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FOOT & ANKLE

Complications of ankle arthroscopy: frequency, prevention, and treatment

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- The complication rate of ankle arthroscopy (AA) ranges from 3.5% to 14%.
- To avoid such complications, it is essential to have a thorough understanding of the anatomy of the ankle, to perform the procedure very carefully and with appropriate instrumentation, and to use a non-invasive distraction technique.
- The most frequent complications are neurological (cutaneous nerve injuries), which are usually caused by direct injury during arthroscopic portals or by a distracting pin when using an invasive distraction technique. They usually resolve spontaneously within a few months.
- The iatrogenic formation of a pseudoaneurysm is a severe but extremely rare complication (an incidence of 0.008%).
- There are several treatments for pseudoaneurysms: external compression; direct thrombin injection, surgical intervention (resection of the damaged segment of the artery and reconstruction with a reversed long saphenous vein interposition graft), and endovascular embolisation.
- Other rare complications include wound infections (localised superficial infection), problems at the portal incisions (prolonged portal drainage, residual pain in the portal, portal scar dehiscence, cyst at the portal site), type I complex regional pain syndrome, instrument breakage, painful scars and nodules, and a number of other rarer complications.
- In conclusion, when performing AA, it is important to remember the potential complications and try to avoid them. When they do occur, it is essential to diagnose and treat them appropriately.

Keywords: ankle arthroscopy; complications; treatment

Introduction

Ankle arthroscopy (AA) has been an important diagnostic and therapeutic tool in orthopaedic surgery for more than two decades (1). AA is a minimally invasive technique for the diagnosis and treatment of various ankle conditions. It has several advantages over open surgery: less surgical morbidity, less postoperative pain, and an earlier return to preoperative activities (2).

AA has provided good to excellent results (up to 90%) in the literature for the treatment of certain intra-articular

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disorders of the ankle. However, due to the superficial location of the ankle joint and its abundance of neurovascular structures, the complications of AA are greater than those occurring in other joints (3). Furthermore, as the indications for AA increase, so do its complications (4).

As early as 1996, Ferkel *et al.* indicated AA for patients with ankle pain, swelling, locking, and instability who did not respond to non-surgical treatment (5). Subsequently, the indications for AA have been expanded (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38). Table 1 summarises the current indications for AA. Figure 1 shows a case of arthroscopic excision of a bony spur in the anterior distal tibia that caused painful anterior bony impingement of the ankle. Figure 2 shows a case of osteochondral lesion of the talus treated by means of arthroscopic debridement. Figure 3 shows a case of chronic ankle instability arthroscopically treated.

The purpose of this article is to perform a narrative review of the literature on the complications of AA (excluding those concerning arthroscopic ankle arthrodesis), their incidence, prevention, and treatment.

Complications of ankle arthroscopy

A complication rate after AA of 9% was published in 2001. These complications included neurological, tendon and ligament injuries, wound complications, infections and instrument breakage. The most frequent complication was neurological injury. Most of the complications associated with AA were transient and resolved in approximately 6 months. The only complication that persisted at 10 years follow-up in that publication was numbness at the incision site (1).

Table 1 Indications of ankle arthroscopy.

Indications
Synovitis (arthroscopic synovectomy)
Anterior bony impingement (bony spur excision)
Loose body (removal)
Anterolateral soft tissue impingement syndrome
Chronic ankle instability
Osteochondral lesion debridement (talus, osteochondritis dissecans)
Partial talectomy
Arthroscopic Broström procedure
Excision of painful os trigonum
Flexor hallucis longus tendinitis (tenolysis)
Insertional Achilles tendinitis
Partial calcanectomy
Arthroscopic ankle debridement for posttraumatic arthrofibrosis
Arthroscopic ankle arthrodesis

In 2011, Young *et al.* analysed 294 AAs performed following an intraoperative noninvasive distraction protocol. There were 20 complications (6.8%); 16 were neurological complications (6 were related to the portal anterolateral, and 8 patients had dysesthesias affecting the dorsal part of the midfoot). The four non-neurological complications were one deep vein thrombosis, one case of prolonged portal drainage, and two superficial infections (6).

In a study of 246 AAs, with a mean follow-up of 10.7 months published in 2012, Deng *et al.* observed that arthroscopy performed in combination with adjunctive procedures showed a trend towards a higher complication rate, but without statistical significance. Twenty cases (7.69%) had AA-related complications. The most frequent complication was cutaneous nerve injury, which affected nine cases (3.46%), and localised superficial infection, which affected eight cases (3.08%). Superficial peroneal nerve injury (SPN) accounted for five of the cutaneous nerve injuries. All cases of postoperative superficial infection resolved with antibiotic treatment and none of them required reoperation (4).

In a level II evidence study published in 2012 by Zengerink and van Dijk, a consecutive series of

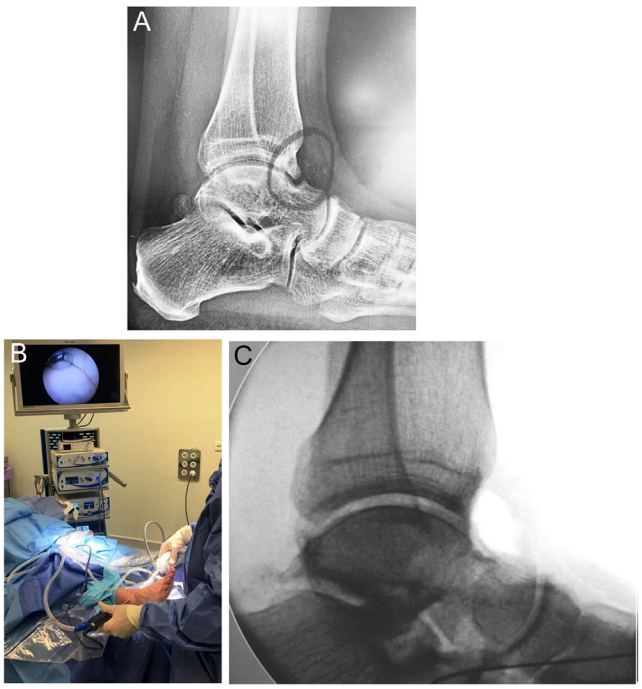

Figure 1

Arthroscopic excision of a bony spur in the anterior distal tibia that caused painful anterior bony impingement of the ankle: (A) anteroposterior radiograph of the ankle showing the osteophyte (circle); (B) intraoperative image of the arthroscopy equipment used and the two arthroscopic portals performed (anterolateral and anteromedial); (C) intraoperative fluoroscopy image showing that the osteophyte had been completely resected.

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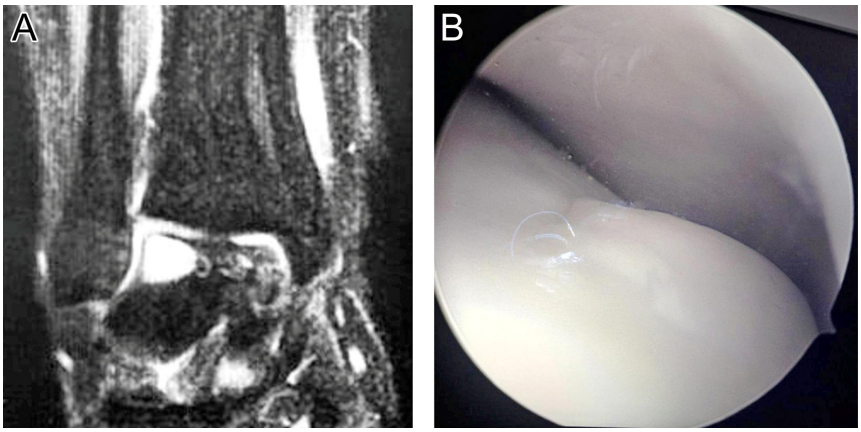

Figure 2

Osteochondral lesion of the talus treated by means of arthroscopic debridement: (A) MRI (magnetic resonance imaging) coronal view before surgery; (B) arthroscopic intraoperative view of the talar lesion.

patients undergoing AA between 1987 and 2006 was reviewed. Anterior AA was performed using a two-portal dorsiflexion method with intermittent soft tissue distraction. Posterior AA was performed using a two-portal hind foot approach. An overall complication rate of 3.5% was found in 1305 procedures. Neurological complications (1.9%) were related to portal placement. Age was a significant risk factor for the occurrence of complications. Most complications, which occurred at a rate of 3.5%, were transient and resolved within 6 months. The complications did not result in functional limitations. Residual discomfort did not influence daily activities. Posterior AA of the ankle using a two-portal hind foot approach was a safe procedure with a complication rate that compared favourably with that of anterior AA (7).

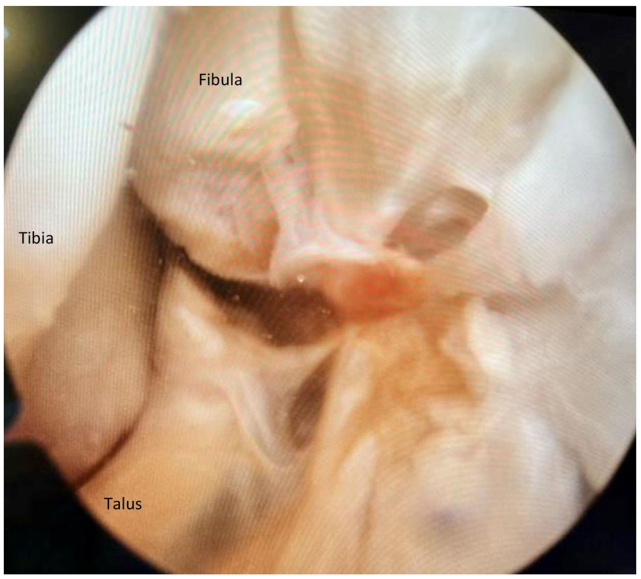

Figure 3

Arthroscopic image of chronic ankle instability. Note the almost complete absence of the anterior talofibular ligament. The problem was resolved by arthroscopic reanchoring of the ligament remnant to the fibula using a harpoon.

In 2016 Blázquez Martín *et al.* analysed 257 arthroscopies, 23% of which were performed at the subtalar joint and 77% at the ankle joint. An anterior approach was used in 69% of cases, a posterior approach in 26% and a combined approach in the remaining 5%. A total of 31 complications (12.06%) were encountered. The most frequent complication was neurological injury (14 cases), with the most affected nerve being the SPN (8 cases). Persistent drainage through the portals was observed in 10 cases, with 4 cases of infection, and 3 cases of type I complex regional pain syndrome (CRPS) (8).

In 2019 by Ahn *et al.* reviewed 514 patients (388 men, 126 women) who had AA performed using a non-invasive distraction technique. Their mean age was 37.2 years; the mean duration of follow-up was 33 months. The diagnoses were anterior bony impingement, anterolateral soft tissue impingement syndrome, chronic ankle instability, and osteochondral lesion of talus. Ahn *et al.* performed several types of surgery: arthroscopic synovectomy, osteochondral procedure, bony spur excision, and loose body removal. The mean operative time was 47 min. There were eight neurological complications, three skin necrosis of the posterior thigh, two surgical instrument breaks, and one superficial wound infection. All complications resolved well. The total duration of distraction plus tourniquet inflation exceeded 120 min in all three cases of skin necrosis. This complication was considered to be due to the long tourniquet duration (9).

Specific complications

Neurological complications

An analysis of 612 patients undergoing AA published in 1996 by Ferkel *et al.* showed a complication rate of 9% (55 complications). There were 27 neurological complications (4.4% of all AA), which accounted for 49.1% of the observed complications. Specifically, the SPN was injured in 15 cases, the sural nerve in 6, the saphenous nerve in 5, and the deep peroneal nerve in 1. All nerve injuries were caused by direct portal injury or a distractor pin (5). In 1998 Freedman *et al.* presented a case of complete

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division of the posterior tibial nerve resulting from apparently overly aggressive intra-articular manipulation during AA performed for loose body removal (10).

In 2001, a case was published of SPN injury following AA in a 20-year-old woman operated on for chronic ankle pain following a sprain. After the operation, the patient complained of pain in the dorsum of the right foot, radiating from the anterolateral portal to the dorsomedial aspect of the foot. Eight months after arthroscopy, a neuroma was detected in the intermediate dorsal cutaneous nerve and a neurolysis of the SPN was performed. Symptoms gradually decreased after surgery, disappearing completely at 45 months. To avoid injury to the SPN, Takao *et al.* stated that the safest placement of the anterolateral portal was 2 mm lateral to the peroneus tertius tendon (11).

An injury to the posterior tibial nerve following AA was published in 2008 (12). Abdul-Jabar *et al.* reported a complete division of the posterior tibial nerve during an anterior AA combined with an additional posterolateral portal. According to these authors, the complication was due to poorly controlled use of arthroscopic instruments (3).

Type I complex regional pain syndrome

One case of type I CRPS was identified by Ferkel *et al.* after AA (5). CRPS is a chronic pain syndrome that is often instigated by postoperative or post-traumatic events (39). In 2011, Shah and Kirschner stated that CRPS is a challenging pain condition for physicians and patients, with a natural history characterised by chronicity and relapses that can lead to substantial disability. CRPS is difficult to detect and manage and needs close follow-up to ensure that progress is being made. Early diagnosis and management are needed to avert a long-standing or permanent disability. Clinical features such as spontaneous pain, oedema, hyperalgesia, temperature or sudomotor changes, motor function abnormality, and autonomic changes are the hallmarks of this condition. The treatment of CRPS includes medications, physical therapy, regional anaesthesia, and neuromodulation (40).

In a systematic review published in 2023 by Sobeeh *et al.* it was affirmed that diffuse thermal and mechanical hypoesthesia with primary and secondary hyperalgesia, enhanced pain facilitation evidenced by increased area of pinprick hyperalgesia, and elevated pain ratings are dominant in adults with CRPS. Adolescents and children with CRPS showed less severe sensory abnormalities (41). In 2023, Cruz *et al.* stated that applications of the capsaicin (capsaicin 8% patch) can be a viable alternative for some patients suffering CRPS (42). In 2023 Reinhold *et al.* identified progressively reduced micro-RNA-223 (miR-223) as a biomarker of chronic CRPS pain. Clinically, their study underlined the importance of early diagnosis and treatment showing that high initial pain does not predict an unfavourable outcome. Finally, pain alleviation and recovery of sensory disturbances appeared independent processes (43).

In 2023 Duong *et al.* evaluated and compared the healthcare costs, time to fitness for work (TFW) between CRPS and non-CRPS. They found that the healthcare costs were higher for CRPS than non-CRPS patients, but the TFW was comparable. This study demonstrated also the significant associations of disability and biopsychosocial factors with the healthcare costs and TFW in CRPS patients (44). According to Naskar *et al.* the role of the sympathetic nervous system appears to be central in causing pain in CRPS. The stellate ganglion block (SGB) using additives with local anaesthetics is an established treatment modality. They compared the efficacy and safety of clonidine with methylprednisolone as additives to ropivacaine in the SGB for treatment of CRPS. The use of additives, both methylprednisolone and clonidine, was safe and effective for the SGB in CRPS. The significantly better improvement in joint mobility with methylprednisolone suggested that it should be considered promising as an additive to local anaesthetics when joint mobility is the concern (45).

Pseudoaneurysms

Iatrogenic pseudoaneurysm formation is a rare complication following arthroscopy, with an incidence of 0.008%, although its diagnosis can go undetected (13, 14). The most common pseudoaneurysm is that of the distal anterior tibial artery (d-ATA), and many clinical cases of such lesions have been published (13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24). Other arteries can also be affected by pseudoaneurysm formation. In 2014 Battisti *et al.* described a clinical case of pseudoaneurysm of the peroneal artery (25). Kashir *et al.* published a case of iatrogenic formation of a pseudoaneurysm of the dorsalis pedis artery (DPA) following AA, using standard anteromedial and anterolateral portals. This rare complication required surgical exploration and ligation, and the patient recovered without complications (26).

In a systematic review of case series published in 2019 by Yammine *et al.*, it was stated that delays in diagnosis are common and could lead to overlying skin necrosis (27). Data from 23 patients with a mean age of 40.9 years were extracted and analysed. The results showed that d-ATA and DPA were affected in 18 and 4 cases, respectively. A single case of fibular artery pseudoaneurysm was described. The mean size of the pseudoaneurysm was 4.2 × 3.9 × 2.1 cm. The mean time to diagnosis of pseudoaneurysm was 50.45 days. The most frequent surgical indications were anterior synovectomy and removal of anterior osteophytes, and ligation was the most common procedure in the treatment of this complication. Yammine *et al.* stated that the variability of the anatomical position of the d-ATA and/or DPA and its involvement with foot position and distraction during AA could play an important role in arterial injury, although portal placement could

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also be a minor factor. Synovectomy and removal of anterior, particularly big-sized, osteophytes could also be considered risk factors. A state of hypocoagulability could affect the healing of the lesion and, consequently, the formation of pseudoaneurysms. The diagnosis of pseudoaneurysm should be considered whenever persistent or pulsatile inflammation is observed over a portal incision (27).

In 2022, Kostenko *et al.* presented a case of d-ATA pseudoaneurysm after AA and Broström procedure (to treat ankle instability) treated with direct thrombin injection (28). A 40-year-old male patient presented with progressive pain and swelling in the anterior aspect of the left ankle 5 months after left ankle arthroscopy and the Broström procedure. Magnetic resonance imaging (MRI) and ultrasound were compatible with a pseudoaneurysm of the d-ATA. He was referred to interventional radiology for treatment. The pseudoaneurysm was successfully treated by ultrasound-guided direct injection of thrombin. Kostenko *et al.* discussed the methods that can be used to treat a pseudoaneurysm: external compression, direct thrombin injection, endovascular treatment, and surgical intervention. According to Kostenko *et al.*, of the treatments mentioned, direct thrombin injection has shown the best combination of efficacy, complication rate and recurrence rate, and therefore appears to be the preferred treatment for pseudoaneurysm (28). Figure 4 shows a three-dimensional CT angiogram demonstrating pseudoaneurysm formation of the anterior tibial artery following ankle arthroscopy.

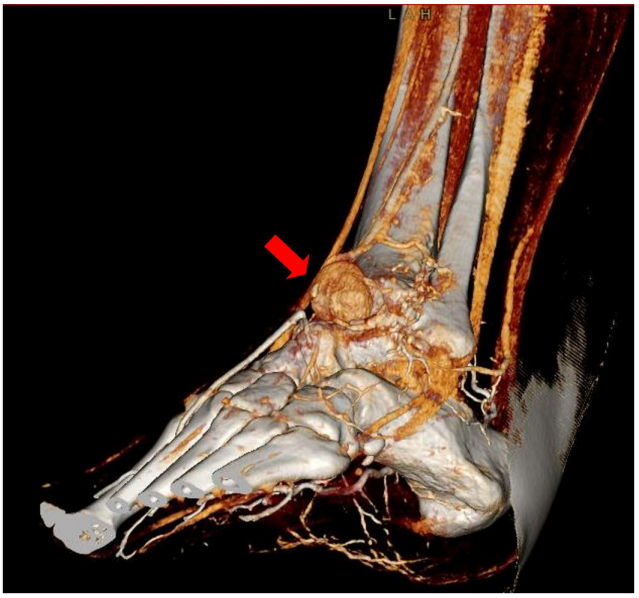

Figure 4

Three-dimensional CT angiogram demonstrating pseudoaneurysm formation of the anterior tibial artery (arrow) following ankle arthroscopy. The complication resolved favourably by arterial embolisation.

Acute compartment syndrome

Foot compartment syndrome is a rare condition. The clinical presentation is frequently less clear than other limb compartment syndromes and needs high clinical suspicion with a low threshold for direct measurement of compartment pressure. Controversy exists regarding the number of anatomic compartments and the most efficacious management. Both acute surgical intervention and delayed treatment can lead to substantial morbidity and long-run sequelae (46).

Imade *et al.* presented a case of leg anterior compartment syndrome following AA after a Maisonneuve fracture (29). A 21-year-old footballer experienced a left ankle sprain, and plain radiographs of the left ankle showed a lateral dislocation of the talus without obvious fractures. Plain radiographs of his left lower extremity showed a spiral fracture of the proximal fibula approximately one-third distal to the fibular head. Based on these findings, a diagnosis of Maisonneuve fracture was made. He was treated by AA and drilling of the talar osteochondral injury, followed by arthroscopic visualisation of the ankle during screw fixation of the syndesmosis. Six hours after surgery, the patient complained of lower extremity pain. Acute compartment syndrome was diagnosed and an emergent fasciotomy was performed. One year after surgery, he was able to fully participate in athletic activities (29).

Han *et al.* presented a case of acute compartment syndrome during AA in an atraumatic patient (30).

Iatrogenic excision of the distal fibula

In 1999, Schmidt and Reddy described a case of AA in which the surgeon excised the distal fibula while attempting to remove a loose body. They stated that a reasonable solution to the problem would have been an ankle fusion. However, they performed osteoarticular fibular grafting, achieving a successful clinical and radiological outcome after 34 months of follow-up (31).

Peroneal tendon irritation after Broström procedure

In 2019 Lee *et al.* reported that with advances in AA, the number of arthroscopic modified Broström procedures (MBPs) was increasing (32). Indeed, all-inside arthroscopic MBP has yielded good to excellent results in the literature, albeit with some risk of complications. Lee *et al.* described a rare complication of arthroscopic MBP. A 34-year-old woman presented with severe right ankle pain and underwent arthroscopic MBP for lateral ankle instability. Approximately 6 months postoperatively, she presented with severe pain in the lateral aspect of the right ankle, especially when walking. Physical examination revealed marked swelling around the ankle and focal tenderness in the posterolateral malleolar area. Ankle ultrasonography revealed a diffuse low-echoic mass-like lesion at the distal fibula between the fibular tip and peroneus tendon. T1-weighted sagittal MRI images revealed an irregularly

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shaped mass-like lesion with a heterogeneous signal near the distal fibula posteriorly where the anchor protruded. The suture anchor in the posterior distal fibula zone, which had irritated the peroneus tendon, was removed with debridement of the granulomatous lesion. At the 3-month follow-up, the patient was almost asymptomatic and had almost full range of movement. At 1 year, no complications or recurrent symptoms were observed. According to Lee *et al.*, three-dimensional CT studies of the appropriate fibular depth and position of suture anchors are needed to standardise the procedure and reduce complications (32).

Complications of posterior ankle arthroscopy

Nickisch *et al.* analysed 186 patients (189 ankles) undergoing posterior ankle and hind foot arthroscopy, performed with the use of posteromedial and posterolateral portals with the patient in the prone position (33). Eighty-two were men and 104 were women; their mean age was 37.1 years. The minimum duration of follow-up was 6 months, and the mean was 17 months. The most frequent preoperative intra-articular diagnoses were subtalar osteoarthritis (46 ankles), an osteochondral lesion of the talus (42 ankles), posterior ankle impingement (34 ankles), ankle osteoarthritis (20 ankles) and subtalar coalition (5 ankles). The most frequent extra-articular diagnoses were painful os trigonum (46 ankles), flexor hallucis longus tendinitis (32 ankles), and insertional Achilles tendinitis (5 ankles). The most frequent intra-articular procedures were osteochondral lesion debridement (44 ankles), subtalar debridement (38 ankles), subtalar fusion (33 ankles), ankle debridement (30 ankles), and partial talectomy (9 ankles). The most frequent extra-articular procedures were os trigonum excision (48 ankles), tenolysis of the flexor hallucis longus tendon (38 ankles) and endoscopic partial calcanectomy (5 ankles). There were 16 complications (8.5%); plantar numbness (4 ankles), sural nerve dysesthesia (3 ankles), Achilles tendon tightness (4 ankles), type I CRPS (2 ankles), infection (2 ankles), and posteromedial portal cyst (1 ankles). One case of plantar numbness and one case of sural nerve dysesthesia did not resolve (33).

In a systematic review with level IV evidence published in 2013 on posterior AA, 452 ankles (452 patients) were analysed. Seventeen complications (3.8%) occurred, although only eight (1.8%) required additional treatment or surgical intervention (34).

Yáñez-Arauz *et al.* analysed the results of posterior AA in 49 patients (33 men, 16 women). Their mean age was 38.6 years and the mean follow-up was 28 months. There were seven complications (14.3%): paresthesia and/or hypoesthesia of the sural nerve (four cases), residual pain in the portal (two cases), and portal scar dehiscence (one patient). The mean improvement of the visual analogue scale (VAS) was 5.53 points, and the improvement of the AOFAS (American Orthopedic Foot and Ankle Society) score averaged 35.78 points (35).

In a review article, Zekry *et al.* studied the complication rates associated with anterior and posterior ankle arthroscopy. The overall complication rate of ankle arthroscopy ranged from 3.4% to 9%. No life-threatening complications with anterior and posterior ankle arthroscopy were identified in the literature. The most frequent complication after anterior and posterior ankle arthroscopy was SPN injury and temporary Achilles tendon tightness, respectively (36). Tables 2 and 3 summarise the complications of ankle arthroscopy (excluding those from arthroscopic ankle arthrodesis).

Prevention of complications

To avoid complications in AA, it is essential to have a thorough knowledge of the anatomy of the ankle joint and to perform the procedure carefully and with appropriate instrumentation (1). Non-invasive distraction techniques should be used (6). The use of the dorsiflexion method for anterior AA can prevent a significant number of complications (7). Careful preoperative planning and adequate postoperative care are important (2, 8). The distraction plus tourniquet requires attention because it can lead to elevated pressure on the posterior thigh leading to soft tissue injury (9).

A variety of complications can occur in anterior AA. The structures most prone to iatrogenic damage are the vessels and nerves; although the vessels and nerves are macroscopically visible and palpable in slightly more than 50% of cases, their arterial branches are not visible because they are located deeper. Lughi *et al.* have investigated how to reduce iatrogenic damage to the complex and variable neurovascular network of the anterior aspect of the ankle. They have performed ultrasound mapping of the neurovascular structures, concluding that ultrasound-assisted mapping is a non-invasive, fast, and safe procedure that can help reduce potential iatrogenic damage when performing anterior AA (37).

According to Tsuyuguchi *et al.*, injury to the intermediate dorsal cutaneous nerve (IDCN) and medial dorsal cutaneous nerve (MDCN) is a common complication during anterior portal placement (38). To avoid such injuries, methods such as topographical palpation of the nerves and marking of the nerves by transillumination of the skin with an arthroscope have been proposed. Recently, Tsuyuguchi *et al.* have developed a venous imaging system that projects images of the subcutaneous vasculature directly onto the skin with the use of near-infrared (NIR) light. Given that anatomical studies have shown that superficial veins accompany IDCN and MDCN, protecting the subcutaneous veins could reduce the risk of nerve injury (38).

In patients with coagulopathy, preventive measures include careful dissection when performing portals, preoperative mapping of the artery with a duplex or

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Table 2 Complications of ankle arthroscopy in the literature.

Study	Year	Study type	LoE	*n*	Complication rate	Conclusions
Ferkel *et al.* (5)	1996	Case series	NA	612	9% (55 complications: 27 of them were neurological complications).	The SPN was injured in 15 cases, the sural nerve in 6, the saphenous nerve in 5, and the deep peroneal nerve in 1. All nerve injuries happened through direct injury by portal or distractor pin placement. Also, 1 case of complex regional pain syndrome was found.
Freedman & Barron (10)	1998	Case report	NA	1	Complete division of the posterior tibial nerve due to an overaggressive intra-articular manipulation during ankle arthroscopy carried out for loose body removal.	All neurological complications in the literature have been attributed to the use of a distractor pin or to portal placement. There is the possibility of damaging the deep peroneal nerve from the utilisation of motorised arthroscopic tools within the anterior ankle joint capsule.
Salgado *et al.* (13)	1998	Case report	NA	1	Pseudoaneurysm of the distal anterior tibial artery.	The pseudoaneurysm was successfully resected without adverse events.
Schmidt & Reddy (31)	1999	Case report	NA	1	Iatrogenic excision of the distal fibula when removing a loose body.	At 34 months osteoarticular fibular grafting was successful.
Mariani *et al.* (15)	2001	Case report	NA	1	Pseudoaneurysm of the anterior tibial artery after arthroscopic ankle synovectomy.	Previously reported anatomic variations of the tibial artery and its close relationship with the anterior ankle capsule might complicate arthroscopic surgery, especially when aggressive synovectomy is carried out.
Takao *et al.* (11)	2001	Case report	NA	1	Eight months after arthroscopy, a neuroma developed on the intermediate dorsal cutaneous nerve. Neurolysis of the SPN was carried out.	To avert SPN injury, the safest placement of the anterolateral portal is 2 mm lateral to the peroneus tertius tendon.
Ferkel *et al.* (1)	2001	Review article	NA	NA	Complication rate: 9%. Numerous complications can happen in ankle arthroscopy, such as neurologic, tendon, and ligament injuries, wound complications, infections, and instrument breakage. The most frequent complication is neurologic injury.	The majority of complications related to ankle arthroscopy is temporary and tend to solve within 6 months. The only complication that continued at 10 years follow-up was a neurologic injury, specifically, numbness at the incision site.
Darwish *et al.* (16)	2004	Case report	NA	1	Traumatic pseudoaneurysm of the anterior tibial artery.	The pseudoaneurysm was treated surgically and had an uneventful recovery.
Kotwal *et al.* (17)	2007	Case report	NA	1	Anterior tibial artery pseudoaneurysm detected 10 days after ankle arthroscopy in a haemophilic patient. Duplex ultrasound scan confirmed the diagnosis.	Evacuation of the haematoma, resection of the damaged segment of the artery, and reconstruction with a reversed long saphenous vein interposition graft was performed with success.
Cugat *et al.* (12)	2008	Case report	NA	1	Intra-articular damage to the posterior tibial nerve.	The standard posteromedial portal is highly risky due to the proximity of the posterior neurovascular structures.
Imade *et al.* (29)	2009	Case report	NA	1	Acute leg anterior compartment syndrome following ankle arthroscopy after Maisonneuve fracture.	Emergent fasciotomy solved the problem.

(Continued)

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Table 2 Continued.

Study	Year	Study type	LoE	*n*	Complication rate	Conclusions
Ramavath *et al.* (14)	2009	Case report	NA	1	Misdiagnosis of traumatic anterior tibial artery pseudoaneurysm, treated as postoperative arthroscopy infection.	Duplex ultrasound scan confirmed the diagnosis. Vascular surgery was successful.
Brimmo & Parekh (18)	2010	Case report	NA	1	Pseudoaneurysm of the anterior tibial artery following ankle arthroscopy with synovectomy.	Surgical treatment led to an uneventful recovery.
Kashir *et al.* (26)	2010	Case report	NA	1	Pseudoaneursym of the dorsalis pedis artery.	Surgical exploration and ligation solved the problem. The patient had an uneventful recovery.
Verbrugghe *et al.* (19)	2011	Case report	NA	1	Pseudoaneurysm of the anterior tibial artery after ankle arthroscopy that was undiagnosed for more than 10 weeks.	The pseudoaneurysm was resected successfully.
Jacobs *et al.* (20)	2011	Case report	NA	1	Pseudoaneurysm of the anterior tibial artery detected 2 weeks after ankle arthroscopy. The diagnosis was confirmed with a Doppler ultrasonography scan.	Endovascular embolisation of the pseudoaneurysm was carried out with success.
Young *et al.* (6)	2011	Case series	NA	294	6.8% (There were 4 non-neurologic complications, including 1 case of deep venous thrombosis, 1 case of prolonged portal drainage, and 2 cases of superficial infection. There were 16 neurologic complications; 6 were related to the anterolateral portal, and 8 patients had dysesthesias involving the dorsal part of the midfoot).	A significant benefit of the utilisation of small-joint arthroscopic instruments and noninvasive distraction techniques is a considerable decrease of the rate of non-neurologic complications
Deng *et al.* (4)	2012	Case series	NA	246	7.69% (The most frequent complication was cutaneous nerve injury (3.46%), and localised superficial infection (3.08%). Injury to the superficial peroneal nerve accounted for half of the cutaneous nerve injuries).	All cases of superficial postoperative infection was solved with antibiotic therapy, and none of the cases needed further surgery.
Nickisch *et al.* (33)	2012	Case series	NA	189	8.5% (*n* = 16; Four patients had plantar numbness, three had sural nerve dysesthesia, four had Achilles tendon tightness, two had complex regional pain syndrome, two had an infection, and one had a cyst at the posteromedial portal. One case of plantar numbness and one case of sural nerve dysesthesia failed to resolve).	These authors stated that that posterior ankle arthroscopy can be carried out with a low rate of major postoperative complications.
Zengerink & van Dijk (7)	2012	Case series	II	1305	3.5% (Neurological complications (1.9%) were related to portal placement. Age was a significant risk factor for the occurrence of adverse events. Most complications were temporary and solved within 6 months. Complications did not result in functional limitations. Residual complaints did not impact daily activities).	The utilisation of the dorsiflexion method for anterior ankle arthroscopy can avert a substantial number of adverse events. Posterior ankle arthroscopy by means of a two-portal hind foot approach was a safe procedure with a complication rate that compared favourably to that of anterior ankle arthroscopy.
Donnenwerth & Roukis (34)	2013	Systematic review	IV	452	3.8% (*n* = 17). Only 8 (1.8%) needed additional treatment or surgery.	Arthroscopic of the ankle was safe with a low rate of adverse events.
Battisti *et al.* (25)	2014	Case report	NA	1	Peroneal artery pseudoaneurysm.	NA

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Table 2 Continued.

Study	Year	Study type	LoE	*n*	Complication rate	Conclusions
Epstein *et al.* (2)	2015	Review	NA	NA	The main indications for anterior ankle arthroscopy are ankle instability, impingement,management of osteochondritis dissecans, synovectomy, and loose body removal.	Anterior ankle has potential complications. Mastery of ankle anatomy and biomechanics, careful preoperative planning and meticulous surgical technique. can diminish the risk of adverse events.
Abdul-Jabar *et al.* (3)	2016	Case report	NA	1	Complete division of the posterior tibial nerve during an anterior ankle arthroscopy combined with an additional posterolateral portal.	This complication was due to a poorly controlled use of the arthroscopic instruments.
Chamseddin & Kirkwood (21)	2016	Case report	NA	1	Anterior tibial artery pseudoaneurysm in a haemophilic patient.	
Blázquez Martín *et al.* (8)	2016	Case series	NA	257	12.06% (31/257). The most frequent complication was neurological damage (14 cases), with the most affected nerve being the SPN (8 cases). Persistent drainage through the portals was found in 10 cases, with 4 cases of infection, and 3 cases of complex regional pain syndrome type 1.	23% of the procedures were for subtalar joint pathology, and 77% of for ankle problems. Anterior approach was utilised in 69% of cases, posterior approach in 26%, and the remaining 5% by combined access.
Davis *et al.* (22)	2017	Case report	NA	1	Pseudoaneurysm of the anterior tibial artery diagnosed 12 months after arthroscopic ankle debridement for posttraumatic arthrofibrosis 2 years following a bimalleolar ankle fracture.	Pain and prominent swelling to anterior ankle. MRI demonstrated a large heterogeneous mass. Doppler ultrasound confirmed the mass to be a pseudoaneurysm of the anterior tibial artery
Tonogai *et al.* (23)	2017	Case report	NA	1	Pseudoaneurysm of the anterior tibial artery after ankle arthroscopy utilising an ankle distraction method.	Anastomosis for the anterior tibial artery injury was carried out successfully.
Tsuyuguchi *et al.* (38)	2018	Technical note	NA	NA	A vein imaging system was developed that projected images of subcutaneous vasculature directly onto the skin with the use of N-IR light to avert injury to the IDCN and the MDCN, which is a frequent complication during anterior portal placement.	This technique created an ankle arthroscopic portal using an NIR imaging system, which displayed the vein image on the skin, to avert injury to the superficial veins and, therefore, diminished IDCN and MDCN injuries.
Tonogai *et al.* (24)	2018	Case report	NA	1	Pseudoaneurysm of the perforating peroneal artery after ankle arthroscopy for traumatic OA associated with nonunion of the medial malleolus.	The perforating peroneal artery injury was repaired by performing end-to-end anastomosis. Before ankle arthroscopy, surgeons should carefully observe the course of the perforating peroneal artery on enhanced 3-dimensional CT, especially in patients with a history of trauma to the ankle joint.
Yammine *et al.* (27)	2019	Systematic review of case series	NA	23	23 pseudoaneurysms (diagnosis should be suspected when a non-resolving or pulsatile swelling over a portal incision is noticed).	The variability of anatomical location of the arteries and the impact of foot position and distraction during the procedure could play a role in the arterial injury. Synovectomy and excision of anterior, specifically big-sized, bony spurs could be deemed as risk factors as well. A state of hypocoagulability might impact injury healing and therefore pseudoaneurysm formation.

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Table 2 Continued.

Study	Year	Study type	LoE	*n*	Complication rate	Conclusions
Lee *et al.* (33)	2019	Case report	NA	1	Peroneal tendon irritation after arthroscopic modified Broström procedure	The suture anchor in the posterior distal fibula area, which had irritated the peroneus tendon, was removed with debridement of the granulomatous lesion.
Han *et al.* (30)	2019	Case report	NA	1	Acute compartment syndrome in an atraumatic patient.	NA
Ahn *et al.* (9)	2019	Case series	NA	514	2.7% (14/514) There were 8 neurologic complications, 3 skin necrosis of posterior thigh, 2 instrument breakages, and 1 superficial wound infection.	All complications were well resolved.
Zekry *et al.* (36)	2019	Review	NA	NA	3.4% to 9%.	The commonest adverse event after anterior and posterior ankle arthroscopy was superficial peroneal nerve injury and temporary Achilles tendon tightness, respectively.
Yáñez-Arauz *et al.* (35)	2021	Case series	NA	49	14.3% (7/49). Paresthesia and/or hypoesthesia of the sural nerve (four cases), residual pain in the portal (two cases), and portal scar dehiscence (one patient).	Posterior ankle arthroscopy without distraction through the classic posterolateral and posteromedial portals was a safe technique, with a low rate of adverse events.
Lughi *et al.* (37)	2022	NA	NA	NA	These authors detected bony and tendinous structures with an ultrasound mapping of the neurovascular structures.	Ultrasound-assisted mapping seemed to be a non-invasive, fast, and safe procedure that can help to diminish potential iatrogenic damage when carrying out anterior arthroscopic surgery.
Kostenko *et al.* (28)	2022	Case report	NA	1	Anterior tibial artery pseudoaneurysm after Broström procedure.	The complication was successfully solved with an ultrasound guided direct thrombin injection.

LoE, level of evidence; IDCN, intermediate dorsal cutaneous nerve; MDCN, medial dorsal cutaneous nerve; *n*, number of procedures; NA, not available; N-IR, near-infra red; OA, osteoarthritis; SPN, superficial peroneal nerve.

handheld Doppler and performing open rather than arthroscopic surgery to remove large osteophytes (17).

Preoperative mapping of vascular structures with a duplex or handheld Doppler is recommended (20). Before performing ankle arthroscopy, surgeons should carefully observe the path of the perforator peroneal artery on enhanced three-dimensional CT, especially in patients with a history of trauma to the ankle joint (24).

Treatment of complications

If the SPN lesion does not spontaneously regress, neurolysis should be performed (11). With respect to pseudoaneurysms, some authors have performed a resection of the pseudoaneurysm without complications, achieving early postoperative recovery without incident (13, 19). Other authors, after evacuating the haematoma, performed a resection of the damaged segment of the artery and reconstruction with a reversed long saphenous vein interposition graft, achieving an uneventful recovery (17).

Other authors have successfully performed surgical exploration and ligation of the pseudoaneurysm (26, 27). Pseudoaneurysms have also been resolved by endovascular embolisation (20). Direct injection of thrombin under ultrasound guidance is also an option (28).

Ultimately, there are several possible treatments for pseudoaneurysms, including external compression, direct thrombin injection, endovascular treatment, and surgical intervention. Of these treatments, direct thrombin injection has shown the best combination of efficacy, complication rate, and recurrence rate, making it the treatment of choice for pseudoaneurysms (28).

If acute compartment syndrome occurs, emergent fasciotomy is essential (29).

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Table 3 Complications of ankle arthroscopy.

Complication/manifestation
Neurologic complications
Numbness at the incision site, plantar numbness, dysesthesias involving the dorsal part of the midfoot, cutaneous nerve injury (superficial peroneal nerve, intermediate dorsal cutaneous nerve, medial dorsal cutaneous nerve), saphenous nerve injury, deep peroneal nerve, sural nerve dysesthesia or paresthesia, complete division of the posterior tibial nerve, posterior tibial nerve
Pseudoaneurysms
Distal anterior tibial artery, dorsalis pedis artery, peroneal artery, perforating peroneal artery
Portal problems
Haematoma at the portal site, prolonged portal drainage, residual pain in the portal, portal scar dehiscence, cyst at the portal site
Wound infections
Localised superficial infection
Complex regional pain syndrome type I
Instrument breakage
Painful scars and nodules
Fibula fracture
Deep vein thrombosis
Skin necrosis of posterior thigh
Temporary Achilles tendon tightness
Acute compartment syndrome
Iatrogenic excision of the distal fibula
Peroneal tendon irritation

Schmidt and Reddy stated that if an iatrogenic excision of the distal fibula occurs when attempting to remove a loose body, a reasonable solution would be to perform an ankle fusion, although osteoarticular fibular grafting can also be successful (31). This is an anecdotal case probably caused by inexperienced or overenergetic surgeons that should never happen. In other words, removal of the tip of the fibula should be avoided at all costs.

If peroneal tendon irritation occurs after Broström procedure because the suture anchor in the posterior distal fibula zone has irritated the peroneus tendon, debridement of the granulomatous lesion should be performed (32).

Discussion

AA is a useful and minimally invasive technique for diagnosing and treating a variety of ankle conditions. It has several advantages over open surgery: less surgical morbidity, less postoperative pain, and an earlier return to activity. AA provides good to excellent results (up to 90%) in the treatment of certain intra-articular disorders. However, due to the superficial location of the ankle joint and the abundance of neurovascular structures in the ankle joint, complications of AA are more frequent than those occurring in other joints. Furthermore, as the indications for AA increase, so do its complications. The rate of complications described in the literature ranges from 3.5% to 14%.

A thorough knowledge of ankle anatomy and intra-articular anatomy and non-invasive distraction techniques are essential to avoiding complications in AA. In anterior AA, the structures most prone to iatrogenic damage are vessels and nerves. They are macroscopically visible and palpable in slightly more than 50% of cases, but their arterial branches are not visible because they are located deeper. Ultrasound mapping of neurovascular structures is a non-invasive, fast, and safe procedure that can help reduce potential iatrogenic damage. Careful preoperative planning, meticulous technique and adequate postoperative care are important. The distraction plus tourniquet requires attention because it can lead to elevated pressure on the back of the thigh, leading to soft tissue injury. To avoid injury to the IDCN and MDCN during placement of the anterior portal, methods such as topographical palpation of the nerves and marking of the nerves by transillumination of the skin with an arthroscope have been proposed. Preoperative mapping of vascular structures with a duplex or handheld Doppler is another good preventive measure. In patients with coagulopathy, it is better to perform open rather than arthroscopic surgery to remove large osteophytes. In patients with a history of trauma to the ankle joint, the path of the peroneal perforator artery should be studied on enhanced three-dimensional computed tomography prior to AA.

The most common complication in AA is neurological injury to the SPN, in the form of numbness at the incision site. This complication usually resolves spontaneously and very rarely requires neurolysis. Pseudoaneurysms are extremely rare but should be suspected when there is postoperative bleeding or pain and swelling (sometimes pulsatile) in one of the arthroscopic portals. The diagnosis should be confirmed with Doppler ultrasonography scan of the ankle. There are several possible treatments for pseudoaneurysms. These include external compression, direct thrombin injection, endovascular treatment, and surgical intervention. Of these possible treatments, direct thrombin injection has shown the best combination of efficacy, complication rate, and recurrence rate, making it the treatment of choice for pseudoaneurysms. Emergent fasciotomy should be performed for acute compartment syndrome.

Conclusion

When an AA is to be performed, it is essential to be aware of its possible complications, which should be avoided whenever possible. When complications do occur, it is essential that they are diagnosed and treated appropriately.

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ICMJE Conflict of Interest Statement
The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

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