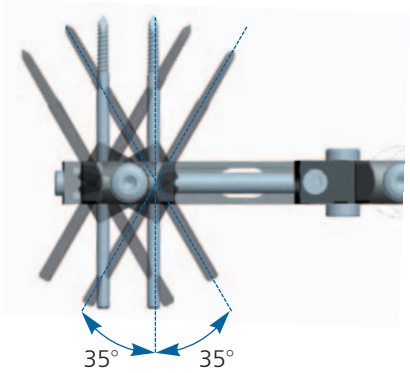
FEATURES AND BENEFITS



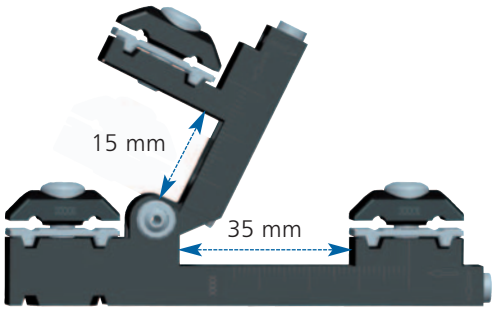
For right or left foot



Swivelling Clamps to allow for angled placement of the pins

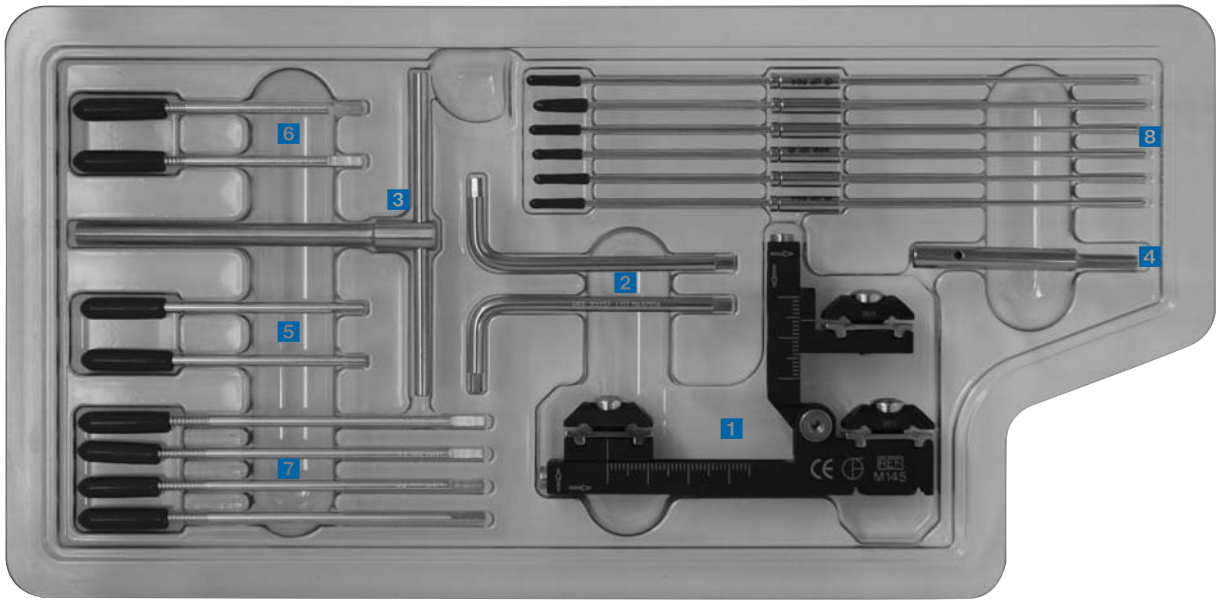


Compression-distraction units to allow for fragment reduction



EQUIPMENT REQUIRED

Calcaneal Fixator Sterile Kit (99-M1450)



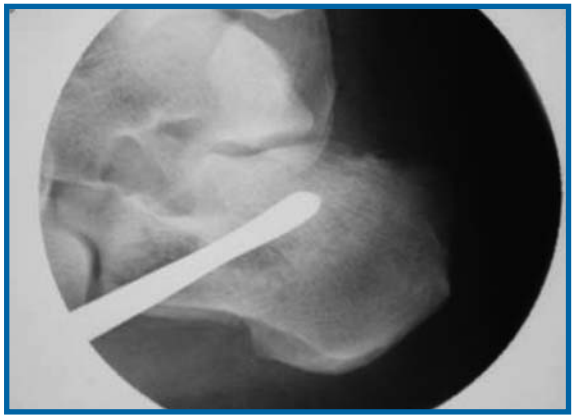
COMPRISES			
1) Calcaneal Fixator	M145	7) Pin 100/30	M317
2) 3 mm Allen Key	10012	8) Calcaneal Template Kit	M224
3) T-Wrench T	M210	*Consisting of:*	
4) Driver	M211	*6 Wires*	
5) Pin 70/15	M321	*6 Wire Guides*	
6) Pin 70/25	M315	*6 Pin Guides*	

PATIENT POSITIONING

The patient is placed in lateral decubitus on theuninjured side with the C-arm (fluoroscopy) positionedto allow lateral and axial view of the hidfoot while notinterfering with the surgical field.A tourniquet can be applied at the base of the limband inflated if necessary, very rare situation with mini-invasive and/or percutaneous approaches for thereduction of articular talamic fragments.

APPLICATION OF CALCANEAL TRACTION

Some authors prefer a supine position in order to apply a calcaneal traction using a Kirschner wire or Steinman Pin and reduce pre-operatively the varus or valgus deformity of the posterior part of the calcaneus.
In case of reduction with a mini-invasive surgical approach, calcaneal traction is not necessary.

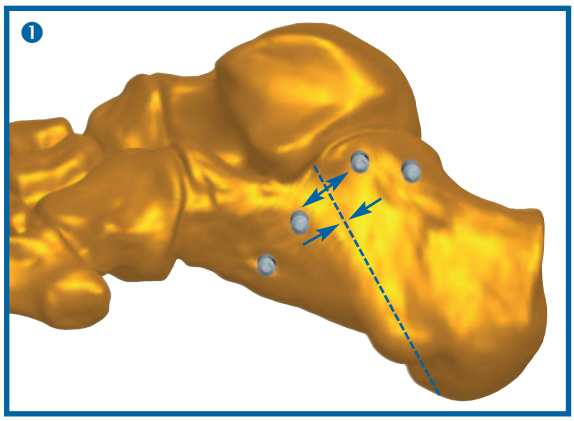


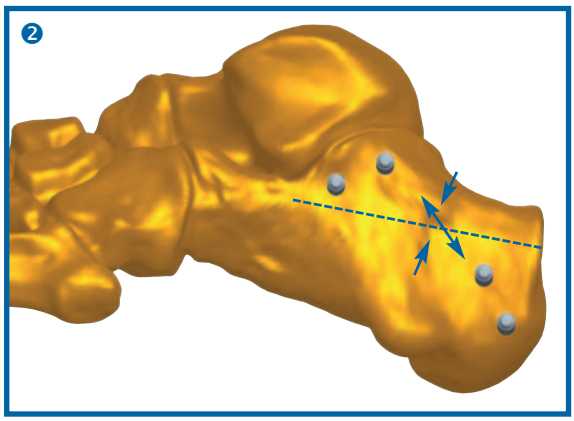
OPERATIVE TECHNIQUE

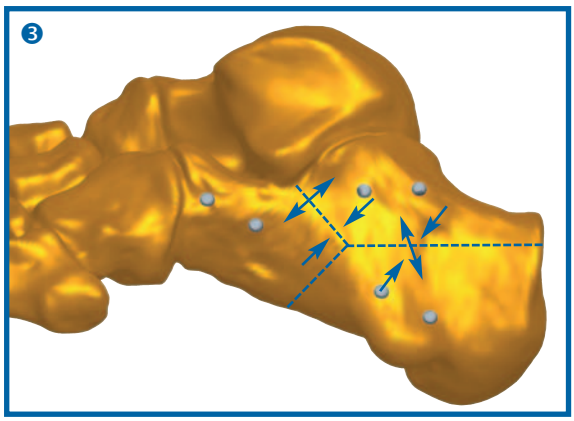
Percutaneous Reduction

Through a percutaneous supra-lateral approach of the external part of the sinus tarsi, used by most authors, insert a small bone lever to lift and rotate the depressed articular talamic fragments to reconstruct the articular surface and the Böhler's angle.

Alternatively, a direct plantar approach through the calcaneal body or a para-Achilles postero-lateral approach directly to the subtalar joint may be used.





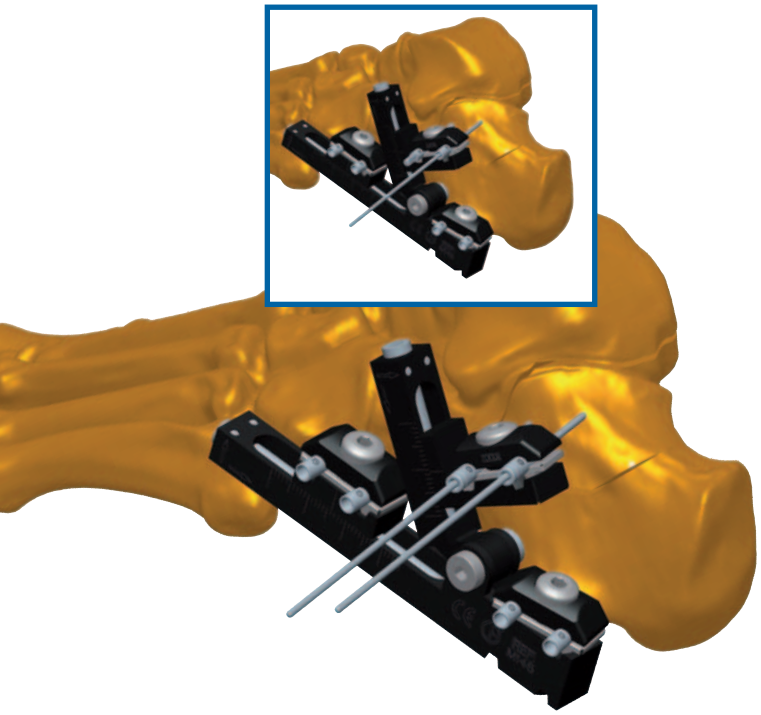


Pin Position

The fixator is positioned according to the fracture pattern. Once reduction of the talamic surface has been achieved, the first two pins should always be positioned on the talamic fragments, in subchondral bone, using the fixator as a template. It is possible to preliminary fix the fragments with wires, wire guides and pin guides of the Calcaneal Template Kit.
Once correct reduction has been achieved, remove the wires and wire guides, insert the pins and remove the pin guides. The remaining pins are inserted so that they create a counterbalance and maintain reduction of the articular surface in height. The position of the second and third clamp depends upon the integrity or fragmentation of the bone grip site and the fracture pattern.

It is advisable to apply pins as follows:

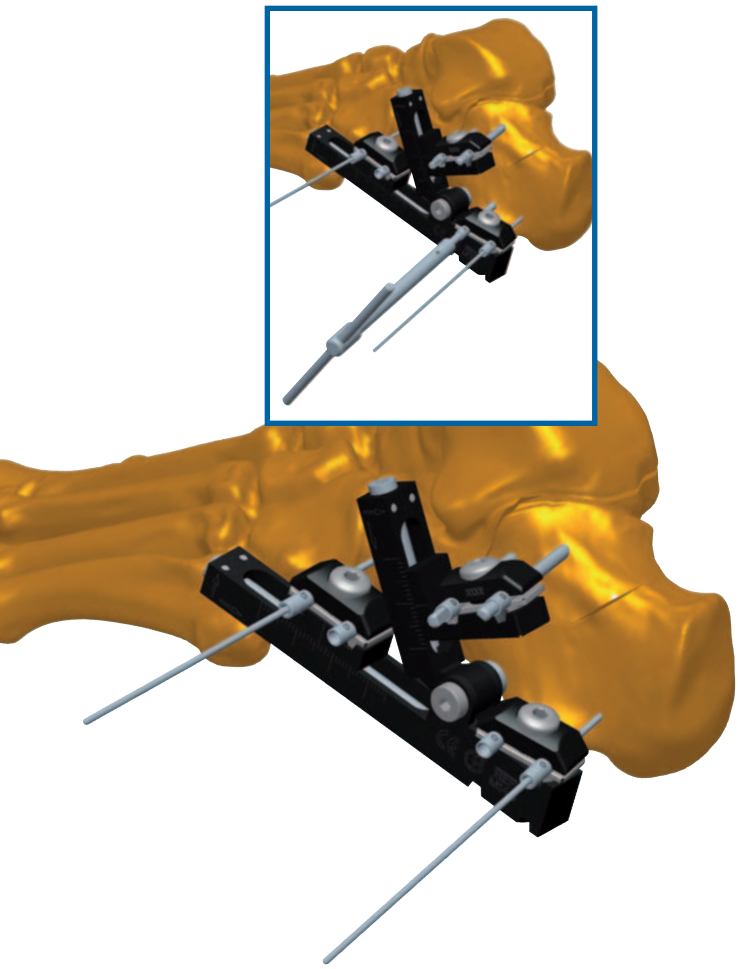
1. at the level of the anterior calcaneal apophysis in Tongue Type fractures, according to Essex-Lopresti classification, in which the articular fragment should be lifted and rotated with a force which is more favourable if exerted from the anterior part of the calcaneus;
2. at the level of the posterior apophysis in Joint Depression Type fractures, according to the Essex-Lopresti classification, in which the articular fargment sould be completely lifted vertically.
3. From both (anterior and posterior) sides in higly comminuted fractures of the entire calcaneal body, or when a greater stability is needed.
   It may be necessary to place one or two pins of the anterior clamp in the cuboid in case of severe comminution of the anterior calcaneal apophysis.



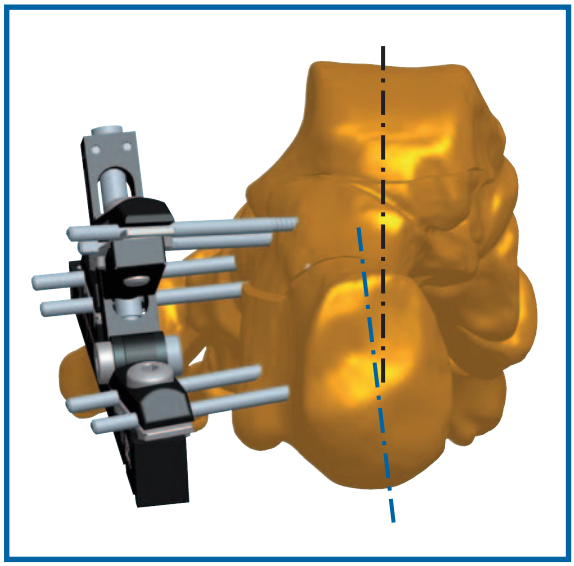
Pin Placement

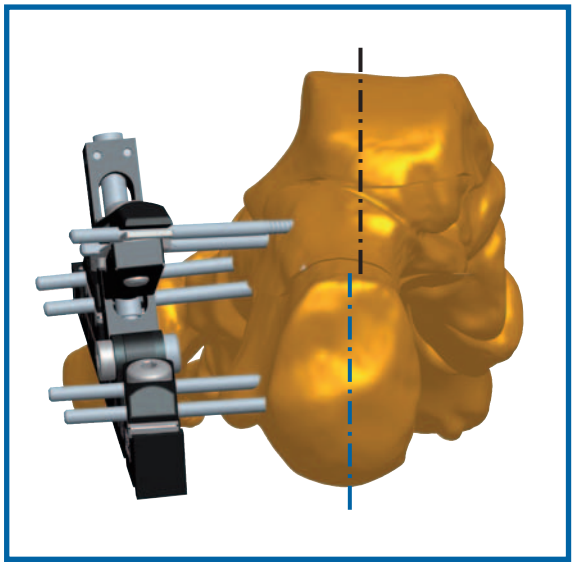
Insert the pin guides into the clamps and tighten the clamp covers to keep them parallel.
Drill the first wire through the wire guide in the anterior pin position of the subtalar or third arm clamp, just below the subchrondral bone of the subtalar joint capturing the sustentacular fragment.

Gentle traction can be applied to the pin to close any fracture gap. The pin can also be used as joy stick to correct any "step off" between fracture fragments.



Using the same procedure, insert the second pin in the talamic fragment and the wires in the anterior and posterior fragments. Once the positions of the wires have been confirmed with fluoroscopy, the first pin is inserted through the empty guide in the clamp, either manually using the T-wrench or with the drill using the driver.



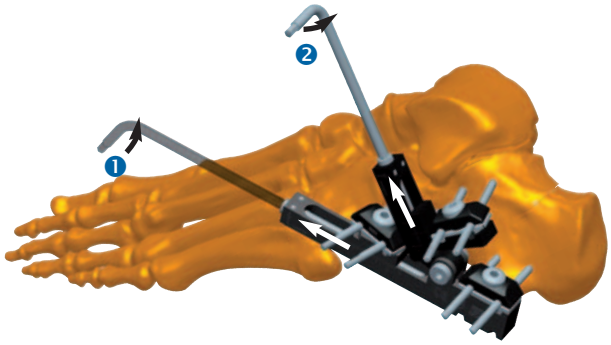


At this stage, when applying the pins at the level of the posterior or anterior calcaneal apophysis, it is possible to correct the varus-valgus deformity of the calcaneal body, by inserting the pin at an angle through the clamp that acts as a template.
This angle can be captured by the pin clamp's swivel head.

Using the pins again as a joy stick, it is possible to achieve correct alignment of the calcaneal body with the articular fragment already fixed with the first clamp.

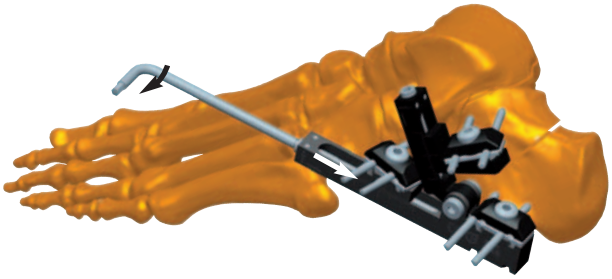
The remaining pins are then inserted and the pin guides removed. With all pins in proper alignment, the external fixator is then locked onto the pins, paying careful attention to allow for any swelling that may occurred.

Fragment Manipulation

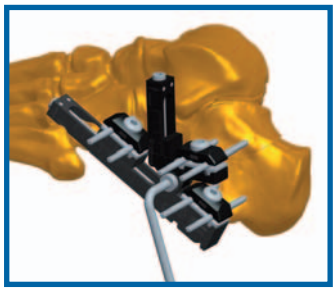


1. The main rail is distracted first separating the posterior and anterior fragments, as well as unlocking the comminuted fragments of the depressed area. The amount of distraction is typically from 5 to 10 mm.

2. After distraction of the main rail, distraction of the subtalar arm is performed until resistance is felt, and viewed under fluoroscopy. A calcaneal axial view should reveal a parallel posterior and middle facet, while the lateral view will demonstrate a reduction of Bohler's and Guissane's angles. Any "step offs" seen between fragments of the subtalar joint should reduce with distraction.



With reduction complete, percutanous placement of bone graft can be performed, if desired. At this point the main rail is then compressed to resistance. This achieves good compression between the two major fragments of the calcaneus (anterior and posterior), while stabilizing the construct against deforming forces. This stability can be tested by movement of the subtalar joint and ankle joint. No crepitation should be felt and motion should be almost equal to the contralateral limb.



POST-OPERATIVE MANAGEMENT

In uncomplicated cases ankle range of motion may begin one day after surgery. During the first post-operative visit (5 to 7 days) pins are cleaned, x-rays are taken if needed, subtalar range of motion is started, light compression dressings applied, and touchweight bearing may begin. The fixator is removed at 6 to 8 weeks depending on radiographic healing. Gradual weight bearing is started early on and full weight bearing occurs at about 8 weeks. The patient continues with physical therapy and mobilising exercises during the entire course of treatment until about 12 weeks.

Bibliography

Barnard L, Odegardd JK. Conservative approach in the treatment of fractures of the calcaneous. Journal of Bone and Joint Surgery, American Volume, 1955; 37-A, 1231-1236.

Benirschke SK, Kramer PA. Wound healing complications in closed and open calcaneal fractures. Journal of Orthopaedic Trauma, 2004; 18, 1-6.

Castelli F. The minimally invasive osteosynthesis of intra-articular calcaneous fractures: early results. Abs. to 7th EFORT CONGRESS, June 2005. P2-504.

Conn HR: The treatment of fractures of the os calcis. Journal of Bone and Joint Surgery American Volume, 1935; 17, 392-405.

Dooley P, Buckley R, Tough S, McCormack B, Pate G, Leighton R, Petrie D, Galpin B. Bilateral calcaneal fractures: operative versus nonoperative treatment. Foot and Ankle International, 2004; 2, 47-52.

Heffernan G, Khan F, Awan N, Riordain CO, Corrigan J. A comparison of outcome scores in os calcis fractures. Irish Journal of Medical Science, 2000; 169(2), 127-128.

Kenwright J.: Fractures of the calcaneum, Journal of Bone and Joint Surgery British Volume,1993; 75(2), 176-177.

Lim EV, Leung JP. Complications of intraarticular calcanear fractures. Clinical Orthopaedics and Related Researches, 2001; 391, 7-16.

Loucks C, Buckley R. Bohler's angle: correlation with outcome in displaced intra-articular calcaneal fractures. Journal of Orthopaedic Trauma, 1999; 8, 554-558.

Magnan B, Caudana R, Campacci A, Barzoi A, Molinaroli F, Zonta L, Martelli S. Follow-up clinico e radiografico mediante T.C. delle fratture di calcagno trattate con mini FEA. Chirurgia del piede, 1992; 16, 145-150.

Morrey BF, Wiedeman GP Jr. Complications and long-term results of ankle arthrodesis following trauma. Journal of Bone and Joint Surgery American Volume, 1980; 5, 777-784.

Nogarin L, Magnan B, Bragantini A, Rebeccato A, Montanari M, Schiavon R. Trattamento a cielo chiuso degli affossamenti talamici con mini-fissatori esterni. Fratture del calcagno. Progressi in medicina e chirurgia del piede. Bologna. Aulo Gaggi editore. 1994.

Paley D, Fischgrund J. Open reduction and circular external fixation of intraarticular calcaneal fractures. Clinical Orthopaedics and Related Researches,1993; 290, 125-131.

Pajenda G., Chatwami S., Loidl G., Osterman R., Vecsei V. Percutaneous screw fixation of the displaced calcaneal fractures. Book of Abstract SICOT/SIROT 2002, p 308.

Rammelt S, Zwipp H. Calcaneus fractures: facts, controversies and recent developments. Injury, 2004; 5, 443-461.

Sanders R. Hansen S.T. Jr, Mc Reynolds I.S. Trauma to the calcaneus and its tendon: fractures of the calcaneous. In: Jahss M.H.: Disorders of the foot and ankle. 2nd edition, Philadelphia, W.B. Saunders Co.,1991.

Talarico LM, Vito GR, Zyryanov SY. Management of displaced intraarticular displaced fractures by using external fixation, minimally invasive open reduction, and early weight-bearing. Journal of Foot and Ankle Surgery, 2004; 43(1), 43-50.

Thornes BS, Collins AL, Timlin M, Corrigan J. Outcome of calcaneal fractures treated operatively and non-operatively. The effect of litigation on outcomes. Irish Journal of Medical Science, 2002; 3, 155-157.

Yong Soo Choi, Ki Soo Kim. Minimally invasive open reduction and cross screws fixation for Sanders tipe II fractures of the calcaneous. Book of Abstract SICOT/SIROT 2002, p 2020.

Yong Soo Choi, Ki Soo Kim, Hyeon Gyu Boem. Biomechanical stability of cross screws fixation fixation for Sanders type II calcaneal fractures. Book of Abstract SICOT/SIROT 2002, p 2021.

Zwipp H, Tscherne H, Thermann H, Weber T. Osteosynthesis of displaced intraarticular fractures of the calcaneus. Results in 123 cases. Clinical Orthopaedics and Related Researches , 1993; 290, 76-86.

Manufactured by: ORTHOFIX Srl
Via Delle Nazioni 9
37012 Bussolengo (Verona)
Italy

Telephone +39-0456719000
Fax +39-0456719380

CE 0123

Your Distributor is:

Deformity Correction | Trauma | Pediatrics | Bone Growth Stimulation

www.orthofix.com

EF-0701-OPT-E0 C 08/10

ORTHOFIX®