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Medial and Lateral Malleolar Arteries in Ankle Arthroscopy: A Cadaver Study

AQ: 1 **Kerem Başarır,[1] Ali Fırat Esmer,[2] Eray Tuccar,[3] Mehmet Binnet,[4] and Berk Güçlü[5]**

Neurovascular injury may occur during ankle arthroscopy. The majority of complications are neurological injuries; however, vascular injuries do exist. Neurovascular structures are especially vulnerable during portal placement and debridement of anterior structures. Routine anteromedial and anterolateral portals are generally accepted to be safe; this is different from the anterocentral portal, which is associated with a higher risk of injury. However, injuries may occur in these relatively safe portals. The purpose of this cadaver study was to examine other relatively minor neurovascular structures such as medial and lateral malleolar arteries and to determine how these portals can be more safely placed. The distance between standard anteromedial, anterolateral portals and the medial and lateral malleolar arteries was measured in 18 ankles from 9 cadavers. These distances varied with the position of the ankle during portals placement, and measurements were obtained in both flexion and extension. The average distance in flexion and extension was 6.41 to 2.47 mm on the lateral side and 4.73 to 1.58 mm on the medial side. The distances significantly increased with ankle flexion and decreased with extension ($P < .005$). The current study demonstrated that there were other minor vascular structures at risk other than tibialis anterior artery and proper positioning of the ankle during portal placement, and that injury risk may be associated with ankle position. Ankle flexion may decrease the risk of damage to malleolar arteries and decrease minor vascular complications such as postoperative bleeding and hematoma. (The Journal of Foot & Ankle Surgery xx(x):xxx, 2007)

Key words: ankle arthroscopy, portal, malleolar artery, complication

Ankle injuries are quite frequent, and ankle arthroscopy has become more popular as a diagnostic and therapeutic procedure (1). Like any surgical procedure, ankle arthroscopy is associated with a risk of complications, which has increased because of the increasing number of more demanding procedures. The incidence of complications for this procedure was noted to be between 0.7% and 17% in different series (2–4). Neurological injuries account for the majority of the complications and are mostly related to portal placement. The anterocentral portal is more commonly associated with complications; however, injury has been reported with the use of more popular anteromedial and anterolateral portals (5–7). Although the localization of portals and their relationship with neurovascular structures is well known, there is no report mentioning relatively minor neurovascular structures at risk during this procedure. We thought that it was important to consider other structures to avoid complications including postoperative bleeding and hematoma, and hypothesize that the distances between vascular structures and standard portals change with ankle position and a safe position can be determined. This cadaveric study of the standard ankle arthroscopy portals determines the proximity of the portals to the medial and lateral malleolar arteries and addresses the course of these arteries to decrease potential neurovascular injury.

Materials and Methods

To determine the course of medial and lateral malleolar arteries and their distance from anteromedial and anterolateral portals for ankle arthroscopy, 18 ankles from 9 formaldehyde-fixed human cadavers were dissected. The mean age of the cadavers was 42 (16-68) years. Seven were men

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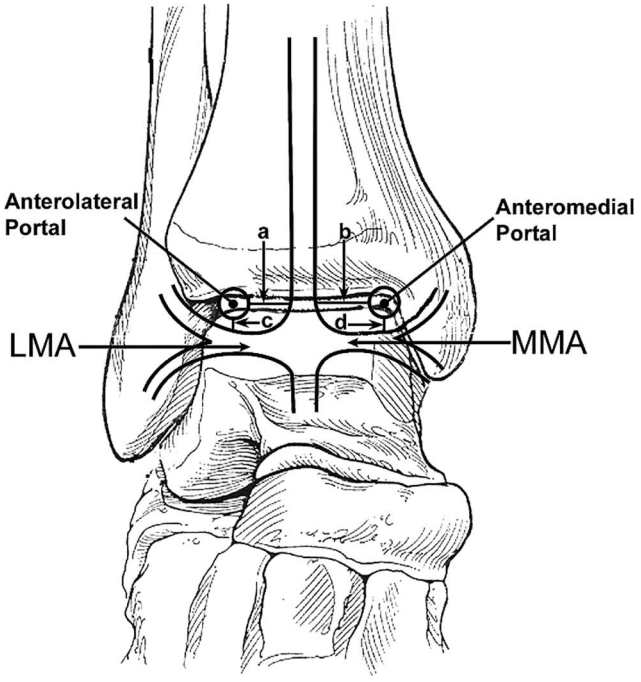

FIGURE 1 A diagram of the anatomy and relationship between the anterolateral-anteromedial portals and the medial-lateral malleolar arteries together with measured distances.

and 2 were women. Microscopic magnification (12×) was used for precise dissection. The popliteal artery of all pairs of cadaver legs was cannulated and infused with colored latex. Dissections and measurements were carried out by a team that included all authors. Initially, standard arthroscopic portals were placed as follows: the anteromedial portal was placed at level of ankle joint line medial to the tibialis anterior tendon, and the anterolateral portal was placed at ankle joint level lateral to the peroneus tertius tendon. The medial, lateral malleolar arteries were isolated, and trochars were inserted into both portals. After the trochar placement, the dissection was performed as follows: the skin, subcutaneous fat, and superficial fascia were carefully removed. Exposure was started proximally with blunt mobilization of the tibialis anterior and extensor digitorum longus tendons, and exposure of the tibialis anterior, dorsalis pedis artery was performed. The tibialis anterior artery (dorsalis pedis) to the foot and its branches (medial and lateral malleolar arteries) was isolated from the point of origin and dissected to the malleoli. An electronic caliper was used for measurements. Various parameters of the medial and lateral malleolar arteries and their relationship with ankle arthroscopy portals were measured as follows: 1) the transverse distance between dorsalis pedis and anteromedial, anterolateral portals (a, b); and 2) the vertical distance between the anteromedial portal and medial malleolar artery (c), and between the anterolateral portal and lateral malleolar artery (d) (Fig 1). The distances between F1

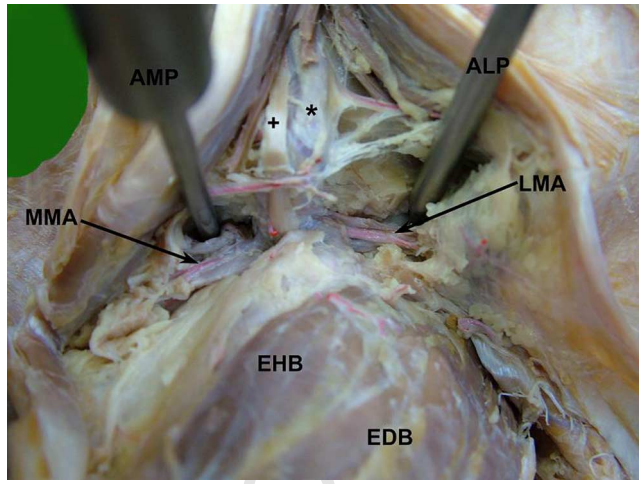

FIGURE 2 A photograph revealing a decrease of the distances between malleolar arteries and standard portals in the dorsiflexed position. (Tendons were retracted for demonstration.)

the malleolar arteries and the standard anteromedial and anterolateral portals (c, d) were measured 2 times at different plantarflexion degrees: 0° and 40° plantarflexion. Significance of flexion extension difference was determined by Wilcoxon signed-rank test, and $P < .01$ was accepted as significant.

Results

The origin of medial and lateral malleolar arteries was close to the ankle joint level. The arteries coursed almost transversely parallel to the joint line. The average distance AQ: 2 between the portals and malleolar arteries was measured both in plantarflexion and dorsiflexion. The average distance was 4.73 mm (range, 1.97-10.16 mm) in plantarflexion and 1.58 mm (range, 0-3.61 mm) in dorsiflexion for the medial side. For the lateral malleolar artery, the average distance in plantarflexion and dorsiflexion was 6.41 mm (range, 4.75-11.37 mm) and 2.77 mm (range, 1.81-4.79 mm), respectively. These distances tend to increase from dorsiflexion (Fig 2) to full plantarflexion (Fig 3). The trans- F2-3 verse distances were identical in plantarflexion and dorsiflexion: 14.63 mm (12.05-20.56 mm) for medial and 15.09 mm (range, 12.09-20.76 mm) for lateral, respectively. The anteromedial and anterolateral portals should be placed in plantarflexion to avoid such injury, and the incision for the portals should involve only skin, not deep structures. The sheath of the arthroscope and sharp trocar should be placed in a flexed position.

When the position of the foot was evaluated as a factor on a safe zone with the Wilcoxon signed-rank test, it was observed that plantarflexion of the ankle during portal placement significantly increased the distance between the artery and portal ($P < .005$).

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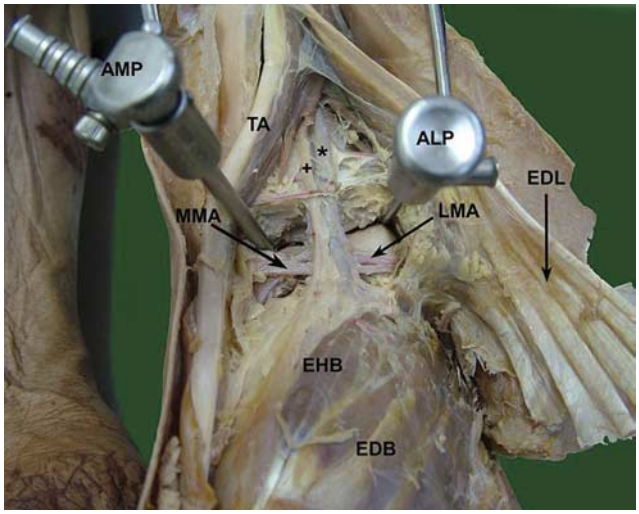

FIGURE 3 In the plantarflexed position, the distances between malleolar arteries and standard portals increase position. (Tendons were retracted for demonstration.) *AMP*, anteromedial portal; *ALP*, anterolateral portal; *EHB*, extensor hallucis brevis; *EDB*, extensor digitorum brevis; *MMA*, medial malleolar artery; *TA*, tibialis anterior; *EDL*, extensor digitorum longus; *LMA*, lateral malleolar artery; *asterisk*, dorsalis pedis artery; *plus sign*, deep peroneal nerve; *a*, anterolateral portal-dorsalis pedis; *b*, anteromedial portal-dorsalis pedis; *c*, anterolateral portal–MMA; *d*, anteromedial portal-LMA.

Discussion

Arthroscopy of the ankle has been increasingly applied to the diagnostic and therapeutic treatment of ankle disorders in recent years (1, 8). The techniques, equipment, and instrumentation have been developed, and execution of more demanding arthroscopic procedures has become possible. Arthroscopic techniques have well-known benefits including direct visualization without wide arthrotomy, decreased surgical dissection and morbidity, and an earlier return to athletic activity for the patient (1). However, it has a certain risk of complications similar to those for arthroscopy of other joints, mainly neurovascular injury.

In one of the earlier series, Small reported a 0.7% complication rate in 146 cases (2). However, in the majority of the series, the complication rate of ankle arthroscopy ranged from 9% to 17% (1, 3, 4). Most of these complications were neurologic and associated with portal placement. Vascular complications also exist, and formation of pseudoaneurysm of tibialis anterior artery was reported in 4 cases (6, 7, 9, 10). The most commonly used anterior portals are anteromedial and anterolateral portals. Anteromedial and anterolateral portals are placed medial to the tibialis anterior tendon and lateral to the peroneus tertius tendons at the level of the ankle joint, respectively. An anterocentral portal has been described but is rarely used because of increased risk of neurovascular damage (11). Ankle arthroscopy is considered to be safe, especially with anterior approaches, with the exception of the central portal. The vascular injuries reported were attributed to the close proximity of the anterior tibial artery and anterior ankle capsule, together with aggressive anterior synovectomy, which may damage the arterial wall. It may occur in both the anterocentral or anteromedial-lateral portals (6, 10).

The relationship between major vascular structures and standard portals was well established (for example, the tibialis anterior artery, saphenous vein, and superficial peroneal nerve); however, relatively minor structures were usually ignored (1, 8, 12). In one case of pseudoaneurysm of the anterior tibial artery, normal flow was seen distal to the damaged artery after ligation of the damaged artery, which may be attributed to an injury of the anterior tibial artery branches (6). AQ: 3

Although vascular injuries after arthroscopy, especially ankle arthroscopy, are quite rare, we believe that minor injuries occur in daily practice such as relatively minor postoperative bleeding and hematomas (10). Anatomic variations of the artery, mainly lateral deviation, which is present in up to 5.5% of people, may increase the risk of vascular injury (13). Darwish et al recommended preoperative mapping of the anterior with duplex scan or handheld Doppler to avoid such complication (6). The average distance between major neural and vascular structures was around 6 to 10 mm, which may be accepted as safe (14, 15). Our study is mainly focused on the ignored branches of the anterior tibial artery, which appear to be in close proximity with the routine anteromedial and anterolateral portals. The malleolar arteries seemed to be in line with the ankle joint line in the neutral position, which increases the risk of damage during both anteromedial and anterolateral portal placement. The proximity increases with dorsiflexion of the ankle parallel to the opportunity of damage. However, the distance between the malleolar arteries and portal sites increases up to 3.15 mm for the medial malleolar artery and 3.64 mm for the lateral malleolar artery with plantarflexion of the ankle, which makes this portal placement safer. Although the results were statistically significant, we recognize the limited number of dissections and the intrinsic limitations of cadaver models, which have different mobilities and underestimate or overestimate the neurologic and vascular injuries. However, they aid in determining a safe zone in various procedures effectively. In daily practice, the risk of vascular injury is quite high during the application of sharp and blunt trocars through the portals several times. AQ: 4

This cadaveric study suggests routine plantarflexion of the ankle during portal placement and application of trocars for 2 reasons. First, the distance between the medial, lateral malleolar arteries and standard portals increases in this particular position. Second, after application of trocars, the risk of injury is reduced so it will not make the arthroscopic procedures more difficult. Further studies are required to

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determine whether plantarflexion has any positive impact on the clinical risk of vascular injury.

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AQ1— Please provide degrees for all authors.

AQ2— Changed “they” to “the arteries.” Correct?

AQ3— Changes to sentence beginning, “The relationship between...” OK?

AQ4— Please add a noun after “anterior” here.