Percutaneus Calcaneal Displacement Osteotomy

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19.1 Introduction

Calcaneal osteotomies are commonly performed procedures in the correction of compound deformities in the foot and ankle.[1] They have been utilized for over 100 years in foot surgery with their first introduction by Gleich in 1893.[1–11] Complications in the performance of the calcaneal osteotomy are rare.[3,6,11] Among the complications seen through the standard lateral approach of a calcaneal osteotomy are: wound dehiscence, sural nerve damage, sural neuritis, delayed union, non–union, infection, and invasion of the medial neurovascular structures.[3,6,9–11]

The Percutaneous Calcaneal Displacement Osteotmy approach has been developed to help avoid the complications commonly seen with the traditional standard open calcaneal osteotomy.[3,6,9–11] Wound dehiscence is a problem encountered when performing these osteotomies open. Large incisions on the lateral aspect of the foot can also cause fibrosis in the area that leads to painful nerve symptoms. When performing these osteotomies open, the surgeon must be cautious about exiting the medial aspect too aggressively due to the neurovascular structures that lie in this area.[10,12]

In an effort to avoid these complications, the percutaneous technique of performing the posterior calcaneal displacement osteotomy has been employed. This technique is performed through four small stab incisions to avoid the open osteotomy incision, which can be prone to dehiscence.[6,9] The technique is also unique in that it avoids major neurovascular structures if performed properly.

In the past 5 years, over 100 percutaneous calcaneal displacement osteotomies have been performed. There has been success in performing an effective calcaneal displacement osteotomy, avoiding wound problems, and avoiding invasion of neurovascular structures.

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N. Maffulli and M. Easley (eds.), *Minimally Invasive Surgery of the Foot and Ankle*,
DOI: 10.1007/978-1-84996-417-3_19, © Springer-Verlag London Limited 2011

19.2 Indications

Calcaneal valgus: The medial displacement osteotomy is presently described throughout foot and ankle literature for the treatment of the flexible flatfoot with good results reported in adults and children.[1,3–8,11,13–19,20,21] Flexible flatfoot is one of the most common orthopedic problems found in children.[18,19] Torosian et al. found that the medial slide calcaneal osteotomy is a simple and effective treatment for hindfoot valgus.[20] When valgus malalignment is detected, medializing the calcaneus provides satisfactory outcomes.[22] In advanced stages of the deformity the medial column may be affected and the need for tendon transfers or joint fusions are effective treatments when combined with the medial calcaneal displacement osteotomy.[22]

Posterior tibial tendon dysfunction: Posterior tibial tendon dysfunction is when the adult aquired flatfoot becomes evident with the heel in valgus position, the flattening of the medial longitudinal arch, and forefoot abduction.[15,17,23] Presently in the literature surgeons are using calcaneal osteotomies in the treatment of posterior tibial tendon dysfunction combined with various ancillary procedures.[3–6,13–18,22,24–33]

Without surgical intervention, the deformity is likely to progress to a fixed malformation.[33] Mann, and Myerson both describe a posterior calcaneal osteotomy in which the posterior aspect of the calcaneus is moved medially. This osteotomy is performed in conjunction with a flexor digitorum longus transfer in the treatment of patients with stage II posterior tibial tendon dysfunction. Both authors are reporting satisfactory results.[5,6,28–30]

Mann describes the foot as a tripod.[5,6] The three legs being – the first metatarsal head, the fifth metatarsal head, and the calcaneus. If too much heel valgus is present, as in the above mentioned indications, the tripod does not function properly and the medial aspect of the foot decreases in height. Performing the posterior medial calcaneal displacement osteotomy places the calcaneus back into its correct position.[5,6]

Loss of calcaneal height status post calcaneal fracture: Loss of hindfoot height or leg length is often times seen status post calcaneal fracture.[22] A posterior calcaneal osteotomy is an effective way of restoring the height of the hindfoot or leg.[22] The osteotomy is performed and the posterior aspect of the calcaneus is shifted plantarly to restore this height.[22]

Calcaneal Varus, and lateral ankle instability: The posterior calcaneal slide osteotomy is also reported in literature for correction of abnormal heel alignment that is rectus or varus.[22,34] The objective of the osteotomy is to reposition the Achilles tendon, plantar fascia and the bone which will reduce stress on the lateral ligaments. The tripod theory is once again applicable here.[34,35] The calcaneal displacement osteotomy can be manipulated and reduce abnormal stresses on the lateral aspect of the foot.[22]

The above mentioned deformities are the indications in which the open posterior calcaneal displacement osteotomy is used. These remain the same indications for the use of the percutaneous calcaneal displacement osteotomy. The percutaneous calcaneal displacement osteotomy can be performed on any patient that would benefit from the traditional open calcaneal displacement osteotomy. There are no contraindications to a percutaneous calcaneal displacement osteotomy versus an open calcaneal displacement osteotomy. The advantages are as follows: better cosmesis, low postoperative morbidity, absence of significant wound problems, less blood loss, minimize the risk for postoperative infection, faster rehabilitation and mobilization (if performed as an isolated procedure), decrease time of union, less stress to the local tissues, less trauma to the tissues and bone, and fewer neurovascular complications. This is probably because periosteal stripping is not necessary and the local circulation remains intact.

19.3 Considerations for Preoperative Planning

A thorough history and physical examination should be performed. This is necessary to evaluate the patients overall health and decide if the patient is the appropriate candidate to undergo reconstructive foot surgery. The examination should focus on vascular, neurological, dermatological and biomechanical function. If deficits are found they should be fully investigated.

Radiologic evaluation of the foot and ankle is very important in assessing the entire deformity. Routine views of the foot should include an anteriorposterior view, a medial oblique view and lateral view.[16,22,36,37] The anteriorposterior view allows one to evaluate loss of normal alignment of Kite's angle, the talus and first metatarsal, and the degree of subluxation of the talus and navicular.[38] The lateral radiograph demonstrates the calcaneal pitch.[38,39] A study was performed by Smith, Sima, and Reischl which deemed this a very reliable radiographic angle in the evaluation of flatfoot and cavus deformities.[38,39] Twenty to twenty–five degrees would be considered normal, less then 15° would been seen in a flatfoot, and greater then 30° in a cavus deformity.[38,39] One may also evaluate subluxation of the talonavicular and navicular cuneiform joints through lateral radiographs.[38] Ankle radiographs should be obtained as well, and should include anteriorposterior, lateral, and mortise views.[16,22] These views will allow for proper assessment of the ankle joint for degenerative processes and malalignment.[38] A long axial view should also be performed to quantify the amount of valgus or varus present.[38,40] Paley describes a method (modified from Salzman and El–Khoury's method, in which the alignment between the body of the calcaneus and the tibia are measured to assess the degree of varus or valgus deformity.[41]

Unless there is trauma all foot and ankle radiographs should be obtained weight bearing, with the knee straight, and comparative contralateral views should be taken.[16,22,36,38] The knee should be straight because deformities of the hind foot, and mid foot are frequently associated with a tight gastrocnemius.[22]

19.4 Surgical Technique

The equipment needed to perform the percutaneous calcaneal displacement osteotomy is minimal and includes: #15 blade, curved Kelly hemostat, straight hemostat, 12 in. flexible gigli saw, large cannulated cancellous screw set, and appropriate suture for closure. A fluoroscopy unit will be necessary to perform this osteotomy. We recommend a small fluoroscopy unit for its ease of use in the operating room.

This procedure is partly designed to limit, if not eliminate, neurovascular compromise when performing a calcaneal osteotomy. Greene et al. performed a study evaluating the medial neurovascular structures that crossed the site of the traditional open calcaneal displacement osteotomy.[10] In this study they found that an average of four neurovascular structures crossed each osteotomy site, most were branches of the Lateral Plantar Nerve and branches of the Posterior Tibial Artery.[10] The sensory branch of the Lateral plantar nerve crossed the osteotomy in 86% of the subjects studied.[10] Baxter's nerve (a distal branch of the Lateral Plantar Nerve) crossed in 95% of the specimens.[10] The Posterior tibial artery distributed from zero to three branches that crossed the osteotomy at variable intervals.[10] It is evident that there are a number of structures to be concerned with on the medial aspect of the foot when performing a calcaneal osteotomy. On the lateral aspect, the Sural nerve and its branches are in the vicinity of the calcaneal displacement osteotomy. The approach of this procedure is through four small stab incisions placed away from neurovascular structures, and the tunnels that are made when performing this procedure are deep to the neurovascular structures that come into play when performing the osteotomy.

The plantar aspect of the foot is also of concern. The origin of musculature, ligaments, and nerves all are in very close proximity to the exit site of the saw when performing this osteotomy. It is of the utmost importance to not violate these structures when exiting the plantar cortex whether performing the procedure open or percutaneously.

19.5 Procedure

The patient should be placed on the operating table in the supine position. Using a marking pen, mark out the four stab incision sites. Two on the lateral aspect of the heel, and two on the medial aspect of the heel. Palpate the plantar medial calcaneal tubercle, make a small mark along the lines of the proposed ostetomy approximately 5 mm distal to the tubercle. Palpate the posterior, superior aspect of the calcaneus medially. Make a skin mark following the skin lines posterior to the Posterior tibial nerve and anterior to the Achilles tendon. Direct your attention to the lateral aspect of the foot. Make the inferior mark along the lines of the proposed osteotomy and parallel with the medial inferior incision approximately 5 mm distal to the plantar lateral tubercle. Palpate the posterior superior aspect of the calcaneus laterally. Make a skin mark here following the skin lines. This mark is posterior to the course of the sural nerve and peroneal tendons, and anterior to the Achilles tendon (Fig. 19.1).

The first stab incision is made at the inferior medial calcaneal mark. Make a stab incision along the lines of the proposed osteotomy full thickness. Using a curved hemostat, bluntly deepen the incision down to the calcaneus. Next, with the curved end pointing toward the skin, create a tunnel toward the superior incision making sure that the tip of the hemostat is directly over the calcaneus as this blunt dissection is performed. The tunnel is made deep to the neurovascular structures. It is important to keep the tip of the hemostats against the calcaneus while tunneling superiorly. Once the superior medial landmark is reached, tent the skin and make a stab incision with in the resting skin line. The tip of the curved hemostat is then exited out the incision site. This is the site that the gigli saw will be introduced. Open the tip of the hemostat and clamp a 12 in. flexible gigli saw. Pull the hemostats inferiorly through the tunnel, and through the inferior incision. One loop of the gigli saw is now exiting the medial inferior incision. Unclamp the hemostat from the end of the gigli saw (Fig. 19.2).

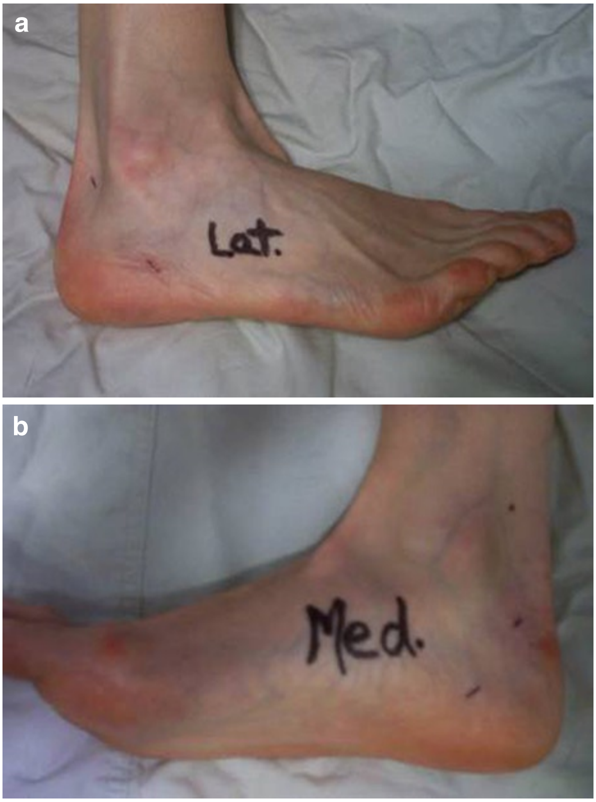

Fig. 19.1 (**a**) A lateral view of the foot with stab incisions for a percutaneous calcaneal displacement osteotomy marked. (**b**) A medial view of the foot with the stab incisions for the percutaneous calcaneal displacement osteotomy marked

Redirect your attention back to the superior medial incision. Using the straight hemostat bluntly tunnel across the superior aspect of the calcaneus. This tunnel is made anterior to the Achilles tendon and posterior to the posterior facet of the calcaneus in Kagers's triangle. Be sure to keep the hemostat on the superior aspect of the calcaneus while tunneling across. Tent the skin at the lateral superior skin mark and make a stab incision within the resting skin line. Remove the hemostat from the foot. Enter the straight hemostat through the superior lateral incision, follow the tunnel just made and exit the superior medial incision. Open the tips of the hemostat and place the free end of the gigli saw into the tip. Clamp down and pull the hemostat back through the tunnel. Exit the superior lateral incision pulling the end of the gigli saw through the incision (Fig. 19.3). Unclamp the hemostat.

Make the fourth stab incision at the lateral inferior incision mark along the lines of the proposed osteotomy. Bluntly deepen this incision down to the calcaneal body. Once again make a tunnel superiorly toward the superior incision being sure to keep the tip of the hemostat against the body of the calcaneus. This tunnel is deep to the neurovascular structures. Exit the superior incision on the lateral aspect and open the tip of the hemostat. Insert the loop of the gigli saw into the tip of the curved hemostat. Pull the hemostat back through the tunnel out the lateral inferior incision. Release the hemostat. Hook the gigli saw handles to the loops of the gigli saw on the medial and lateral aspects of the foot. Pull the gigli saw taught being sure not to kink the saw and to have equal amounts of the gigli saw

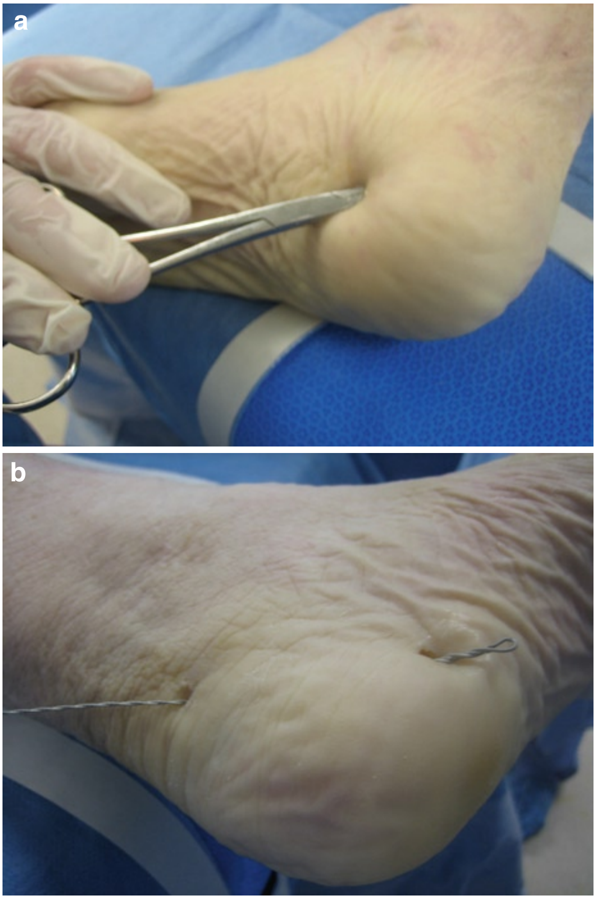

Fig. 19.2 (**a**) The first stab incision is made and deepened on the medial side down to the calcaneus to perform the medial tunnel for the gigli saw. (**b**) The gigli saw in place in the medial tunnel

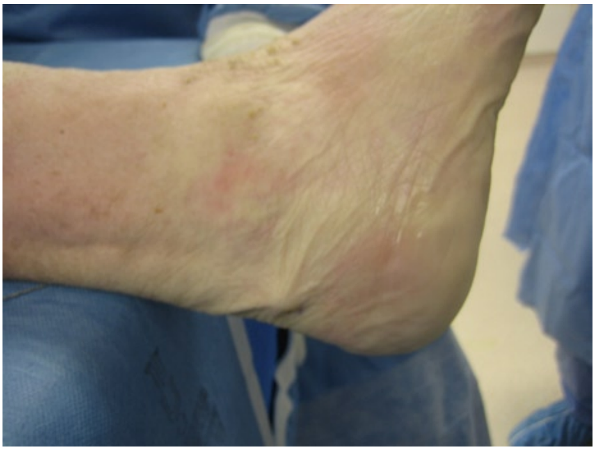

Fig. 19.3 The straight hemostat creates a tunnel in Kager's triangle and tents the skin before the superior lateral stab incision is made

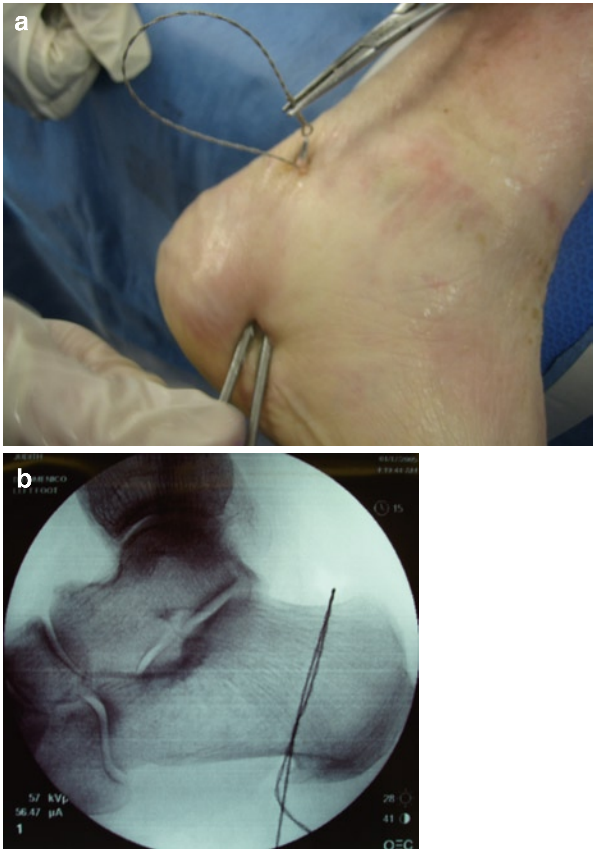

Fig. 19.4 (**a**) Lateral aspect of the foot, using the curved hemostat to grip the gigli saw and pull through the lateral tunnel. (**b**) Lateral view of the foot with fluoroscopy to view the placement of the gigli saw before performing the osteotomy

exiting each inferior incision. The gigli saw should now be taut to the calcaneus, deep to all neurovascular structures, across the superior aspect and along the medial and lateral body of the calcaneus (Fig. 19.4).

Using a mini fluoroscopy unit, take a lateral view of the foot. This will ensure proper placement of the saw. Check to be sure there are no kinks in the saw and that the saw is in the desired placement. It is now time to perform the osteotomy. The placement of the incisions ensures that the osteotomy is performed in the proper plane, which should be inclined posteriorly at 45° to the plantar surface of the rear foot.[4] Grip the gigli saw handles and perform the osteotomy. Your assistant needs stabilize the lower leg, dorsiflex the foot, to tighten the plantar fascia, and Achilles tendon to lock the osteotomy in place.via dynamic stabilization. As the saw advances through the calcaneus the surgeon should widen his/ her arms to avoid harming the skin as the cut is made. As the surgeon advances toward the plantar aspect of the calcaneus extreme care should be taken to not exit the calcaneus forcefully and violate the vital plantar structures. If necessary another lateral view can be taken as the plantar cortex is approached. Once the osteotomy is completed cut one end of the gigli saw to the incision line. Pull the opposite end of the saw out of the foot (Fig. 19.5).

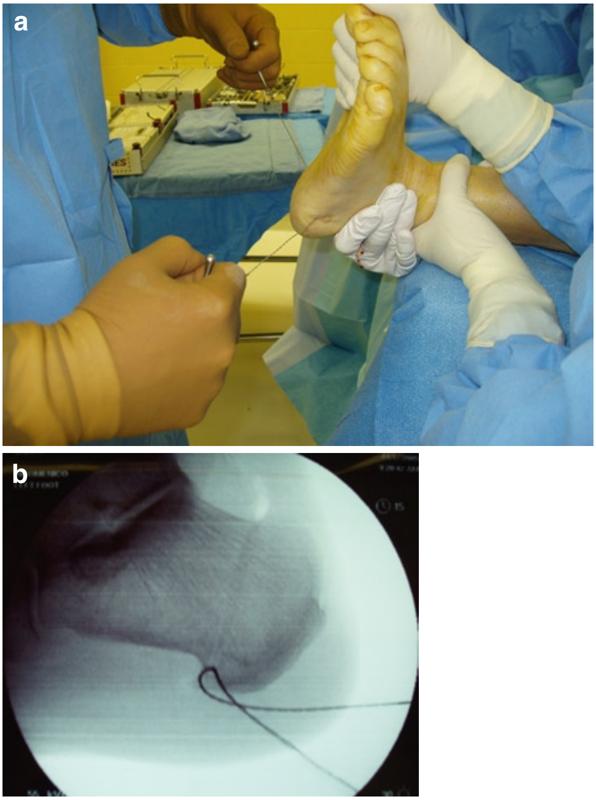

Fig. 19.5 (**a**) Performing the percutaneous calcaneal displacement osteotomy, note the surgeons arms are spread to not harm the skin of the inferior incisions with the gigli saw. (**b**) A fluoroscopic view of the foot after the osteotomy is made

Now displace the free posterior calcaneus to the desired plane of correction. As you displace the osteotomy your assistant should plantarflex the foot. This will loosen the plantar fascia, and Achilles tendon to allow one to manipulate the posterior aspect of the calcaneus into the desired position with very little resistance. Once in desired position dorsiflex the foot to tighten the plantar fascia, and Achilles tendon to lock the osteotomy in place via dynamic stabilization. Next drive two guide wires perpendicular to the osteotomy site, from the large cannulated cancellous screw set, through the plantar posterior aspect of the foot. Using fluoroscopy check the wire placement with a lateral, calcaneal axial and anteriorposterior view. The surgeon should try to purchase the sub cortical bone just inferior to the posterior calcaneal facet. This bone allows for strong screw purchase. Once the desired placement is achieved make two stab incisions at the entrance site of the wires. Deepen the incisions down to the calcaneus. Measure and drive two cannulated cancellous screws. Once again check the screw position with fluoroscopy using lateral, calcaneal axial and anteriorposterior views (Fig. 19.6). It is very important not to violate the posterior facet of the calcaneus. Close all incisions.

Postoperative management is 2 weeks in a below the knee posterior splint non–weight bearing. Ancillary procedures will dictate the course of postoperative management. If the osteotomy was performed as an isolated procedure, the first postoperative visit the patient can be placed in a cast boot, partial weight–bearing, for 4 more weeks. Physical therapy is recommended after 6 weeks to strengthen the musculature.

Fig. 19.6 An interoperative fluoroscopic view of the foot with the posterior aspect of the calcaneus in the desired position after the osteotomy is performed

19.6 Pitfalls and Bailouts

Intraoperative complications while performing this procedure are few. If the gigli saw used is not flexible enough the surgeon may encounter kinks in the saw. We recommend the use of the Depuy 12 in. gigli saw due to it's flexibility. It is also recommended to have a ¼ inch straight osteotome present. This can be used to pry the osteotomy apart and/or complete the osteotomy if any difficulties are encountered when trying to manipulate the posterior aspect of the osteotomy.

For the surgeon who is not experienced in this particular procedure two guide wires can be placed in the calcaneus as an osteotomy guide. This is not necessary but can be helpful in guiding the surgeon through the osteotomy. The guide wires are placed along the lines of the desired osteotomy.

If the assistant is not holding the leg and foot very stable, it is possible the gigli saw can get stuck in the bone partially through the osteotomy. If this occurs, cut one end of the gigli saw close to the skin and pull out the other end. At this time use the same incisions and insert a new gigi saw within the tunnels. Be sure to have the assistant dorsiflex the toes/foot and stabilize the leg very well.

To date the percutaneous calcaneal displacement osteotomy has not encountered much difficulty in which an open procedure was needed. If any problem should occur, this can easily be converted to an open procedure by connecting the lateral incisions to produce the traditional incision for the open calcaneal displacement osteotomy.

19.7 Outcomes

In the evaluation of over 100 percutaneous calcaneal displacement osteotomies one of the most prevalent complication encountered with the technique was painful fixation. In the patients who encountered this complication all of them had the fixation removed and all of the patients' pain associated with the fixation were relieved.

Four of the patients that underwent the procedure had neuritis complaints on the lateral aspect of the foot. In all of these cases these were transient symptoms that resolved in 10–12 weeks time. Ancillary procedures were performed with the osteotomy on all of these patients. Our theory is that neuritis symptoms may be due to the ancillary procedures, in particular the gastrocnemius recession, or post–operative swelling. There was one case of skin irritation in a patient in which there was a prominent lateral shelf of calcaneus as a direct result of the osteotomy causing the skin irritation. This patient was revised by taken back to surgery to correct this problem by resecting the prominent bone. The patient's symptoms resolved following this procedure.

These results suggest that the low complication rate indicates that this procedure is an effective alternative to the traditional open calcaneal displacement osteotomy.

A cadaver lab was performed by the authors in which the osteotomy was performed on five specimens (Fig. 19.7). The neurovascular structures were dissected out on all of the specimens after performance of the osteotomy. There was no evidence of neurovascular injury to any of the specimens.

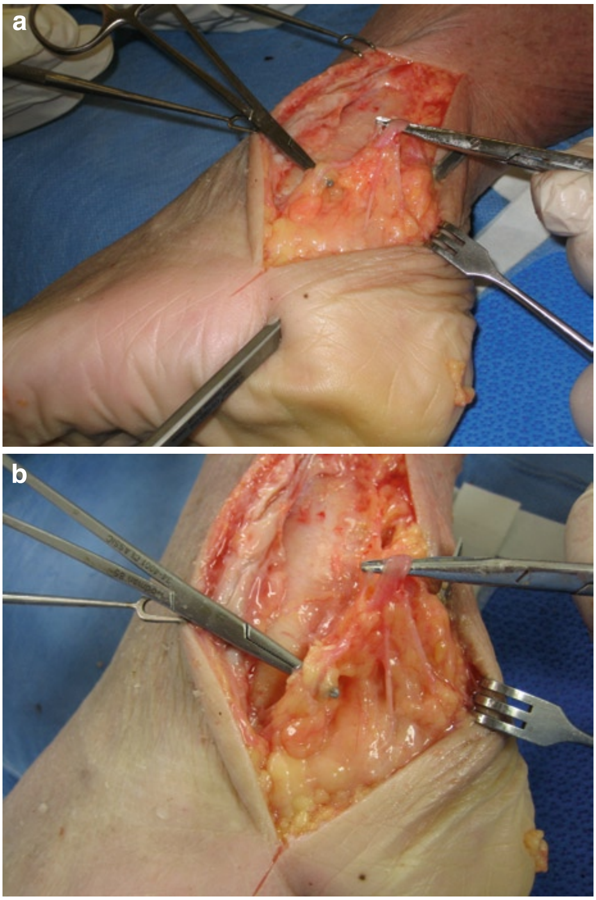

Fig. 19.7 A cadaveric study was performed to view the medial and lateral neurovascular structures following the percutaneous calcaneal displacement osteotomy. Note the intact neuro–vascular structures

To date no study has been performed on biomechanical outcome or pain relief after the performance of the percutaneous calcaneal displacement osteotomy. The literature is full of good results of posterior displacement osteotomies. This osteotomy parallels the correction of the open posterior displacement osteotomy and yields the same outcomes as far as biomechanical correction and pain relief (Figs. 19.8 and 19.9).

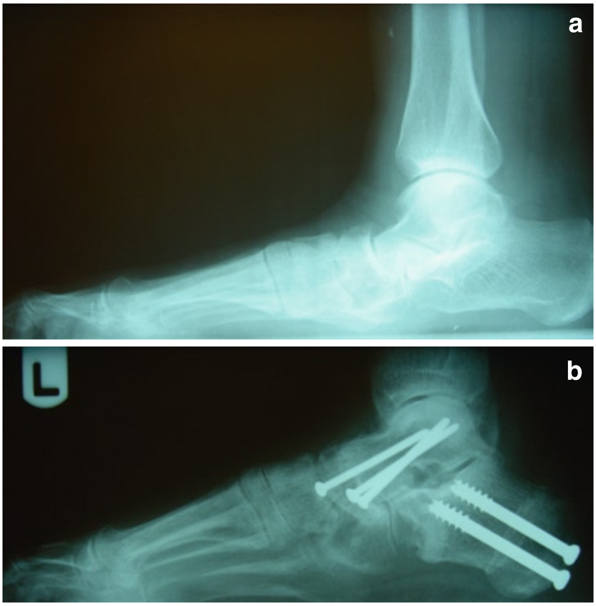

Fig. 19.8 (**a**) Pre operative percutaneous calcaneal displacement osteotomy. (**b**) Post operative percutaneous calcaneal osteotomy

Fig. 19.9 (**a**) Pre operative lateral radiograph of a pediatric flatfoot deformity (**b**) Intraoperative lateral view demonstrating a Percutaneous Calcaneal Displacement Osteotomy utilizing a gigli saw (**c**) Post operative lateral view Percutaneous Displacement Calcaneal Osteotomy

19.8 Summary

Calcaneal osteotomies have and will remain a vital part in the surgical treatment of compound hind foot deformities. The percutaneous calcaneal displacement osteotomy is a very effective way of reducing hind foot deformities and avoiding post–operative complications.

Indications:

- Hind foot valgus
- Posterior Tibial Tendon Dysfunction
- Hind foot Varus
- Lateral ankle instability
- Status post calcaneal fracture

Complications:

- Infection
- Painful fixation
- Neuritis
- Prominent bone on side that posterior calcaneus is displaced

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