Ankle Anatomy for the Arthroscopist. Part I: The Portals

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Over the last decade, arthroscopy of the ankle has become an important tool for the diagnosis and treatment of numerous pathologies. The considerable increase in the use of endoscopic techniques has led to significant changes in the field of orthopedic surgery and a new concept of human anatomy. The typical visualization in three dimensions on the part of surgeons and anatomists has become a two-dimensional, magnified view with the capability to observe anatomic structures that cannot be accessed by open surgery or dissection without altering their location or morphology. Because endoscopic procedures are performed using small incisions through which instruments are passed from the surface to the depths of the area under treatment, an anatomic focus is required that is based on the relationships between the structures susceptible to lesion and the arthroscopic access routes or portals.

Hence, adequate knowledge of the anatomy of the joint to be treated should cover not only the most common anatomic configurations (extra-articular and intra-articular) in statistical terms but also the possible anatomic variations to avoid confusion and serious technical errors. This anatomic knowledge is particularly important in arthroscopy of the ankle because of the significant risk of associated complications, which can be prevented or decreased only by profound familiarity with the anatomy of the region and the use of a “protocolled,” reproducible technique [1].

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Some of the most important aspects of arthroscopic procedures that have an anatomic basis as their focus are (1) the use of incisions that only affect the skin and are placed parallel to the neighboring tendinous and vasculonervous structures, which run from the leg to the foot in a proximal to distal direction; (2) the use of blunt dissection with a vascular or mosquito clamp until the joint capsule is reached; (3) the use of blunt trocars to avoid injury to the articular cartilage (a frequent problem, particularly in arthroscopists who have limited experience); (4) the use of arthroscopy sheaths with no lateral window to avoid leakage of irrigation fluid into surrounding tissues and that are interchangeable to prevent soft tissue trauma by repetitive insertion of the instruments; and (5) the use of arthroscopic cannulas to introduce motorized instruments [2,3].

In 1931, Burman [4], a pioneer in establishing the anatomic basis of arthroscopy of the ankle and foot, stated that the ankle joint “is not suitable for arthroscopy.” He maintained that the joint space was extremely narrow and traction could not separate the articular surfaces. Although he believed access to

Fig. 1. Frontal section of the ankle joint. 1, lateral malleolus; 2, tibia; 2', medial malleolus; 3, talus; 4, calcaneus; 4', sustentaculum tali; 5, tibiofibular syndesmosis; 6, talocrural joint; 7, posterior subtalar joint; 8, peroneus brevis tendon; 9, peroneus longus tendon; 10, tibialis posterior tendon; 11, flexor digitorum longus tendon; 12, flexor hallucis longus tendon; 13, lateral and medial plantar artery.
the posterior region was not feasible, he described the possibility of accessing
the joint through an anterior approach located lateral to the extensor tendons
and concluded that perhaps "something" could be done in a live patient with a
smaller arthroscope. Effectively, the technologic advances that have taken place
since that time and particularly in the last decades have yielded smaller-diameter
arthroscopes than those used by Burman and systems of traction/distraction
that allow better access to the joint, thereby increasing the indications for
the technique.

The advantages of arthroscopy for treating the ankle and foot are similar to
those observed in other joints; however, the fast increase in the popularity of this
technique is also due to the fact that other noninvasive methods are not suitable
for the diagnosis of certain ankle alterations. This is particularly true for the soft
tissue lesions known as "soft tissue impingement syndrome," which together
with osteochondral lesions are among the main indications for arthroscopy [5].

The authors' objective in this article is to present the anatomy of the ankle
joint specifically from the perspective of arthroscopy, omitting general and other
considerations that are not highly relevant in arthroscopic practice.

The ankle joint or talocrural articulation is formed by the articular surfaces of
the distal tibial and fibular epiphyses and the talus in its superior, lateral, and
medial aspects. The morphology of these surfaces forms a hinge-type synovial
joint with a single axis of movement (bimalleolar axis) that allows dorsiflexion
(flexion) and plantar flexion (extension) of the ankle and foot in the sagittal plane.
Because of this configuration and the fact that the ankle is a load-bearing joint,
the interarticular space is narrow, making insertion of arthroscopic instruments
between the articular surfaces difficult (Fig. 1). Hence, articular distraction
systems are required to perform complete arthroscopic inspection of the joint.

Landmarks

The anatomic landmarks of bone and tissue in the ankle joint are easily
palpated and should be delimited on the patient’s skin with a dermographic
marker. Landmarks are essential for proper positioning of the portals and fa-
cilitate orientation during the procedure despite the edema associated with the
technique. The following landmarks are the most important: (1) both malleoli
(lateral and medial); (2) the anterior joint line, which is easily palpated by moving
the joint in dorsiflexion–plantar flexion and located approximately 2 cm proximal
to the tip of the lateral malleolus and 1 cm proximal to the tip of the medial
malleolus; (3) the tibialis anterior tendon, fibularis tertius tendon, and calcaneal
or Achilles tendon; (4) vascular landmarks such as the great saphenous vein,
which runs in front of the medial malleolus, and the superficial peroneal nerve
with its dividing branches: the medial and intermedial dorsal cutaneous nerves.
These vessels are easily identified in thin patients when inversion of the foot is
performed. Neural structures such as the sural nerve, which usually runs 2 cm
posterior and distal to the lateral malleolus, together with the small saphenous vein, are also easily palpated (Figs. 2 and 3) [2].

**Arthroscopic portals**

The numerous arthroscopic portals described for the ankle can be grouped into anterior, posterior, transmalleolar, and transtalar. The use of some of these portals involves considerable technical difficulty or an elevated potential for neurovascular lesion, and for these reasons, they have fallen into disuse.

The first description of the anteromedial, anterolateral, and posterior portals of the ankle was reported by Watanabe in 1972 [6]. In later years, investigators such as Ikehuchi [7], Chen [8], Drez and colleagues [9,10], Parisien and colleagues [11–13], and Andrews [14] described additional portals and the extra-articular
and intra-articular anatomy of the ankle and standardized the technique, which was ultimately popularized by Ferkel and Fischer [15]. Subsequently, several investigators described new portals to fill the need to access specific regions of the joint, particularly the central and posterior areas (Box 1) [16–20]. This need also led to the development of various systems of distraction to allow easy, safe, and more complete visualization of the ankle joint [21–29].

Owing to the fact that all the portals run through an anatomic region surrounded by numerous neurovascular structures susceptible to injury, several anatomic studies to assess the potential for lesion to each of them have been published (Fig. 4) [15,16,30–37].

**Anterior portals**

**Anteromedial portal**

The anteromedial portal is the first to be performed. It is established just medial to the tibialis anterior tendon at the anterior joint line of the ankle and coinciding with a soft spot, a visible and palpable depression seen when the ankle is in dorsiflexion. There is a potential for injury to the saphenous nerve and the great saphenous vein, which at this level, divides into numerous branches that communicate with the deep venous system (see Fig. 4; Figs. 5 and 6). These structures lie at a mean safe distance of 9 mm (3–16 mm) for the saphenous vein and 7.4 mm (0–17 mm) for the saphenous nerve [30]. Although some investigators consider these structures risk-free [32], Chen [8] reported one case of saphenous vein lesion in 67 ankles treated with arthroscopy and Ferkel and col-
Box 1. Arthroscopic portals described for the ankle joint

**Anterior portals**
- Anteromedial
- Accessory anteromedial
- Anterocentral
- Medial midline portal \[18\]
- Anterolateral
- Accessory anterolateral

**Posterior portals**
- Posteromedial
- Accessory posteromedial
- Modified posteromedial \[17\]
- TransAchilles \[16\]
- Posterolateral
- Accessory posterolateral
- Coaxial portals \[20\]
- Endoscopic portals \[19\]

**Transmalleolar portals**
- Medial
- Lateral

**Transtalar portals**
- Medial
- Lateral

leagues \[5\] described 27 neurologic complications, 5 corresponding to saphenous nerve injuries.

At the anterior edge of the tibia, where it joins with the medial malleolus, there is a notch (medial notch of Harty) \[38\] that provides the anteromedial portal with additional space to allow easier passage of the instruments in the anteroposterior direction \[39\] (Fig. 7).

**Anterolateral portal**

The anterolateral portal is created at the anterior joint line just lateral to the peroneus tertius tendon (present in 90% of cases) \[40\] or, in its absence, lateral to...
the extensor digitorum longus tendons. The main structure at risk of injury when performing this portal is the intermediate dorsal cutaneous nerve (the lateral branch of the superficial peroneal nerve) [41] (see Figs 4 and 5). Most of the complications described in arthroscopy of the ankle involve this nerve [5,42,43].

The superficial peroneal nerve, which is the motor for the muscles of the lateral compartment of the leg (peroneus longus and peroneus brevis) and the sensory nerve for the greater part of the dorsal foot, has been the subject of numerous anatomic studies [30–33,44–46]. After providing motor innervation, the superficial peroneal nerve runs along the lateral intermuscular septum and penetrates the crural fascia, where it becomes a sensory nerve. The point of
Fig. 5. Transverse section at the level of the ankle joint. (A) Anteromedial portal. 1, saphenous nerve and great saphenous vein. (B) Anterolateral portal. 2, intermediate dorsal cutaneous nerve (lateral terminal branch of superficial peroneal nerve). (C) Anterocentral portal. 3, medial dorsal cutaneous nerve (medial terminal branch of superficial peroneal nerve); 4, deep peroneal nerve and anterior tibial artery and veins.

Fig. 6. (A) Medial view of the ankle. (B) Anatomic dissection (veins are filled with blue latex for better identification). 1, tibialis anterior tendon; 2, great saphenous vein and communicans branches.
penetration varies, although it is usually found at a distance from the medial malleolus equivalent to one-third the length of the tibia [44]. Distal from this point, the superficial peroneal nerve usually divides into two branches: the more laterally located intermediate dorsal cutaneous nerve and the medial dorsal cutaneous nerve (Fig. 8). Various types or patterns have been described according to the level and manner in which the superficial peroneal nerve divides into its branches [31,32,44–46]. The distance from the intermediate dorsal cutaneous nerve to the anterolateral portal has been quantified [30,31,33]. Feiwell and Frey [30] reported a mean distance of 6.2 mm (0–24 mm). In the authors’ experience, these data are not very useful because it is almost impossible to know the patient’s nerve distribution. Nevertheless, the arthroscopist should be aware that this important nerve lies very close to the anterolateral portal and that a protocolled arthroscopic technique can avoid injury to this structure.

It is fortunate that this nerve is visible on clinical examination (it is the only nerve in the body that can be seen in this way) [47]. By performing inversion of the ankle, the nerve is tensed (particularly the intermediate dorsal cutaneous branch), and its subcutaneous course becomes evident (see Fig. 3) [2]. Another means to achieve this end was reported by Stephens and Kelly [47], who proposed flexion of the fourth toe to accentuate the subcutaneous course of the dividing branches of the superficial peroneal nerve. A vertical incision affecting only the skin, together with blunt dissection up to the capsule, contributes to decreasing the risk of injury to the nerve. The anterolateral portal can also be created by an inside-out technique through the anteromedial portal, similar to the way the anterior portal is made in arthroscopy of the shoulder. Cutaneous transillumination obtained in this manner allows localization of the superficial peroneal nerve (intermediate dorsal cutaneous nerve) [5,48].
Anterocentral portal

The anterocentral portal is established between the extensor digitorum longus tendons at the level of the joint line. This portal provides a wide field of view and facilitates passage of the instruments in the anteroposterior direction [21]. Nevertheless, most investigators discourage the use of this portal because there is a high associated risk of injury to numerous neurovascular structures. These structures include the medial dorsal cutaneous nerve (medial branch of the superficial peroneal nerve), which runs subcutaneously, and the deep peroneal nerve and the anterior tibial and dorsalis pedis arteries and veins, which are found lying on the joint capsule (see Figs. 4 and 5). The fact that these structures are in such close relationship to the capsule justifies the potential for injury to the anterior tibial or dorsalis pedis artery (pseudoaneurysm). Injury does not occur because the central portal is used for access but occurs when tibial osteophytes are removed or when an anterior synovectomy is performed through the anteromedial and anterolateral portals [49–51]. Moreover, anatomic variations in the course of the anterior tibial artery at the ankle may lead to vascular lesions [52,53]. Lateral deviation of this vessel, placing it in front of the tibiofibular syndesmosis, has been found in 5.5% of patients (Fig. 9) [54]. This possibility has made some investigators recommend the use of Doppler ultrasound at the joint line to localize the anterior tibial or dorsalis pedis artery [52,53].
The medial midline portal was first described by Buckingham and colleagues [18], with the aim of obtaining an interarticular view similar to that of the anterocentral portal but with a lower risk of lesion to vital structures. The portal is located just lateral to the tibialis anterior tendon, between the tibialis anterior and the extensor hallucis longus tendon, which is located medial to the portal. This approach can also be used to introduce fluid into the joint.

**Accessory portals**

Additional portals can be performed proximal to the anterolateral and anteromedial portals. The separation between the main portal and the accessory portal should be wide enough to allow proper triangulation and instrumentation and to avoid the risk of cutaneous necrosis.

These portals can facilitate the instrumentation in certain diseases or can be used to introduce fluid into the joint.

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**Fig. 9. Anatomic dissection showing varying course of the anterior tibial artery (lateral deviation).**

1, lateral malleolus; 2, tibia; 3, talus; 4, anterior tibial artery; 5, dorsalis pedis artery; 6, anterior malleolar artery; 7, anterior tibiofibular ligament; 8, anterior talofibular ligament.
Posterior portals

Because of the anteroposterior convexity of the joint, the posterior joint line is located 4 to 6 mm distal to the anterior joint line and is a difficult landmark to palpate. According to Guhl [39], the posterior joint line can be determined externally and is located 0.5 cm above the tip of the medial malleolus and 1 cm from the tip of the lateral malleolus. The authors do not favor use of the metric system for determining the position of the portals, although it can be useful in some cases. The authors prefer to use a spinal needle inserted under arthroscopic observation through the anterior portals to identify the joint line and determine proper positioning of the entrance point.

Posterolateral portal

The posterolateral is the most widely used of the posterior portals because it presents the lowest risk of neurovascular injury. It is located 1.2 to 2.5 cm proximal to the tip of the lateral malleolus, adjacent to the lateral axis of the Achilles tendon [2]. The sural nerve and its branches and the small saphenous vein are in close proximity and at risk of injury (Fig. 10) [5,21,42]. Ferkel and colleagues [5] reported five cases of sural nerve lesion in 612 arthroscopic procedures of the ankle. According to Feiwell and Frey [30], the sural nerve is

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Fig. 10. (A) Anatomic dissection showing neurovascular relationships from the posterolateral portal. 1, Wissinger rod located in the posterolateral portal; 2, lateral border of calcaneal tendon. (B) Macrophotography. 3, sural nerve; 4, lateral calcaneal nerve (collateral branch of sural nerve); 5, small saphenous vein and branches.
located at a mean distance of 6 mm (0–12 mm) and the small saphenous vein at 9.5 mm (2–18 mm) from the posterolateral portal.

This portal is usually made with an outside-in technique. It is also possible to use an inside-out technique for this purpose [55], but considerable articular distraction is required to overcome the difference in positioning of the two joint lines, necessary for anteroposterior passage of the instruments.

In any case, after meticulous anatomic study of the posterior ligaments of the ankle joint [56] and having performed and observed numerous arthroscopic procedures in this articulation, the authors concluded that the posterolateral portal is always established between two posterior ligaments of the ankle joint—the transverse ligament and the posterior intermalleolar ligament—which are con-

Fig. 11. (A) Arthroscopic image of the right shoulder through the anterior portal. Matthews and colleagues [57] described an intra-articular anatomic triangle used as a landmark to safely establish the anterior portal in shoulder arthroscopy. The triangle is delineated by the following: 1, glenoid cavity; 2, humeral head; and 3, long biceps brachii tendon; 4, anterior labrum; 5, subscapularis tendon; 6, middle glenohumeral ligament. (B) Ankle arthroscopy images (Courtesy of Prof. Pier Paolo Mariani, Department of Sports Traumatology, IUSM, University of Motor Sciences, Rome, Italy) of the posterior ligaments of the ankle through the anterolateral portal. Upper panel: 21-gauge needle inserted in optimal location of the posterolateral portal. Lower panel: Mosquito clamp used to open joint capsule before introducing cannula. 1, tibia; 2, medial border of the transverse ligament (deep component of the posterior tibiofibular ligament); 3, lateral border of the posterior intermalleolar ligament or tibial slip; 4, the triangular area where the posterolateral portal is usually created (delimited by the medial border of the transverse ligament and the posterior intermalleolar ligament, with the base at the tibia). The triangle is visible when the ankle is in dorsiflexion; the posterior intermalleolar ligament tenses and a gap is created between the intermalleolar and transverse ligaments.
stant and visible by arthroscopy. In dorsiflexion, the arrangement of these ligaments, together with the tibia, delimits a triangular area, with the base at the tibia and the tip at the lateral malleolus [56]. This space is similar to the anatomic intra-articular triangle of the shoulder used as a landmark to safely establish the anterior portal, as described by Matthews and colleagues [57] (Fig. 11).

**TransAchilles portal**

The transAchilles portal was described by Voto and colleagues [16] to obtain a wide field of view in the posterior compartment of the joint. It is established through the calcaneal tendon at the posterior joint line. This portal is not commonly used and has been discouraged by some investigators such as Ferkel and colleagues [2,5,15] because of the limited mobility of the instruments, the morbidity to the calcaneal tendon, and the potential for injury to the flexor hallucis longus tendon [15].

**Posteromedial portal**

The posteromedial portal is located adjacent to the medial axis of the calcaneal tendon. As occurs with the anterocentral portal, the use of this access route is not recommended because of the elevated risk of injury to several structures including the tibial nerve, the posterior tibial artery and veins, the flexor digitorum longus tendons, and the flexor hallucis longus tendon [15].

**Posterior endoscopic portals**

Even though numerous portals for accessing the ankle joint have been described and there are several available systems of distraction, the morphology of the joint makes access to the posterior region from the anterior portals difficult. For this reason and with the aim of resolving treatment of periarticular pathology, van Dijk and colleagues [19] described two posterior endoscopic portals that allow better access to the posterior ankle joint regions: the posterior aspect of the ankle joint and the subtalar joint.

To use these portals, the patient must be in the prone position, whereas for the portals described up to now, the patient is in the supine position (Fig. 12). As the authors understand it, van Dijk and colleagues [19] perform a modification of the method for establishing the conventional lateral and medial posterior portals, providing the possibility to treat periarticular pathology without necessarily accessing the articular space and considerably decreasing the risk of neurovascular lesions. By means of this technique, it is possible to inspect and treat lesions in the posterior part of the ankle joint and pathology in the subtalar joint. Among 86 consecutive endoscopic procedures performed, the investigators had no complications.

The posterolateral portal is created at the same level as or slightly above the tip of the lateral malleolus, just lateral to the calcaneal tendon. A blunt dissection is performed with a vascular or mosquito clamp, and the arthroscope shaft with a blunt trocar is inserted in the direction of the webspace between the first and second toe until it touches the talar bone (see Fig. 12A).
Subsequently, the posteromedial portal is established at the medial edge of the calcaneal tendon, at the same height as the posterolateral portal. The direction of the portal is the most important aspect to consider. The mosquito clamp is introduced and then arthroscope shaft with the blunt trocar is inserted in a medial-to-lateral direction until it touches the arthroscope shaft positioned in the posterolateral portal (see Fig. 12 B). It then slides along the shaft, which acts as a guide, until the tip is reached (see Fig. 12 C). After the periarticular fatty tissue is removed, the flexor hallucis longus tendon, the lateral talar process, the ankle joint capsule with the posterior ligaments of the joint, and the subtalar joint capsule can be identified. Among these structures, the flexor hallucis longus tendon acquires special relevance because the tibial neurovascular bundle (tibial nerve, posterior tibial artery and veins) is located medial to it (see Fig. 12). Care should be taken to avoid injury to the flexor hallucis longus tendon, which is considered the main endoscopic landmark because its lateral border determines

Fig. 12. (A–C) Macrophotography of a transverse section at the ankle joint. To show the anatomic relationships of the posterior portals, the arthroscopic cannulas have been added digitally (Adobe Photoshop). PL, posterolateral portal; PM, posteromedial portal; 1, lateral malleolus; 2, medial malleolus; 3, calcaneal tendon; 4, sural nerve and small saphenous vein; 5, flexor hallucis tendon (musculotendinous); 6, tibial nerve and posterior tibial artery and veins.
the working area. Proper positioning of the ankle and the hallux results in better visualization of the tendinous portion of the flexor hallucis longus muscle and avoids unnecessary resection of some of the muscle fibers that reach the lateral tendinous border in a semipeniform morphology. Plantar flexion of the ankle or hallux flexion facilitates visualization of the flexor hallucis longus tendon proximal to the lateral talar process.

During resection of the periarticular fatty tissue, fascial fibers that have a transverse course and a consistent appearance can easily be recognized. These fibers are part of the deep crural fascia that, because of its constant movement, is considerably thickened at the level of the ankle joint. In 1932, Rouvière and Canela [58] gave this structure the name fibulotalocalcaneal ligament (Fig. 13).

The growing interest in the development and clinical application [34,35] of these two portals prompted Lijoi and colleagues [34,37] and Sitler and colleagues [36] to perform anatomic studies to verify the safety of their use relative to the structures susceptible to injury (the tibial nerve and the posterior tibial artery and veins); the investigators concluded that both portals are safe.

Summary

Although a large number of portals have been described, in most cases, only three—the anteromedial, the anterolateral, and the posterolateral—are required to perform diagnostic and therapeutic arthroscopy.

According to the recommendations of van Dijk and colleagues [59–61], clinicians should consider abandoning simultaneous use of anterior and posterior portals because of the difficulty involved in performing this combined technique that increases the risk of injury to vascular structures [36]. Given that it is di-
agnostic suspicion supported by numerous complementary examinations that determines the indication for arthroscopy, it seems reasonable to adopt a separation of arthroscopic pathology of the ankle into anterior compartment pathology and posterior compartment pathology [59–61]. Similarly, such diagnostic suspicion helps to determine whether there is a need to use distraction. The authors believe that the contribution of van Dijk and colleagues [59–61] in the use of distraction systems follows clear anatomical logic.

The ankle joint capsule is similar to the capsule of any other joint, with the exception of a singular characteristic: the anterior capsular insertion in the tibia and talus occurs at a distance from the cartilaginous layer. According to Testut and Latarjet [62], the distance is approximately 6 to 8 mm in the tibia and 8 to 10 mm in the talus. In a recent study, the distance was found to be 4.3 mm (0.5–9.0 mm) and 2.4 mm (1.8–3.3 mm) in the tibia and talus, respectively [63]. This peculiarity determines the existence of a substantial anterior capsular recess that allows the arthroscopist to encounter a working area. Nevertheless, the size of this area depends on the position of the foot. When the foot is in dorsiflexion, the capsular recess is evident, whereas when it is in plantar flexion, capsular tension makes the recess smaller. Hence, van Dijk and colleagues [64] recommended that treatment of anterior pathology should be done with the joint in dorsiflexion: “the anterior working area is opened up and a bony or soft tissue impediment in front of the malleolus, at the talar neck or at the distal tibia can be visualised and treated.” Moreover, when the joint is in dorsiflexion, the talus is protected within the articulation, and the risk of injury to the cartilage when creating the anterior portals is minimized. Similarly, when distraction is

Fig. 14. (A) Schematic view of the ankle joint at 90° and the anterior working area. 1, anterior capsular joint; 2, posterior capsular joint; 3, transverse ligament or deep component of posterior tibiofibular ligament; 4, posterior talofibular ligament; 5, posterior intermalleolar ligament. (B) The anterior working area is opened in dorsiflexion of the foot; anterior impingement can easily be treated. (C) When the foot is in plantar flexion, the anterior working area is reduced.
used, the tension in the articular capsule is increased and applied to the bone ends, reducing the working area (Fig. 14).

If we transfer these concepts to the posterior compartment and to the use of the classic posterolateral portal, there are some differences. In contrast to what occurs with the anterior portal, the posterior articular recess is smaller, and the presence of structures that reinforce the capsule, such as the posterior intermalleolar ligament or tibial slip, convert it into multiple small recesses, making interarticular positioning of the arthroscope or instrumentation difficult in the posterolateral portal. In addition, when a distraction system is applied, capsular tension reduces the working space even more. Thus, the authors believe that the classic posterolateral portal does not provide any relevant advantage (Fig. 15).

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References

ANKLE ARTHROSCOPY PORTALS


