Technical Note

Lateral Hind-Foot Endoscopic Anterolateral/ Posterolateral (LEAP) Subtalar Arthrodesis: An Effective Minimally Invasive Technique to Achieve Subtalar Fusion and Deformity Correction

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Abstract: Arthrodesis surgery aims to provide relief for chronic joint pain and correct limb alignment by achieving a stable union between articulating bones. The key factors to achieving sound arthrodesis is adequate debridement of arthritic cartilage and creating well-apposed bleeding subchondral bone surfaces without compromising the surrounding soft tissue envelope. Arthroscopic subtalar arthrodesis is technically demanding but provides better visualization of the articular surfaces and is safer for the surrounding soft tissues compared to the open approach. Early published reports of the arthroscopic subtalar arthrodesis from the lateral sinus tarsi approach and posterior approach have shown promising results with high rates of union and less wound healing complications. However, there are concerns about access to all facets of subtalar joint, nerve injury, and deformity correction. In this technique, the article authors describe the lateral endoscopic anterolateral/posterolateral (LEAP) approach for subtalar arthrodesis to improve visualization and access to all facets of the subtalar joint to ensure adequate preparation of apposing surfaces, sound union, and facilitate deformity correction of hind-foot. Strategic portal placement also avoids injury to sural nerve. This is a safe and effective minimally invasive technique for subtalar arthrodesis.

Arthrodesis surgery aims to provide relief for chronic joint pain and correct limb alignment by achieving a stable union between articulating bones. The key factors to achieving sound arthrodesis are adequate debridement of arthritic cartilage and creating well-apposed bleeding subchondral bone surfaces without compromising the surrounding soft-tissue envelope.

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Arthroscopic subtalar arthrodesis is technically demanding but provides better visualization of the articular surfaces and is safer for the surrounding soft tissues compared with the open approach. Early published reports of the arthroscopic subtalar arthrodesis from the lateral sinus tarsi approach[1] and posterior approach[2] have shown promising results, with high rates of union and fewer wound healing complications. However, there are concerns about access to all facets of subtalar joint, nerve injury, and deformity correction.

The lateral hind foot endoscopic anterolateral/ posterolateral (LEAP) approach has been described for endoscopic procedures of lateral ligament repair,[3] lateral ligamentoplasty,[4] and peroneal stabilization.[5] The LEAP approach has been adapted for subtalar arthrodesis to improve visualization and access all facets of the subtalar joint to ensure adequate preparation of apposing surfaces and allow for any deformity correction of hindfoot. This study aims to describe the detailed surgical technique of LEAP subtalar arthrodesis.

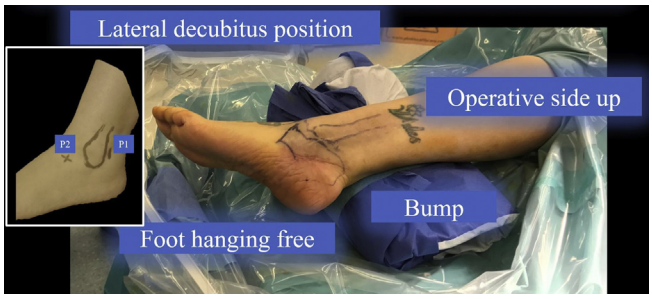

Fig 1. Patient position and portal placement. The image depicts the patient placed in right lateral decubitus position with the operative left side above the right side. The operative leg is prepared and draped free. It is placed on a bump beneath the distal part of the leg with the foot hanging free. Inset image: The image depicts the portal placement. Fibula and lateral malleolus are marked. P1/peroneal portal is established using a 1.5-cm incision posterior to the lateral malleolus over the peroneal tendon sheath. It is depicted in the image with a vertical line. P2/sinus tarsi portal is established over the soft spot. It is represented in the image using a "x" mark.

Surgical Technique: LEAP Subtalar Arthrodesis (With Video Illustration)

Patient Setup

The patient is anesthetized, and a thigh tourniquet is applied on the operative lower limb. The patient is placed in a lateral decubitus position with the operative leg up, supported using a foam, with the foot hanging free (Fig 1). A bolster is placed under the medial malleolus to naturally open the subtalar joint. The position is stabilized with a posterior sacral and an anterior support for the anterior superior iliac spine. Traction must be avoided, as it is detrimental to access and deformity correction. The leg is prepared and draped free and the bony prominences are marked.

Step 1: Portal Placement

The LEAP approach for subtalar arthrodesis is a true lateral approach performed using 2 lateral portals—posterolateral/peroneal and anterolateral.

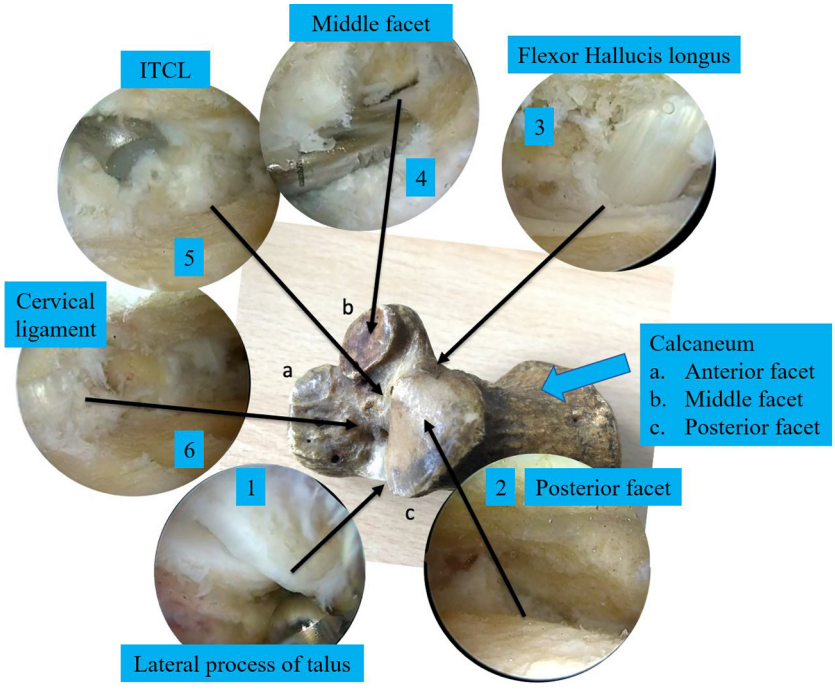

Fig 2. Surgical steps for LEAP subtalar arthrodesis. The image depicts the cadaveric specimen of calcaneum as seen in the superior view. Anterior, middle, and posterior facets of the calcaneum are marked as a, b, and c. Arthroscopic images marked from 1 to 6 depict the key surgical steps of LEAP subalar arthrodesis. (1) Image depicts the lateral process of talus with the arthroscope in the P2 portal. It is well visualized after creating a lateral endoscopic space and clearing the soft tissues with arthroscopic shaver. Lateral subtalar joint line is seen posterior to the lateral process of talus. (2) Image depicts the view of the posterior facet of the calcaneum with the arthroscope in the P2 portal. It can be accessed after clearing 1-2 mm of cartilage and subchondral bone from the lateral subtalar joint line. After clearance the scope and shaver enter the subtalar joint and self-distract the opposing bone surfaces of the posterior facet. This facilitates access to the posterior facet to prepare the bone surfaces from lateral to medial side. Instrumentation and viewing portals should be switched to ensure adequate visualization and preparation of the posterior facet. (3) As the posterior facet is prepared from lateral to medial side, FHL tendon can be visualized medially. It marks adequate preparation and debridement is avoided medial to the FHL tendon. (4, 5) After preparation of the posterior facet as we navigate anteriorly deep ITCL is visualized. It is debrided with scope and shaver to access the middle facet for debridement and preparation of the opposing surfaces. (6) After preparation of the middle facet, further navigation can be continued anteriorly to visualize the cervical ligament. It can be debrided to access the anterior facet if required for isolated subtalar arthrodesis. (FHL, flexor hallucis longus; ITCL, interosseous talocalcaneal ligament; LEAP, lateral endoscopic anterolateral/posterolateral.)

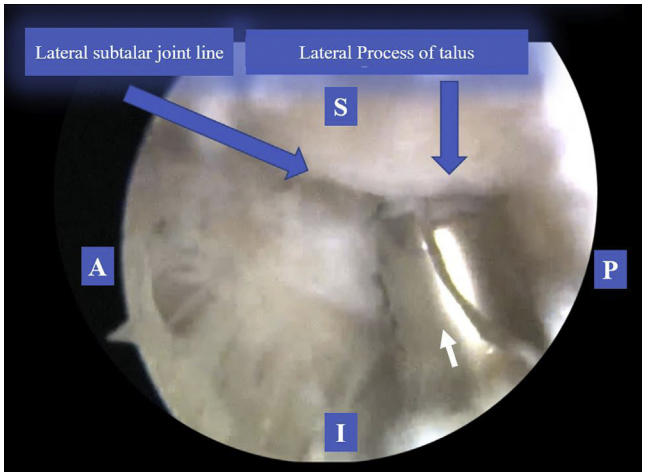

Fig 3. Identification of lateral process of talus. This is an endoscopic image of the left foot. The peroneal (P1) portal is used as the viewing portal and the sinus tarsi (P2) portal as the instrumentation portal. The arthroscopic shaver (white arrow) is used from the sinus tarsi portal to create the lateral endoscopic space by debriding the soft tissues. The arthroscopic shaver is pointing to the lateral process of talus and just inferior to this lies the lateral subtalar joint line. The arthroscopic shaver is used to debride the soft tissues and remove bone along the identified lateral subtalar joint line to create space for the shaver to enter the posterior facet of the subtalar joint. (I, inferior; L, lateral; M, medial; S, superior.)

Posterolateral/Peroneal (P1) Portal

The P1 portal runs through the bed of the peroneal tendon sheath and it acts as the "freeway" to the hindfoot. It is placed directly behind the lateral malleolus over lying peroneal tendons. It is established using a 1.5-cm incision posterior to the lateral malleolus over the peroneal tendon sheath (Fig 1). The tendons are retracted posteriorly, and the arthroscopic sheath is placed anterior to them and pushed under the tip of the fibula deep to the calcaneofibular ligament. As P1 portal is established anterior to the peroneal tendons, it lies farther away from the saphenous vein and sural nerve.

Sinus Tarsi (P2) Portal

The P2 portal is taken at the soft spot of the sinus tarsi (Fig 1). The trocar is pushed down onto the lateral process of the talus and then along lateral joint line to develop the lateral hindfoot endoscopic space.

Step 2: Identification of the Lateral Process of the Talus

After establishment of the portals, it is essential to move from one landmark to another to navigate the subtalar joint. The first step is identification of the lateral process of talus. The trocar is used via P2 to create a working lateral endoscopic space, so that the lateral process of talus is directly seen with the scope in P2 portal (Fig 2 and 3).

Step 3: Identification of the Lateral Subtalar Joint Line

With the camera in the P2 portal, the focus is moved posteriorly along the lateral process of talus to reach the lateral subtalar joint line (Fig 2 and 3). It is essential to make sure that the scope remains directly on the bone, deep to the calcaneofibular ligament. This creates a common pathway between the P1 and P2 portals and facilitates later portal switching.

Step 4: Preparation of the Posterior Facet From Lateral to Medial

A 4.5-mm hooded bone shaver in the P1 portal is used to start clearance of the posterior facet from lateral to medial. This commences as an endoscopic procedure but once cartilage and 1 to 2 mm of subchondral bone are removed, then the shaver and scope can enter and self-distract the subtalar joint (Fig 2 and 4). Switching of portals may be needed to ensure full clearance of the posterior facet, including the posteromedial corner.

Step 5: Identification of the Flexor Hallucis Longus (FHL) Tendon

The posterior facet is cleared and the FHL tendon is visualized on the posteromedial aspect of the subtalar joint (Fig 2 and 4). This ensures that adequate clearance of posterior facet is done. Then the hooded shaver is turned, protecting the FHL tendon, and used to remove bone from the medial joint line whilst minimizing the bone removal laterally or vice versa to assist with deformity correction. The FHL is also the key landmark for progression forward into the

Table 1. Postoperative Regimen

Week	Immobilization	Weight-Bearing	Other
0-2	Back-slab plaster cast	Non–weight-bearing	Antibiotics on induction only. Low molecular weight heparin for 2 weeks postsurgery.
2-8	Walker boot	Weight-bearing with crutches	Boot off to dress, bathe, and start sagittal plane motion.
8-12	Boot can come off as tolerated	Full weight-bearing without crutches in boot, and as required without boot	Computed tomography scan for assessment of union and boot off when this is confirmed.

Table 2. Surgical Steps, Pearls, and Pitfalls for LEAP Subtalar Arthrodesis

Surgical Step	Pearls	Pitfalls
Portal placement	• Two portals placed wide apart makes triangulation easier and do not interfere with each other. • Preparation of common working lateral endoscopic space facilitating subfibular debridement. • Can visualize and address pathologies related to peroneal tendons • Portals established without localizing the subtalar joint line, which is difficult to palpate and may require image intensifier guidance • Prevents in jury to sural nerve	• P1 portal is established using open technique, may lead to excess fluid extravasation
Identification of lateral process of talus	• Easy direct visualization of lateral process of talus	
Identification of lateral subtalar joint line	• Easy to localize by moving posteriorly from lateral process of talus	
Debridement of posterior facet from lateral to medial	• Opportunity to correct the coronal deformity. • Can be used for preparation of subtalar joints with fixed deformities as in tarsal coalition • Saddle shape of the posterior facet does not interfere with access to the apex or even the posteromedial part of the posterior facet.	• Technically demanding • Requires orientation to arthroscopic anatomy of subtalar joint
Identification of flexor hallucis longus tendon	• Landmark to limit the medial clearance of posterior facet and protect the medial neurovascular structures • Ensures adequate preparation of posterior facet of subtalar joint.	
Preparation of middle facet	• Avoids dorsiflexion of talus postoperatively • Facilitates adequate correction of any degree of coronal plane deformity.	
Bone microfracture	• Creates a healthy bleeding bone bed for adequate arthrodesis	
Alignment and fixation	• Percutaneous fixation under image intensifier	• May need removal of screws at a later date

LEAP, lateral endoscopic anterolateral/posterolateral.

anterior compartment for preparation of the middle facet. Medial dissection is avoided beyond the FHL tendon to remain clear of the neurovascular structures medially.

Step 6: Preparation of the Middle Facet

In front of the middle facet lies the deep interosseous talocalcaneal ligament (deep ITCL) (Fig 2 and 5). It can look like joint capsule and may give a false impression that the bone preparation for subtalar arthrodesis is complete. In fact, the deep ITCL is very thick and strong and covers the middle facet and has to be resected to access and prepare the middle facet using 4.5-mm hood bone shaver (Fig 2 and 5). Once the deep ITCL is resected, the subtalar joint becomes freely correctable and it is usually not necessary to progress anteriorly through the cervical ligament (Fig 2 and 6) to the anterior facet preparation for isolated subtalar fusions.

Step 7: Bone Microfracture

A 5-mm osteotome is used for microfracture of the sclerosed parts of the subchondral bone to ensure bleeding bone surfaces. It is introduced via one portal and viewed via the other. Under direct vision, microfracture is completed.

Table 3. Advantages and Limitations of LEAP Subtalar Arthrodesis

Advantages	Limitations
• Facilitates correction of any degree of hindfoot deformity. • Preparation of both posterior and middle process of talus • Avoids dorsiflexion of talus postoperatively • Preserves the intrinsic cervical ligament • This surgical approach can be used in patients with comorbidities and poor condition of surrounding soft tissues	• Procedure is technically demanding and requires a long learning curve • Procedure requires orientation to arthroscopic anatomy of the subtalar joint

LEAP, lateral endoscopic anterolateral/posterolateral.

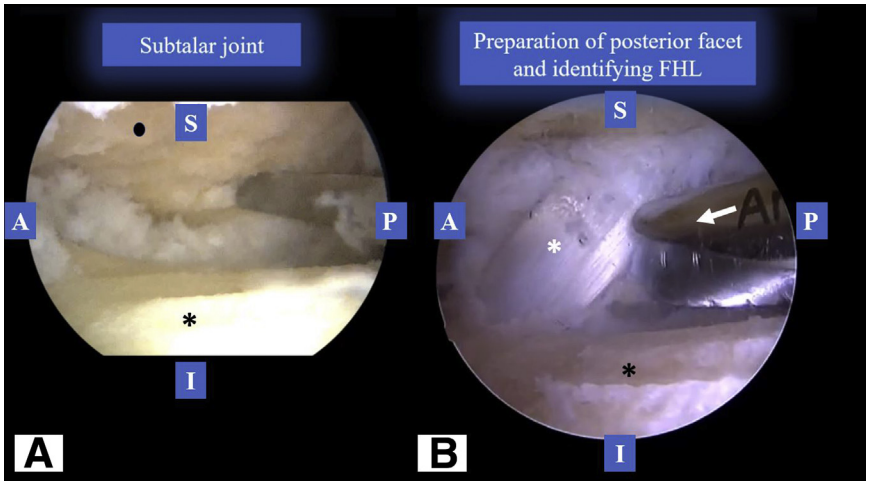

Fig 4. Visualization and preparation of the posterior facet of the subtalar joint. (A) This is the arthroscopic view of the posterior facet of the subtalar joint of patients left foot. The peroneal (P1) portal is used as the viewing portal and the sinus tarsi (P2) portal as the instrumentation portal. After creating space for the arthroscopic shaver to enter the posterior facet of the subtalar joint through the lateral subtalar joint line (as explained shown in Fig 3), the arthroscopic shaver is advanced along the posterior facet of the subtalar joint. It also acts as an instrument which distracts the talus (black dot) and calcaneum (black asterisk) and improves visualization of the posterior facet. (B) This is an arthroscopic image of the posterior facet of the subtalar joint of the left foot. The arthroscopic burr (white arrow) is used to prepare the posterior facet of the subtalar joint (black asterisk). The medial extent of the bone preparation is marked by the visualized FHL tendon (white asterisk). Care is taken not to debride the tendon while preparing the bone surface. Care is also taken not to go medial to the FHL tendon to avoid damage to the neurovascular structures. The viewing portal and the instrumentation portal can be switched to ensure adequate bone preparation of the whole of the posterior facet. (FHL, flexor hallucis longus; I, inferior; L, lateral; M, medial; S, superior.)

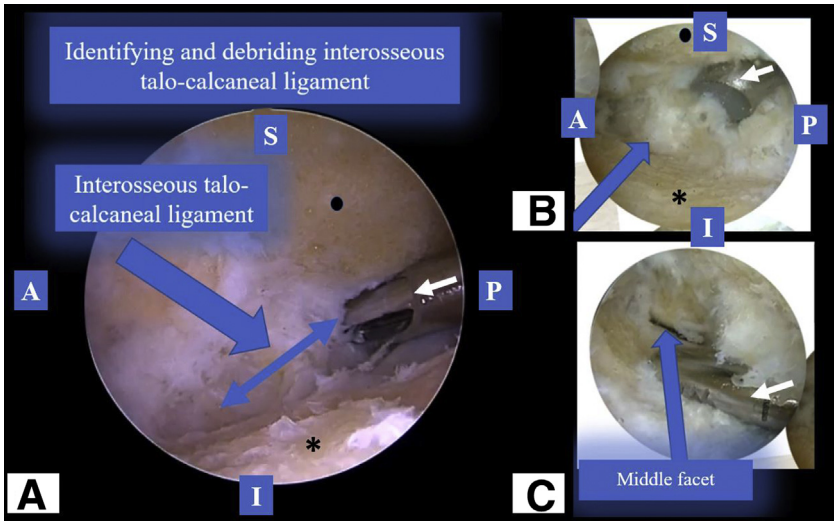

Fig 5. Debridement of the interosseous talo-calcaneal ligament and identification and preparation of the middle facet of the subtalar-joint. Images are of the left foot subtalar joint are shown. (A) After the preparation of the posterior facet the next step is preparation of the middle facet. The peroneal (P1) portal is used as the viewing portal and the sinus tarsi (P2) portal as the instrumentation portal. The scope is tuned anteriorly to visualize the interosseous talo-calcaneal ligament (blue line). This connects the talus (black dot) and calcaneum (black asterisk). This is a tough structure and is debrided with an arthroscopic shaver (white arrow). (B) This is an arthroscopic image that is showing the interosseous talo-calcaneal ligament (blue arrow), talus (black dot), and calcaneum (black asterisk). Since this is a tough structure, to ensure its complete debridement, a sharp-edged scoop (white arrow) is used to supplement the arthroscopic shaver. Complete debridement of the interosseous talo-calcaneal ligament is essential to align the talocalcaneal bone surfaces and correct the deformity in hind-foot. (C) This image shows the middle facet (blue arrow) of the subtalar joint. This lies medial to the interosseous talo-calcaneal ligament and can only be accessed once the ligament is completely debrided. After debridement of the inter-osseous talo-calcaneal ligament the arthroscopic shaver (white arrow) is advanced to debride and prepare the middle facet. (In this image, remnants of the inter-osseous talo-calcaneal ligament can be seen superior to the arthroscopic shaver). (Note: viewing and the imaging portal can be interchanged if necessary, for adequate debridement of the interosseous talo-calcaneal ligament and preparation of the middle facet.) (I, inferior; L, lateral; M, medial; S, superior.)

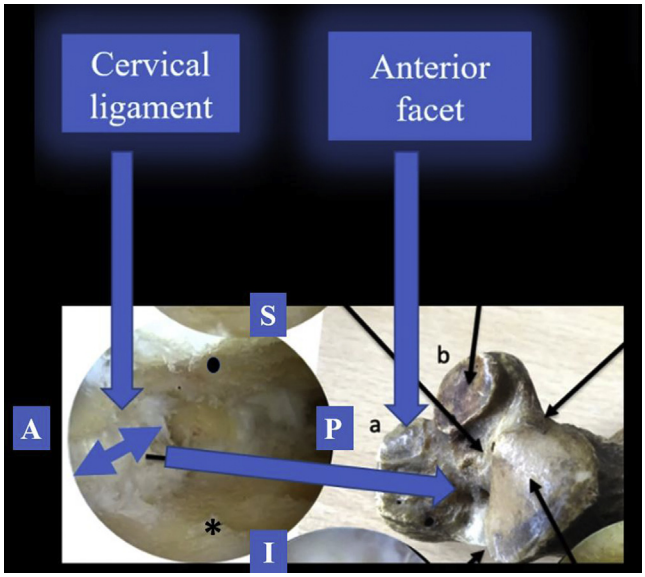

Fig 6. Identification and preparation of the anterior facet. The image depicts an arthroscopic view of the cervical ligament (blue line) and provides reference to a cadaveric specimen of calcaneum to demonstrate its exact location and better orient the readers. The arthroscopic image is from the left foot subtalar joint. The peroneal (P1) portal is used as the viewing portal and the sinus tarsi (P2) portal as the instrumentation portal. The black dot in the arthroscopic image depicts the talus and the black asterisk depicts the calcaneum. After preparation of the middle facet is complete the last step is preparation of the anterior facet. This is located anterior to the cervical ligament (blue line). Cervical ligament (blue line) can be visualized as the scope is moved anteriorly after preparation of the middle facet of the subtalar joint. The anterior facet can be accessed and prepared after debridement of the cervical ligament (blue line) with an arthroscopic shaver. In the senior authors' opinion, preparation of the anterior facet is not always essential in patients undergoing isolated subtalar arthrodesis. It should be routinely prepared while preparing the subtalar joint as a part of the arthroscopic triple arthrodesis. (I, inferior; L, lateral; M, medial; S, superior.)

Step 8: Alignment and Fixation

The subtalar joint is reduced with the foot in plantar flexion. Once reduced, the foot is dorsiflexed to naturally lock it in the reduced position. The subtalar joint is stabilized using a 2-screw technique with 6.5-mm partially threaded cannulated screws inserted in a vertically parallel configuration[6] (Fig 7). The accurate placement of the screws is confirmed by the use of image intensifier. This completes the LEAP subtalar arthrodesis.

Postoperative Management

The postoperative rehabilitation plan followed is illustrated in the Table 1. This plan is more aggressive, and patients are allowed weight-bearing mobilization at any time after surgery. Generally, patients are able to fully weight bear without support on the operated limb within 7 to 14 days after surgery.

Discussion

LEAP subtalar arthrodesis is an effective minimally invasive surgical technique for subtalar fusion and deformity correction of the hindfoot. The described arthroscopic approaches for subtalar arthrodesis make use posterior and/or lateral approach.[1,2,7] LEAP subtalar arthrodesis uses 2 lateral portals placed at different location compared with the described lateral portals for arthroscopic subtalar arthrodesis. The strategic placement of portals facilitates creation of the lateral endoscopic working space, makes triangulation and maneuvering easier, and avoids injury to the sural nerve (Table 2). With endoscopy, it is possible to decompress lateral calcaneal wall and address symptomatic or impending subfibular impingement, especially in patients suffering from post-traumatic sequelae. This also facilitates switching in-between portals, which aids in direct visualization around the apex of posterior facet and ensures comprehensive preparation of posterior facet, including posteromedial corner. In contrast, in open surgery a laminar spreader is used to distract the subtalar joint. If it is placed laterally, it narrows the vision of the medial side and if it is placed deep in the joint, it interferes with access to the posterior facet, which may lead to inadequate preparation, malreduction, and postoperative nonunion.

Debridement of deep ITCL, release of periarticular soft tissues, and, if required, controlled differential subchondral bone removal medially and laterally helps to correct the coronal plane hindfoot deformity with LEAP subtalar arthrodesis (Table 3). Severe coronal deformity is not a contraindication for this approach. In fact, the worse the deformity the safer it is to correct it arthroscopically. Similarly, arthroscopic approaches are safer in patients with comorbidities, including diabetes, vascular disease, or previous infection/trauma/surgery. Interestingly, none of the studies on arthroscopic subtalar arthrodesis detail the postoperative alignment or ability to correct deformity. However, in our experience, it is easier to correct severe deformity arthroscopically than with an open approach.

With LEAP, subtalar arthrodesis dorsiflexion of the talus is avoided (Table 3). Dorsiflexion of the talus is a risk in posterior arthroscopic subtalar arthrodesis[8] as curvature posterior facet hinders access to the anterior part without removal of more bone posteriorly and the preserved middle facet provides a pivot point anterior to the posterior facet for talus to dorsiflex.

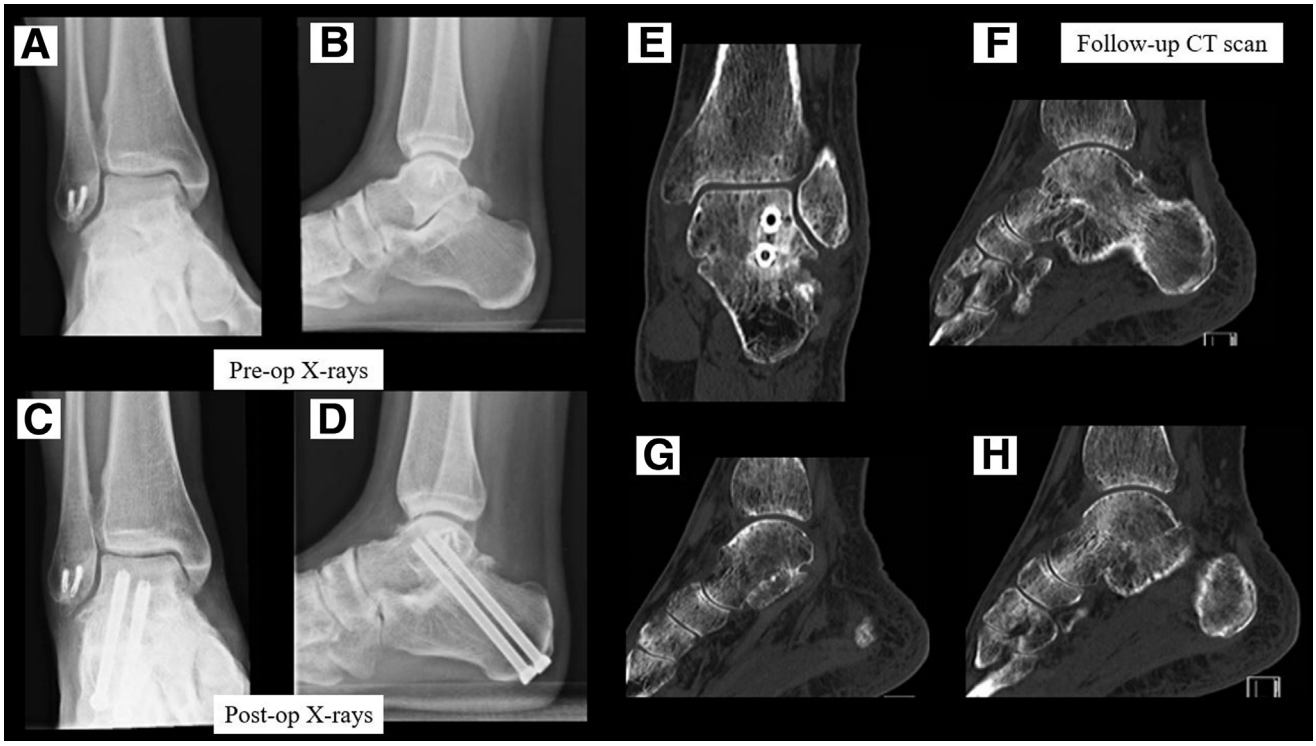

Fig 7. Pre- and postoperative radiologic imaging. (A-B) Preoperative anteroposterior and lateral radiographs depicting arthritis of the subtalar joint. (C-D) Postoperative anteroposterior and lateral radiographs depicting arthrodesis of the subtalar joint with the LEAP surgical technique. The partially threaded cannulated cancellous 6.5-mm screws can be seen in vertically parallel configuration. (E-H**)** Follow-up computed tomography scan images in sagittal and coronal sections are shown that depict sound arthrodesis of the subtalar joint using LEAP surgical technique. (LEAP, lateral endoscopic anterolateral/posterolateral.)

Conclusions

LEAP subtalar arthrodesis technique is an efficient way to correct the hindfoot deformity and achieve sound arthrodesis of the subtalar joint.

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