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Arthroscopic Ankle and Subtalar Arthrodesis – Indications and Surgical Technique

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Additional information is available at the end of the chapter

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1. Introduction

The history of arthroscopy begins in 1918 when Takagi performed a knee arthroscopy in a cadaver. Due to its narrow joint space, the ankle joint was not considered suitable for arthroscopy in those days. Despite this, in 1939, Takagi described an arthroscopic technique for the ankle joint in a Japanese Orthopaedic Association Journal (Takagi 1939). Watanabe describes in 1972 the anteromedial, anterolateral and posterior portals to the ankle joint. (Watanabe, 1972). In the last few years, thanks to the development of arthroscopic instruments for small joints, and the description of new arthroscopic techniques, ankle and foot arthroscopy have developed significantly (Andrews et al., 1985; Drez et al., 1981; Ferkel, 1996; Gollehon & Drez, 1983; Johnson, 1981; Ogilvie-Harris DJ et al., 1997; Parisien & Vangsness, 1985; Tol & van Dijk, 2004; van Dijk & Scholte, 1997).

Use of minimally invasive techniques leads to less postoperative pain, lower infection and complication rate and a shorter hospital stay. (Cannon, 2004; Ferkel & Hewitt, 2004; Glick et al., 1996; Golanó et al., 2006; Lui, 2007; Myerson & Quill, 1991).

Degenerative osteoarthritis of the ankle is a common pathology. It is generally associated with traumatic events in the ankle joint, but can also be found in rheumatic patients, infectious processes, osteochondritis, talar necrosis and neurological conditions.

As trauma is the leading cause of this condition it affects younger patients and should be able to ensure a near complete resolution and return to activity.

Arthroscopic instruments and techniques have improved significantly over the last few years, and arthroscopic surgery is now widely used in the ankle joint. It has proven to be a

useful tool to diagnose unknown lesions within the arthritic ankle and an efficient therapeutic option to avoid its progression. In our opinion it is a superior alternative to open surgery and it is our first choice technique for both ankle and /or subtalar arthrodesis.

2. Diagnosis of ankle arthritis and preoperative Planning

A complete clinical history and a thorough clinical examination are vital to establish an accurate diagnosis so the correct treatment is indicated. X-rays, CT scan and MRI scan are very useful tools and provide additional information for operative planning.

2.1. Patient assessment

Take into consideration any history of trauma, the nature of the pain, any movements that induce it, whether other joints are involved and record the ankle ROM. Carry out a thorough clinical examination. Consider associated pathologies like rheumatic diseases, gout, diabetes and its relation with Charcot arthropathy or other less common conditions like hemochromatosis.

A complete neurovascular assessment of the limb should be done preoperatively. A note should also be made of the patient's expectations from the surgery

2.2. Imaging

Weight bearing plain x-rays of the ankle joint provides very useful information. AP, lateral and mortice projections should routinely be taken. A foot X-ray can be very useful to evaluate hind-foot axis and varus /valgus deformities for preoperative planning purposes.

MRI scan is useful to visualize chondral lesions, bone necrosis, and ligamentous injuries.

Technetium Bone Scintigraphy is very helpful to evaluate subtalar joint involvement.

2.3. Surgical indications and contraindications

Ankle, subtalar or double arthrodesis is indicated in cases of painful ankle, subtalar or combined degenerative osteoarthritis, which has not responded to other conservative measures (analgesics, NSAIDs, steroid injections, physiotherapy, and adequate shoe-wear). The most common indications include posttraumatic arthritis, Rheumatoid arthritis, Sero negative arthritis and Charcot's arthropathy.

The listed contraindications are well known (Table 1). Joint infection, neuropathic conditions and talar necrosis are absolute contraindications.

Axial varus/ valgus deformities $>15-20^\circ$ and anterior tibial shift are relative contraindications. These deformities can be corrected if a wide joint release is associated and is not regarded as a contraindication nowadays.

CONTRAINDICATIONS

ABSOLUTE:

- ACTIVE INFECTION
- ACTIVE CHARCOT ARTHROPATHY
- TALAR NECROSIS
- SIGNIFICANT BONE LOSS

RELATIVE:

- SMOKER
- VARUS/VALGUS $\geq 15\text{-}20^\circ$

ANTERIOR TIBIAL SHIFT

Table 1. Ankle arthrodesis contraindications.

3. Method of treatment

In this chapter we intend to describe our method of arthroscopic ankle and subtalar arthrodesis. There are various techniques and their variants described previously in literature. However the basic principles of most remains the same. Majority of the patients are referred to our Arthroscopy Unit with painful arthritic ankles that have not responded to conservative treatment (physiotherapy, NSAIDs). Trauma was the underlying cause leading to painful arthritic joint. A 20 years old female was the youngest patient who underwent the procedure under our care.

In all cases, a diagnostic protocol was completed. This included a complete clinical history, laboratory tests (FBC, ESR, CRP); imaging (X-rays, CT and MRI scans), bone scintigraphy (Tc, Ga); and, occasionally, an ultrasound of the tibialis posterior and Achilles tendons. In some cases bone scintigraphy and CT scans are repeated after a period of 6-12 months to assess subtalar joint involvement.

3.1. Surgical procedure

The anaesthetist determines the appropriate anaesthetic technique: spinal anaesthesia, general anaesthesia or a combination of both. In some cases a popliteal catheter is associated to provide better postoperative pain control.

The patient lies supine on a conventional surgical table in cases of isolated ankle arthrodesis (Figure 1); in prone position if an isolated subtalar arthrodesis is to be done (Figure 2) and in lateral and posterior supine position if both ankle and subtalar arthrodesis are planned (Figure 3).

Joint distraction is required only in a minority of cases (Figure 1).

The procedure typically lasted between 90 and 100 minutes

3.2. Specific surgical procedures

3.2.1. Ankle arthrodesis

The patient lies in supine position with the affected limb on a leg support in slight abduction. If traction was needed, an external device is attached to the surgeon's waist or a stirrup (Smith and Nephew) is used (Figure 1).

The use of tourniquet and limb axanguination is optional. In our Hospital it is routinely used at the beginning of the arthroscopic procedure and is released after the joint has been reduced and fixed.

The extremity is draped above the knee joint to allow a complete visualization of the leg.

Prior to the incision we recommend identifying and marking the anatomical landmarks of the ankle, specifically: both maleoli, the joint line and the Tibialis Anterior tendon on the medial side, the Peroneus Tertius tendon and the Superficial Peroneal nerve on the lateral side. Superficial Peroneal nerve is palpated like a cord on the lateral aspect of the ankle with the foot in plantar flexion and supination.

Portals: We favour the antero-lateral and the antero-medial arthroscopic portals and follow the standard technique as described by Glick and Morgan. (Glick and Morgan, 1996). After injecting 10-15 cc of saline into the joint, the scope is introduced through the antero-medial portal (medial to the sheath of the Tibialis Anterior tendon, with the ankle in dorsal flexion in order to release the capsule). An incision is made with an no° 15 blade and the capsular incision is dilated with a mosquito. A 30 degree 4,5 mm arthroscope is then introduced into the joint. Using a 21 G needle, the lateral portal is defined. This is located lateral to the Extensor Digitorum tendons and 5 to 10 mm lateral to the Superficial Peroneal Nerve.

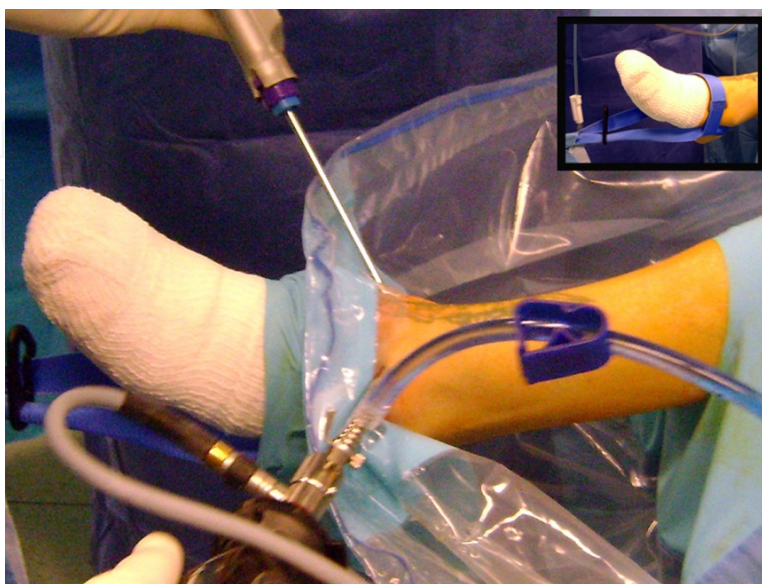


Figure 1. Surgical view of a left ankle arthrodesis in supine position. Triangulation detail and stirrup traction device.



Figure 2. Anatomical landmarks used for left foot subtalar arthrodesis in prone position. Trans-illumination detail.



Figure 3. Anatomical landmarks marking before a right ankle and subtalar combined arthrodesis usually done in lateral position. Inset: Use of trans-illumination to define the accessory portal.

Table 2 relates the anterior portals to the ankle joint and the main anatomical structures at risk. Their anatomical relationship is shown in Figure 4.

Anatomical relations. Anterior approach to the ankle joint		
PORTAL	RELATIONS	STRUCTURES AT RISK
Anterolateral	Lateral to peroneus tertius tendon	Extensor digitorum Superficial Peroneal Nerve Peroneus Tertius
Anteromedial	Medial to tibialis anterior tendón	Tibialis anterior tendon Extensor hallucis longus Saphenous vein and nerve
Anterior	Between extensor digitorum tendons	Extensor digitorum Dorsalis pedis artery Branches of the superficial and Deep peroneal nerve
Medial Joint line	Between Extensor Hallucis Longus and Tibialis Anterior	Tibialis Anterior tendon Superficial and Deep Peroneal Nerves Dorsalis pedis artery Extensor Hallucis Longus

Table 2. Anatomical relations between the anterior portals to the ankle joint. The main anatomical structures at risk.

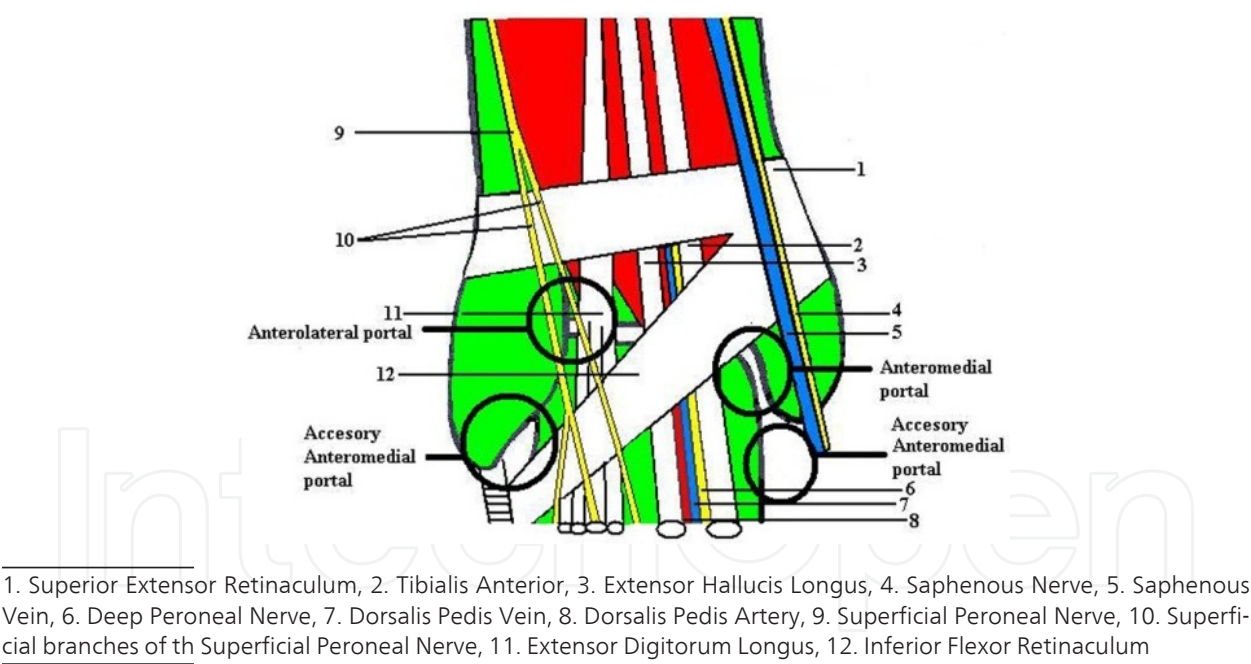


Figure 4. Illustration showing the anterior arthroscopic portals to the ankle joint and their anatomical relations with surrounding structures (Right ankle, anterior view).

The soft tissues are then debrided with a powered blade at 10.000 rpm. Once the articular surface is visualized, we proceed to shave it with a curette or with a 4mm powered bur. A small retractor can be used to better visualize the posterior joint and the lateral gutters (Figure 5). As the bone is being removed, access becomes easier and traction can be released.

3.2.1.1. Correction of severe deformities

We strongly recommend a thorough debridement of the lateral gutters. This allows a good view of the capsular insertions (Figure 6).

In cases of severe valgus /varus deformities, the capsule should be widely released to allow free mobilization and opposition of the joint surfaces in order to achieve a correct anatomical alignment. Figure 7 shows a case of severe deformity where the anterior tibial shift is corrected.



Figure 5. Surgical instruments needed. Different sized curettes and a small bivalved retractor that can be introduced through an extended arthroscopic portal.

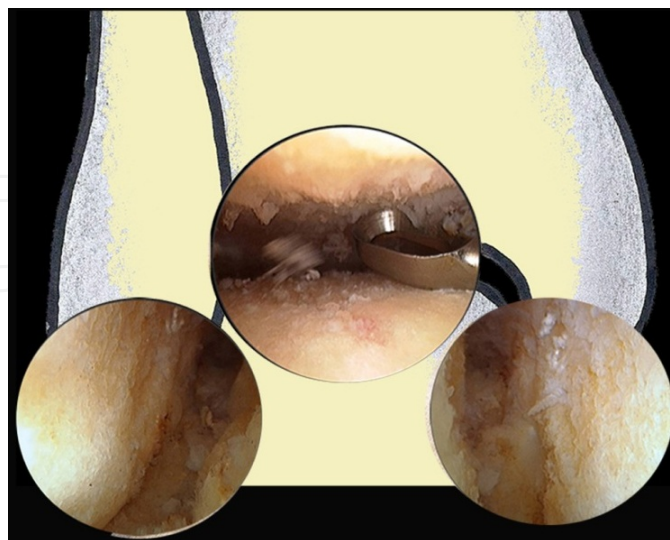


Figure 6. Photo composition of an ankle arthrodesis. Several aspects of the surgical debridement and release of the gutters in order to visualize the capsular insertion that has to be resected in cases of severe deformity.

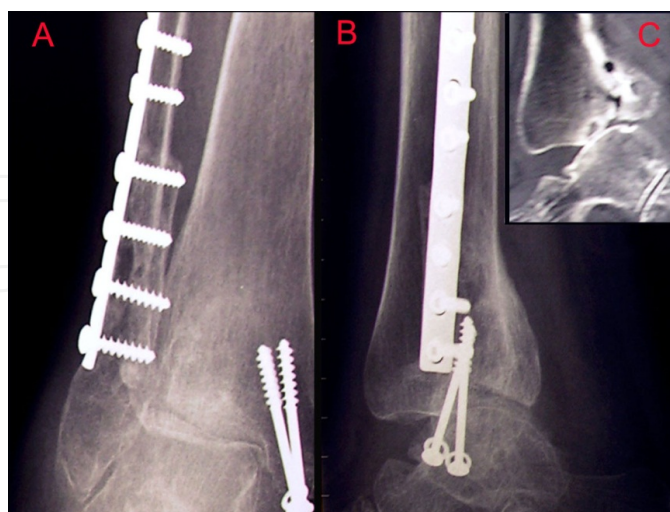


Figure 7. Gross ankle deformity (anterior tibial shift) following an old fracture dislocation of the ankle that had been operated in the past. AP and lateral X-rays.- CT scan detail.

If the articular surfaces were sclerotic, perforations should be made to create a bleeding bed. Exceptionally, a bone graft may be needed to fill bone defects and achieve a better joint congruency (Figure 8).

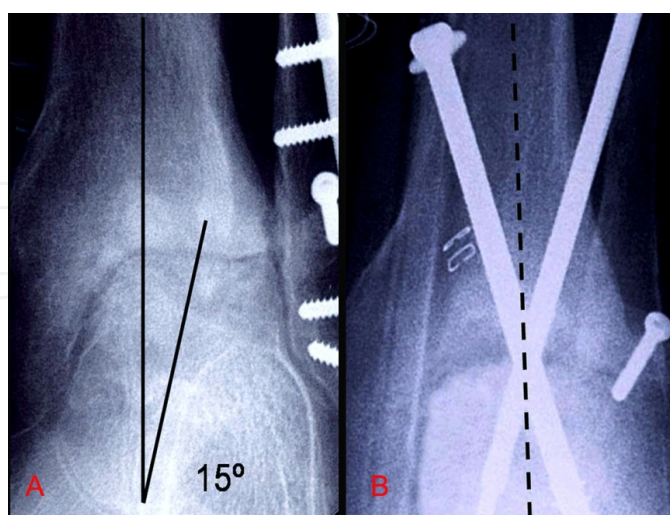


Figure 8. AP X-ray showing severe axial deformity in 15° of varus in an old fracture dislocation of a right ankle that had been operated in the past. Right. Intraoperative control previous to the introduction of the second screw. Notice the axial correction and the placement of a bone graft in the medial side to improve joint congruency.

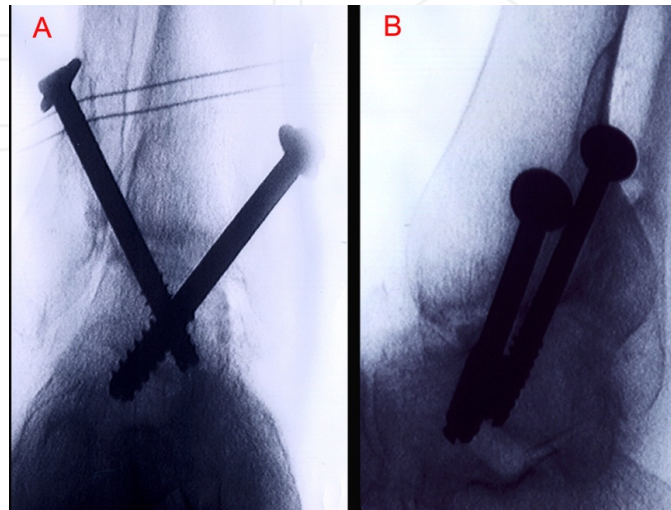


Figure 9. Intraoperative AP and lateral X-ray control showing correction of the anterior tibial shift of figure 7 case.

3.2.1.2. Correction control

Visual and radiological checks of the ankle axis are done with the leg in extension after debriding the articular surfaces and before inserting the screws (Figures 8, 9).

The ankle should be fixed in neutral dorsiflexion, 0-5° of valgus, 5-10° of external rotation (or similar to the contralateral ankle) with a slight posterior talar tilt. Shortening should be avoided or kept to a minimum

3.2.1.3. Fixation

Once the joint surfaces are congruent and the axis of the ankle joint is correct, 2 Kirschner wires are introduced as described by Glick and Morgan (Glick and Morgan, 1996). The first wire is introduced anterolaterally 5 cm above the joint line. It should be angled 10-20 ° to target the posterior half of the talus. Care should be taken not to damage the Sural Nerve or the Peroneus Superficialis tendon.

The second wire is introduced postero-medially and anterior to the Tibialis Posterior tendon.

In order to improve stability, it should be directed in an X-crossed shape from the postero-medial aspect of the tibia towards the antero-central area of the talar dome (Figure 10).

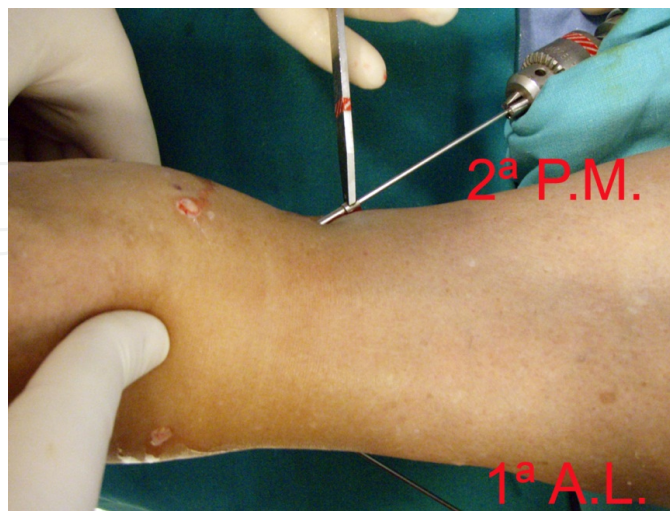


Figure 10. X-ray guided ankle arthrodesis fixation with 2 Kirschner wires. The first one introduced anteromedially 5 cm above the joint line, angled 10-20° posteriorly. The second wire posteromedially and directed anterior to the Tibialis Anterior sheath.

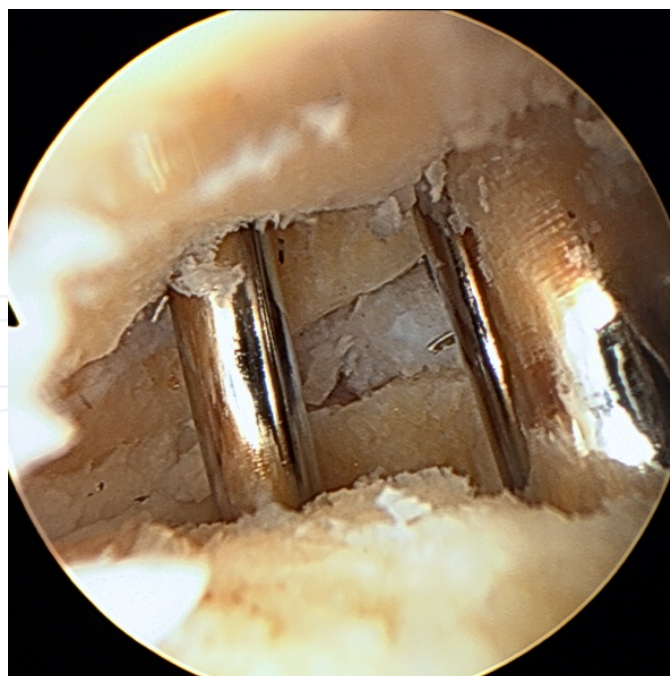


Figure 11. Arthroscopic control to assess the guide wires is correctly positioned to avoid screw contact.



Figure 12. X-ray showing consolidation of an ankle arthrodesis despite screw interposition.



Figure 13. Delayed consolidation 6 months after ankle arthrodesis. Using 6,5 mm conventional cannulated screws.

We recommend visualizing the guide wires position through the arthroscope to avoid the screws interfering with each other (Figure 11). In the case shown in Figure 12, the lateral screw got blocked with the medial one. Despite our efforts to introduce it further or to withdraw the screw, this was not possible. The screw was left and the arthrodesis consolidated successfully.

Definitive fixation is achieved with 2 cannulated screws creating compression independently as described by Glick and Morgan. (Glick and Morgan, 1996). Originally we used 6,5 mm screws, but after having a few cases of delayed consolidation (Figure 13), we now use Acutrak (Acumed®), size 6/7 screws.

At the end of the procedure, AP and lateral X-rays should be taken (Figure 9).

3.2.1.4. Postoperative protocol

The leg is immobilized in a well padded plaster backslab that is removed after two weeks together with the stitches. A plaster boot is then applied allowing partial weight bearing. Some studies allow full weight bearing after 2 weeks (Cannon, 2004).

Control X-rays are taken at 6-8 weeks to assess bone consolidation.

If the X-rays are not conclusive, a CT scan may be useful.

At 10 weeks free full weight bearing is allowed.

A course of 4 to 4 weeks of Physiotherapy may be beneficial to gain proprioception, particularly in older patients.

It is recommended to use MBT shoes.



Figure 14. Photo composition of a subtalar arthrodesis of a left ankle. The patient lies prone with the ankle out of the table resting on a roll. The contralateral leg is positioned in abduction. The anatomical landmarks are highlighted. Both malleoli, the Achilles Tendon and the axis of the first ray are marked.

3.2.2. Subtalar arthrodesis

The posterior arthroscopic ankle approach was described as subtalar approach in 1985 by Parisien and Vangness. (Parisien & Vangness, 1985). In 2000 Van Dijk described the two posterior ankle portals (van Dijk et al., 2000; van Dijk, 2006). Pérez- Carro suggested the subtalar approach with the patient set in prone position (Pérez-Carro et al., 2007).

The patient is positioned prone with one third of the ankle set off the table. This rests on a sand roll so the ankle is elevated in order to allow dorsiflexion and better access to the subtalar joint. The contralateral leg is kept in abduction (Figure 14).

Both maleoli and the Achilles tendon are marked with a pen. An incision is made just above the medial maleolus 3mm medial to the Achilles tendon. After dilating the portal with a mosquito, a 4, 5 mm arthroscope is introduced with a 30° lens, directed towards the first space (Figure 15).

With the arthroscope resting on bone, the antero medial portal is made. We use the touch and slide technique to get oriented with the motorized cutter (Figure 16).

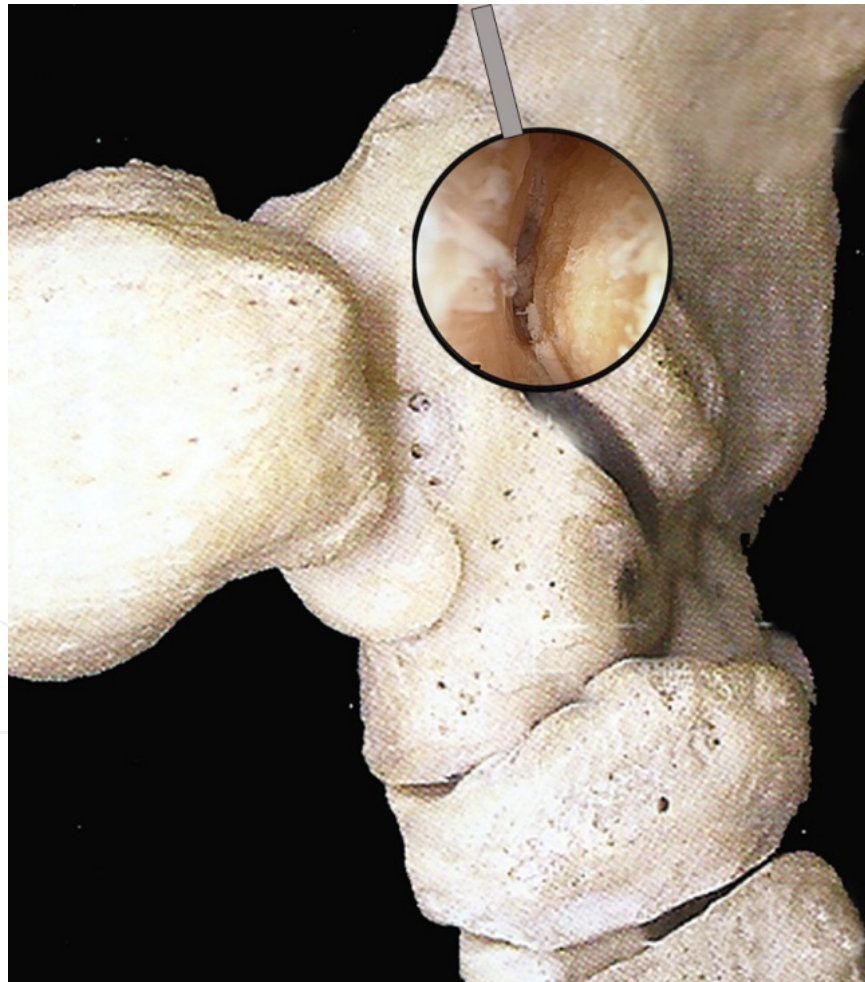


Figure 15. An incision is made lateral to the Achilles T and the arthroscope is introduced towards the 1st space.

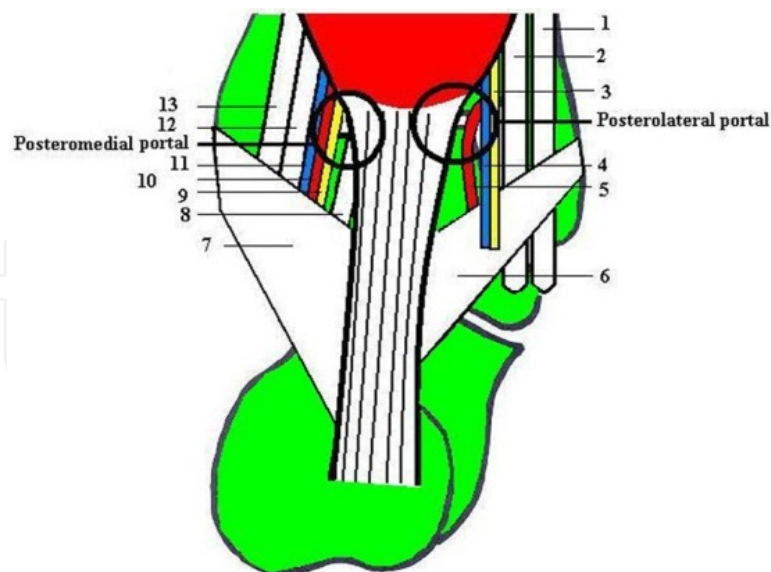


Figure 16. Orientation technique resting the shaver on top of the arthroscope and sliding it until visual contact is made.

Anatomical relations. Posterior approach to the ankle joint		
PORTAL	RELATIONS	STRUCTURES AT RISK
POSTEROLATERAL	Lateral to the Achilles tendon	Sural Nerve Lesser saphenous vein
POSTEROMEDIAL	Medial to the Achilles Tendon	Tibialis Posterior artery Tibial nerve and Calcaneal branches Flexor hallucis longus tendon Flexor digitorum longus

Table 3. Anatomical relations between the posterior portals to the ankle joint and the main anatomical structures at risk.

Table 3 relates the anterior portals to the ankle joint and the main anatomical structures at risk. Their anatomical relationship is shown in Figure 17



1. Peroneus Longus, 2. Peroneus Brevis, 3. Sural Nerve, 4. Lesser Saphenous Vein, 5. Peroneal Artery, 6. Peroneal Retinaculum, 7. Flexor Retinaculum, 8. Flexor Hallucis Longus, 9. Tibialis Posterior Nerve, 10. Tibialis Posterior Artery, 11. Tibialis Posterior Vein, 12. Flexor Digitorum Longus, 13. Tibialis Posterior

Figure 17. Illustration showing the posterior arthroscopic portals to the ankle joint and their anatomical relations (Right ankle, posterior view).

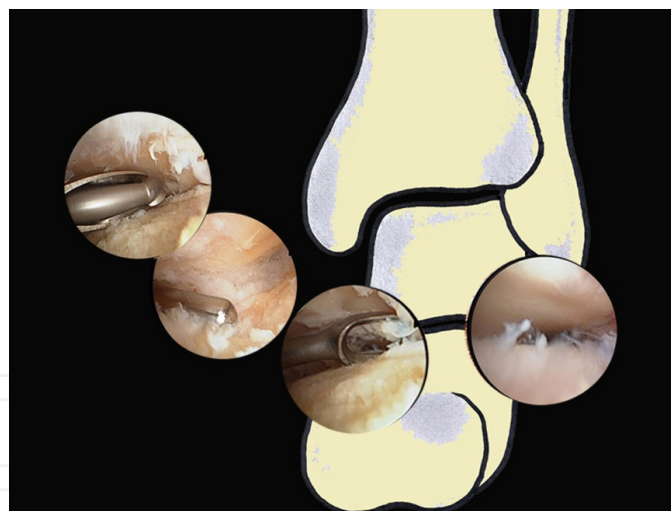


Figure 18. Photo composition of a subtalar arthrodesis. Initial visualization and arthroscopic debridement.

The Flexor Hallucis Longus tendon should be identified. The neurovascular bundle lies medial to it. If the tendon is found to be compressed either by osteophytes or by soft tissue adhesions, the flexor retinaculum should be released and a synovectomy should be carried out.

The soft tissues are debrided with a powered synovial blade at 1200 rpm until the subtalar joint space is well defined. The articular surfaces are then roughened with curettes or a motorized 4 mm burr until the posterior facet of the talus is well visualized (Figure 18).

With a lateral ankle x-ray, the subtalar articular surfaces and the hindfoot position are checked before proceeding with the fixation.

Figure 19 shows the surgical field during a subtalar arthrodesis.

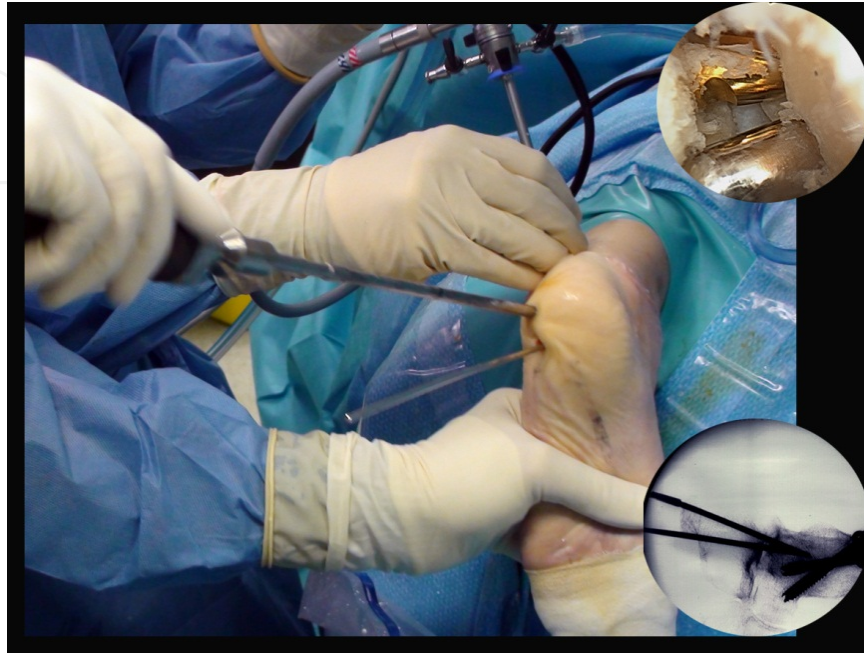


Figure 19. Subtalar arthrodesis of a left foot in prone position. Arthroscopic control (right upper corner). X-ray control (right inferior corner).

3.2.2.1. Correction control

Visual and radiological checks of the ankle axis should be carried out with the joint at 90° flexion during the procedure and before completing the screw insertion

3.2.2.2. Fixation

2 temporary Kirschner wires are introduced in neutral position from the postero-medial aspect of the calcaneum. A check X-ray should be taken. If the position is satisfactory, we proceed with the fixation using two size 6/7 Acutrak (Acumed) cannulated screws (Figure 20).

3.2.2.3. Postoperative recommendations

A compressive bandage is applied and early ankle movements are encouraged.

During the first 6 weeks partial weight bearing is allowed in a Walker type orthosis.

Full weight bearing is allowed when X-rays show the posterior facets are consolidated and the patient is pain free.

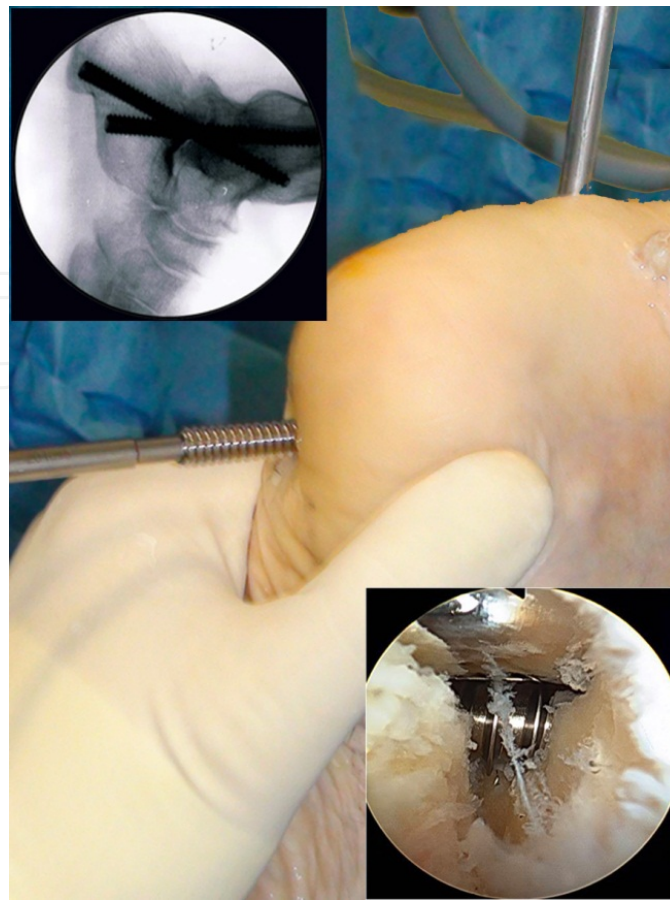


Figure 20. Screw insertion of subtalar arthrodesis of a left foot in prone position: X-ray control (left upper corner); arthroscopic control (right inferior corner).

3.2.3. Combined ankle and subtalar arthrodesis

Combined ankle and subtalar arthrodesis can be done focusing on each separate joint at a time during the same surgical procedure (Lui, 2007). In this case, the patient is initially positioned prone (Figure 3), and is then changed to the lateral position (Figure 21).

The use of the tibio-talo-calcaneal nail (Boer et al., 2007; Gagneux et al., 1997; Hammett et al., 2005; Jehan et al., 2011; Mendicino et al., 2004; Pelton et al., 2006) allows approaching the subtalar joint through an extended lateral approach over the sinus tarsi (Figure 3) using the lateral portals as described by Parisien (Parisien & Vangsness, 1985).

The approach to the ankle and to the subtalar joint can be done either arthroscopically or via a mini opening assisted with X-ray control. In both cases the patient is initially positioned prone and then changed to the lateral position when approaching the subtalar joint.

In some cases, i.e. rheumatoid patients, where no major axial corrections need to be made and the joints are severely affected, the reaming done during the intramedullary nailing procedure may provide enough bone graft and burring the subtalar joint may not be needed.



Figure 21. X-ray showing consolidated ankle and subtalar arthrodesis that were done separately.

3.2.3.1. *Surgical recommendations*

In cases of tibio-talo-calcaneal arthrodesis, we use the Trigen HFN (hind foot nail), Smith & Nephew (Figure 22). This offers the possibility of introducing longitudinally an extra screw incorporating the calcaneocuboid joint.

The most important step in this technique is positioning of the guide wire in the centre of the tibia. The entry point in the plantar aspect of the foot should rather be more medial than lateral and should be assisted with X- ray control. If the position of the guide wire is not correct, a second guide wire can be introduced through the additional holes provided in the entry positioning tool.

Relevant points for a correct indication and successful surgery are summarized in Table 4.

4. Clinical evidence

We have revised retrospectively 62 cases of ankle arthrodesis operated between 1997 and 2007 in our University Hospital. 50 cases were done by conventional open surgery and the remaining 12 were done arthroscopically.

Ankle arthroscopy offers a lower morbidity and infection rate. It provides a much better visualization and access to the lateral gutters, which allows a wider capsular release that facilitates mobilization of the joint surfaces in cases of severe axial deformities or anterior tibial shift.

TIPS FOR THE SURGERY

- Diagnostic Local anesthetic injections in the tibial and subtalar joint to identify the source of pain
- Rule out a fixed hindfoot deformity that may need a different type of surgery
- Beware of the Superficial peroneal Nerve laterally
- The patient position should allow good access to the Image Intensifier
- Check hindfoot alignment following the provisional fixation
- Use the “touch and slide technique” to get oriented
- Have both straight and curved curettes available
- Once the bone surfaces are roughened, release the tourniquet so a bleeding bed can be visualized
- Visualize the guide wires position through the arthroscope to avoid the screws interfering
- Both screws should be mechanically independent

Table 4. Relevant points for a correct indication and successful surgery



Figure 22. X-ray showing a combined ankle and subtalar arthrodesis by intramedullary nailing.

Traditionally, major varus/valgus deformities $>15^\circ$ or anterior tibial shift were regarded as absolute contraindications for this technique. In the last few years this technique is routinely used in our Hospital environment even in cases of major ankle deformities (Figure 23). These advantages are summarized in Table 5.



Figure 23. year follow up control X-ray showing radiological consolidation. Note the correction of the anterior tibial shift in AP and lateral views compared to figures 7 and 9.

Features	Advantages
Better pathology visualization	Allows treatment of severe axial $\geq 15^\circ$ and anterior tibial shift deformities
Better access to lateral gutters	
Less surgical Trauma	Less postoperative morbidity
Less damage to bone vascularization	Lower complication rate
	Shorter hospital stay
Better access to associated pathology	Allows double / triple arthrodesis
No alteration of bone contours	

Table 5. Features and main advantages of arthroscopic versus open ankle arthrodesis

There is no significant difference between the mean consolidation times with either technique (4 to 6 months). There were a few cases of delayed consolidation in patients where conventional cannulated screws were used (Figure 13). Despite this, all cases consolidated successfully.

Subtalar osteoarthritis developed following arthroscopic ankle arthrodesis in one case and following traditional open surgery in another case. There were no signs of subtalar arthritis in the pre-op Xrays or bone scintigraphy- in neither case and diagnostic injections with local anesthetic did rule out subtalar involvement. Osteoarthritis developed 24 months following surgery and both cases required subsequent subtalar arthrodesis (Figure 24).

In a nail subtalar joint arthrodesis It would appear reasonable to assume that both articular surfaces should be roughened but is no clinical evidence that the consolidation rate is higher than in cases that have not been burred.

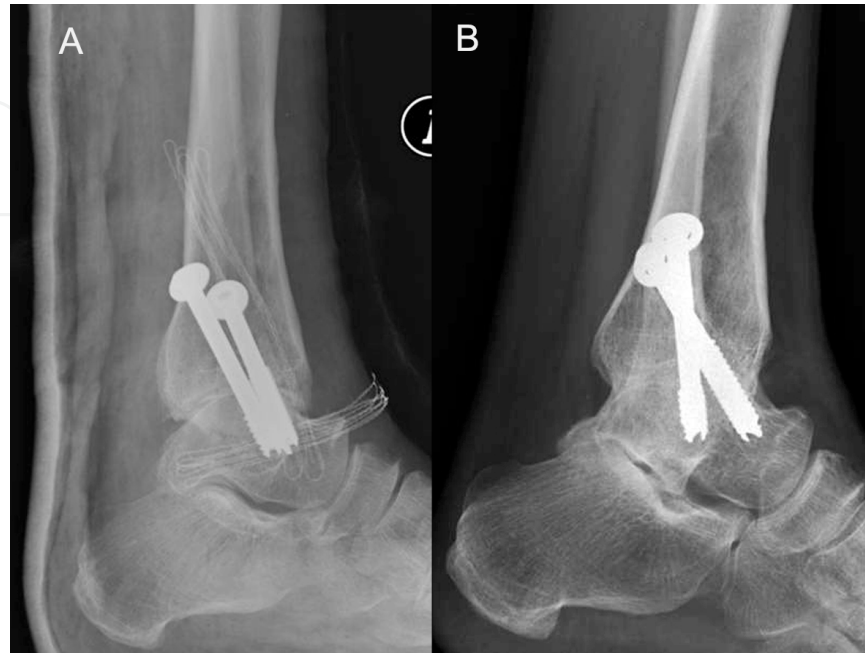


Figure 24. Subtalar osteoarthritis 27 months following ankle arthrodesis.

5. Discussion

Arthroscopic ankle arthrodesis allows joint fixation maintaining the main joint anatomy and keeping subcondral bone loss to a minimum.

The complication rate in the immediate postoperative period is smaller compared to open surgery. The convalescence time is shorter. Myerson & Quill, 1991).

The operating time and the hospital stay are shorter. (O'Brien et al., 1999).

The infection rate and other soft tissue complications rate is lower in arthroscopically treated cases

The bone consolidation rate is similar in both groups. In our experience 85% of ankle arthrodesis had consolidated after 4-5 months postop.

Recent studies have shown good or excellent results in 85 of cases with a low complication and non-union rate (Glick et al., 1996; Tasto et al., 2000; Wasserman et al., 2004; Zvijac et al., 2002).

In severe varus/valgus deformities $>10^\circ$ with anterior tibial shift, a good correction can be achieved arthroscopically if an adequate capsular joint release is made. This was regarded as a contraindication in the past.

This technique allows early postoperative mobilization and is ideal in elder patients with associated inflammatory processes.

Excellent results have been published in some series of subtalar arthroscopic arthrodesis, where the consolidation time was 8, 9 weeks with no infection or non union cases reported.

Ankle arthroscopy is constantly developing and has become the favourite surgical technique amongst many ankle and foot surgeons.

6. Conclusions

Arthroscopic ankle arthrodesis is a reproducible and reliable, technique with a lower complication rate than traditional open ankle surgery.

It is a rapidly developing technique that broadens the possibilities and the indications of ankle and foot surgery.

The long term results are similar to those of traditional open ankle surgery.

Arthroscopic ankle and subtalar arthrodesis induces less trauma to the soft tissues and this translates in a lower complication rate, a shorter hospital stay, an early mobilization and a higher success rate. All these factors have made arthroscopic surgery, our first choice technique for ankle and subtalar arthrodesis.

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