

Ankle osteoarthritis: comprehensive review and treatment algorithm proposal

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- Ankle osteoarthritis (OA) is much less frequent than knee or hip OA, but it can be equally disabling, greatly affecting the quality of life of the patients.
- Approximately 80% of ankle OA is post-traumatic, mainly secondary to malleolar fractures, being another of the main causes untreated in chronic instability. The average age of the patient affected by ankle OA is around 50 years, being therefore active patients and in working age who seek to maintain mobility and remain active.
- The authors conducted a comprehensive review of the conservative, medical, and surgical treatment of ankle OA.
- Initial conservative treatment is effective and should be attempted in any stage of OA. From a pharmacological point of view, non-steroidal anti-inflammatory drugs (NSAIDs) and intra-articular infiltrations can produce temporary relief of symptoms.
- After the failure of conservative-medical treatment, two large groups of surgical treatment have been described: joint-preserving and joint-sacrificing procedures.
- In the early stages, only periarticular osteotomies have enough evidence to recommend in ankle OA with malalignment. Both ankle arthrodesis and ankle replacement can produce satisfactory functional results if correctly indicated in the final stages of the disease.
- Finally, the authors propose a global treatment algorithm that can aid in the decision-making process.

Keywords

- ▶ ankle osteoarthritis
- ▶ conservative treatment
- ▶ surgical treatment

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Introduction

Ankle osteoarthritis (OA) is a chronic disease affecting approximately 1% of the world population, with an estimated incidence of 30 cases per 100 000 inhabitants, and corresponds to between 2 and 4% of all patients with general OA (1, 2). Cadaveric, radiologic, and clinical studies have indicated that ankle OA is far less common than knee and hip OA (1, 2, 3), what reflects in clinical practice, with symptomatic knee OA being 8 to 9 times more prevalent than ankle OA, and approximately 24 times more total knee replacements being performed than arthrodesis and arthroplasty of the ankle joint combined (3, 4). While traditionally the clinical impact and functional limitation of early ankle OA on patients have not been considered

particularly relevant, it can be extremely debilitating in advanced stages and can have similar repercussions on the quality of life as severe hip OA, advanced kidney failure, and congestive heart failure (4, 5).

Unlike hip and knee OA, primary ankle OA is not the most common etiology (1, 6, 7, 8), with only 7–9% of the cases being idiopathic OA and 13% secondary to other causes (rheumatoid arthritis, hemochromatosis, hemophilia, or osteonecrosis). Therefore, the main etiology, representing 75–80% of all cases, is a traumatic event (post-traumatic ankle OA), with fractures in the ankle region (malleolus, distal tibia, talus, etc.) (Fig. 1) being responsible for 62% of cases and the remaining 16% due to chronic ligament instability, particularly those affecting the lateral collateral ankle ligament (which some authors call ligamentous



Figure 1

Post-traumatic osteoarthritis after 12 years of bimalleolar ankle fracture.

ankle OA) (Fig. 2) (8, 9). Ankle instability increases the peak joint contact stresses of the ankle joint, resulting in cartilage deterioration that ultimately leads to ankle OA (9).

Another point of controversy is the relation between osteochondral lesions of the talus and the development of ankle OA. Weigelt *et al.* (10) reported in a 14-year-old



Figure 2

Ligamentous ankle osteoarthritis: osteoarthritis with varus deformity due to chronic lateral instability.

follow-up study that osteochondral lesions of the talus that successfully undergo an initial nonoperative treatment period have minimal symptoms in the long term, a low failure rate, and no relevant ankle OA progression. On the contrary, Stufkens *et al.* (5) stated that anterolateral talar, posteromedial tibial, and medial malleolar osteochondral lesions are more likely to develop ankle OA.

Given its predominantly post-traumatic etiology, patients with ankle OA tend to be younger (18–44 years) than those with other degenerative joint diseases in the

lower limbs (2). They also suffer a more rapid loss of function, with progression to advanced stages of ankle OA occurring 10–20 years after the onset, although clinical studies show that the initial degenerative changes secondary to an ankle fracture develop within 12–18 months of the traumatic injury (7, 11).

Pathophysiology peculiarities of tibiotalar articular cartilage

Although the ankle joint is frequently injured, clinically relevant ankle OA is much less common than in other weight-bearing joints; this is probably due to specific anatomical, biochemical, and biomolecular peculiarities of the cartilage of the ankle joint (12). Ankle cartilage receives the greatest force per unit area of all hyaline cartilage in the human body (500 N/350 mm² compared to the same force per 1100 mm² or 1120 mm² in the hip or knee, respectively). Furthermore, the load distribution in the ankle differs from other joints, such as the knee, which means the compressive forces are distributed in a greater area. Ankle cartilage (1–1.62 mm) is therefore thinner than knee cartilage (1.69–2.55 mm) (12, 13, 14). Biologically, ankle cartilage is believed to have a greater capacity for self-repair than knee cartilage (14). It has more stiffness and less permeability due to a higher degree of water and proteoglycan content (11). In addition, the extracellular matrix is denser which improves its load-bearing capacity and reduces its susceptibility to mechanical damage (12). It has also been shown that chondrocytes in the ankle are metabolically more active than in the knee and exhibit a greater response to anabolic factors such as osteogenic protein-1 and C-propeptide of type II collagen, upregulating cartilage synthesis. Ankle joint cartilage is also less sensitive to catabolic mediators such as fibronectin and interleukin-1 beta, which are factors that inhibit collagen synthesis (12, 15). Last but not least, for several years a biochemical alteration has been demonstrated in the synovial fluid of arthritic ankles, specifically in the concentration of certain cytokines such as matrix metalloproteinases (15) and a number of key markers have been identified in chronic OA (aggrecan and BMP-7, both increasing with OA progress). In contrast, high levels of BMP-2 have been related to a good clinical function and low signs of OA-related radiographic changes (16).

Given all these reasons, the articular cartilage in the ankle joint is less prone to degeneration than the cartilage of the knee or hip, but it is highly susceptible to lesions when there is an asymmetric distribution of stresses and forces, as in the case of joint fractures, injuries accompanied by impacts, or malalignment of the weight-bearing axis (11, 16). Such factors may explain the high correlation between ankle OA and a history of a traumatic event (17).

Clinical evaluation

Clinical diagnosis is based on the presence of joint pain with mechanical characteristics with or without joint effusion and/or deformity, as well as a loss of mobility, particularly ankle dorsiflexion (2, 11). Scarring is common due to a history of prior surgery (osteosynthesis, hardware removal, cheilectomy, etc.). Other clinical signs include leg muscle atrophy and gait disturbances (2, 3). Imaging diagnosis is based on weight-bearing anteroposterior and lateral conventional radiographs (CR), as well as a hindfoot alignment view such as the Saltzman view (2). OA may be hard to diagnose in early stages using CR as the technique often underestimates the severity of the disease, so advanced three-dimensional (3D) imaging such as CT and particularly MRI can be utilized to provide a more accurate picture of the number, location, and size of any points of cartilage damage. Newer MRI modalities, such as T2 mapping techniques, have also been tested for early diagnosis of ankle OA, although these techniques have proven more useful in assessing the quality of repair tissue after surgery (18). In recent years, the use of single-photon emission CT (SPECT-CT) has increased in popularity, adding details on the activity of the OA or chondral lesions to the anatomical information (19). The new generation of SPECT-CT scans permits exact localization of focal degenerative lesions. The SPECT-CT sensitivity can be attributed to their ability to detect increased subchondral metabolic osseous activity, which can detect early degenerative changes before appearance of clinical symptoms, for this reason it is particularly helpful in early stages of ankle OA. In addition, it can be indicated for defining OA of multiple joints with different stages and inconsistent clinical assessment of pathologies in closely adjacent structures such as talonavicular and subtalar joints (19, 20, 21). In more recent years, the appearance and development of the weight-bearing CT scan has allowed a better 3D understanding of ankle OA and associated supra- and infra-malleolar deformities of the foot and ankle, in a physiological, standing, and loaded condition (22, 23, 24, 25, 26, 27).

Classification

Perhaps the best-known system is the Tanaka Classification (28) (Table 1) which defines four stages and is clinically important because the authors established limits for joint-preserving surgery according to the grade of joint degeneration. An interesting study in 2016 by Claessen *et al.* assessed three different radiological classification systems (Van Dijk, Kellgren–Lawrence, and Tanaka) and concluded that none of them were reliable as decision-making tools or for establishing a prognosis for post-traumatic ankle OA (29).

Table 1 Tanaka classification for ankle osteoarthritis.

Stage	Radiographic finding
1	No narrowing of the joint space, but early sclerosis and formation of osteophytes
2	Narrowing of the medial joint space
3A	Obliteration of this space with subcondral bone contact (medial gutter only)
3B	Extension of the obliteration to the roof of the dome of the talus
4	Obliteration of the whole joint space with complete bone contact

Ankle osteoarthritis treatment

Treatment relies on three main pillars (30) (Fig. 3):

1. Conservative treatment
2. Joint-preserving surgical procedures
3. Joint-sacrificing surgical procedures

Conservative treatment

Regardless of the degree of ankle OA, conservative treatment should be tried first for at least 6 months to assess its effectiveness. There are various treatment options that can be combined to alleviate the signs and symptoms of

ankle OA, although there is only weak scientific evidence to support it, with mainly level IV and level V studies (30, 31, 32).

Patient education

It is important to inform patients about the modifiable risk factors related to the development/progression of OA. Obesity (BMI ≥ 30.0 kg/m²) is associated with an increased risk of functional impairment and is considered the most modifiable risk factor for knee OA (33, 34), being a factor associated with the onset and progression of musculoskeletal disorders as well. Additionally, it has been shown that weight loss can reduce the pain derived from OA (35). Patients should avoid lifestyle habits that provoke or aggravate OA such as high-impact sports or ascending and descending stairs and be advised to use a cane or walking stick if necessary.

Diet

Although it has not been specifically studied for the ankle, metabolic syndrome and type 2 diabetes have been associated with the risk of onset or progression of

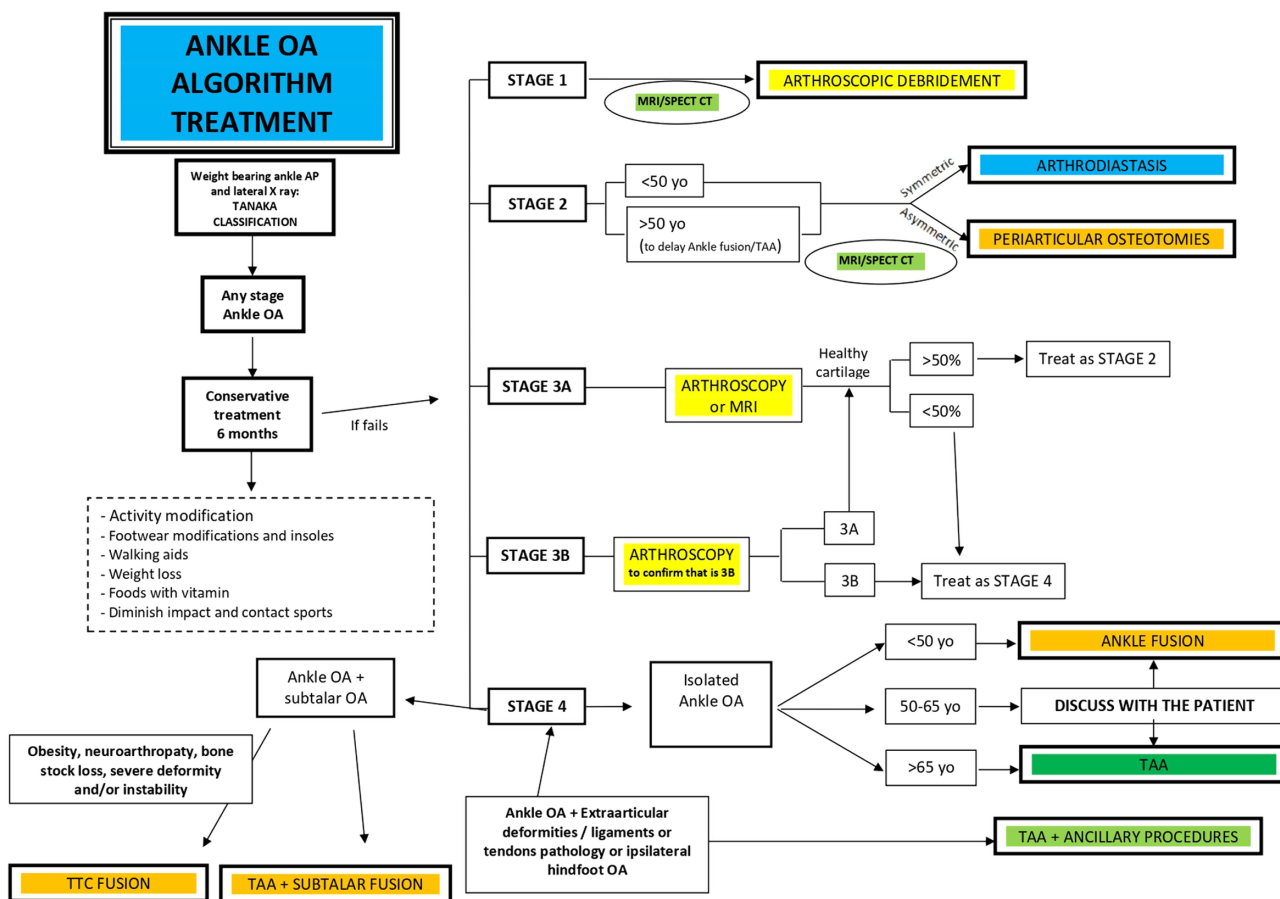


Figure 3 Global treatment algorithm for ankle osteoarthritis.

OA (36, 37). Hence, the modification of lipids in the diet of OA patients is recommended as it has been shown that a greater consumption of long-chain omega-3 fatty acids from fatty fish or fish oil supplements can improve pain and function in patients with OA. Reducing levels of blood cholesterol and increasing the intake of foods rich in vitamin K, which plays an important role in the mineralization of bones and cartilage, are also beneficial for OA. On the other hand, the influence and efficacy of vitamin D supplements are currently controversial in the treatment of OA (36). Regarding the diet–OA relationship, a systematic review recently highlighted the importance of the so-called Mediterranean diet for improved general health but could not demonstrate the long-term efficacy of this diet in preventing or improving the symptoms of OA (37).

Physical measures

Strengthening of the musculature that stabilizes the ankle joint, regular practice of stretching exercises, and locally applied cold therapy are some of the most important measures (32). As ankle OA progresses, it can cause an early decline in daily living activities, so recommending patients to seek support from occupational therapy is also essential (31, 32).

Footwear modifications

Gait pattern can be improved by wearing single rocker sole shoes which have been shown to unload pressure not only from the heel but also from the ankle joint during the push-off phase of gait (38).

Orthotics and insoles

Treatment with orthotics aims to reduce pain by maintaining a correct alignment and limiting ankle mobility while walking in order to reduce the mechanical load on the ankle. Ankle–foot orthoses are effective in patients with instability or misalignment (38). Regarding the use of insoles with a lateral or medial wedge for the treatment of medial or lateral tibial OA, most studies in the literature studied the effect of wedges on knee OA, and only one clinical trial assessed the effect of using a lateral wedge insole in the ankle joint space width and found no clinical repercussion (39).

Pharmacological treatment

Although there are no clinical guidelines for the specific management of ankle OA, it seems reasonable to follow the accepted recommendations for OA in other weight-bearing joints, such as the knee (40).

Acetaminophen (paracetamol) has been classically used as a first-line analgesic; however, the efficacy of this medication in treating OA is controversial and possibly

not superior to placebo (40). The American College of Rheumatology/Arthritis Foundation questions the effect of acetaminophen monotherapy for OA and only recommends it for short-term use in patients who have a contraindication to other pain reliever drugs (41).

Topical NSAIDs (diclofenac patches, ibuprofen creams, etc.) are safe options and should be considered as a complement to non-pharmacological measures. There are several systematic reviews that support the use of topical NSAIDs for pain relief and improvement of physical function related to OA, with results superior to placebo (40, 41).

Topical capsaicin has been shown to be effective in treating knee OA and could be considered as an alternative treatment to ankle OA, replacing topical NSAIDs (41).

The use of oral NSAIDs, such as the cyclooxygenase (COX)-2 inhibitors, should be considered, particularly when acetaminophen, topical NSAIDs, or capsaicin is ineffective in controlling ankle OA symptoms. Although the clinical improvement in OA-related symptoms is limited, pain control is usually greater than acetaminophen for most patients (41). This group of drugs helps relieve pain and inflammation, but its effectiveness decreases as patients develop tolerance. They should be used with caution, as their long-term use has been shown to cause gastrointestinal, renal, and cardiovascular side effects (40, 41).

The support for the use of *opioids* (tramadol, morphine, oxycodone, etc.) in the setting of OA is scarce in the literature and its use has been related to side effects and toxicity particularly in the elderly, as well as the increased risk of dependence. Currently, its use in both oral and transdermal forms is either contraindicated or accepted only as a third-line of treatment (41).

Symptomatic slow-acting drugs for OA such as glucosamine, chondroitin sulfate, and diacerein can also be used. OA reduces the concentration of intra-articular hyaluronic acid, which has anti-inflammatory, analgesic, lubricating, and shock-absorbing properties (42). Glucosamine can alleviate symptoms because it acts as a substrate for chondroitin sulfate formation, which in turn stimulates synovial production of hyaluronic acid (42). Although there are studies that show that both glucosamine and chondroitin are superior to placebo in reducing pain in knee OA, the evidence of these positive effects is still a matter of debate and the different international organizations do not recommend its widespread use (41).

Intra-articular therapies

Hyaluronic acid

Intra-articular injections in OA of the ankle are tolerable and effective, producing a quick clinical improvement in terms of pain, stiffness, functionality, and satisfaction,

while also reducing the need for analgesics. In most studies, a significant improvement was observed for up to 6 months after the injection (30, 31, 32), while in others the effects were seen to last for up to 18 months (43).

Corticosteroids

They provide short-term symptomatic relief lasting between 4 and 8 weeks. According to the available body of evidence, they should be reserved for persistent pain in higher-grade OA with a maximum of three or four injections a year, because of the damaging effect to the joint cartilage (44).

Platelet-rich plasma

Recent studies seem to indicate that platelet-rich plasma (PRP) therapy is more effective at reducing pain than hyaluronic acid. Mei-Dan *et al.* studied the efficacy of intra-articular hyaluronic acid vs PRP injections over a 28-week follow-up period in 30 patients with osteochondral lesions of the talus (45). They found that patients in the PRP group reported less pain and better functionality. Anghong *et al.* observed an improvement in pain, with a mean follow-up of 16 months following the PRP injection; however, MRI studies did not show any radiological improvements (46). Repetto *et al.* reported that PRP injections once a week for a month were effective in delaying the indication for surgery in patients with ankle OA (47).

Mesenchymal stem cells

Most studies are based on their use in the knee and the evidence in the ankle is scarce, the main problem with this therapy continues to be the bias produced by the dosage, the site where the cells were obtained, the number of cells obtained, and characterization of the delivered populations, since there is no standard procedure that can answer these questions (48). Although they represent a promising field within the biological treatment options, their use in OA is still controversial.

More recently, Boffa *et al.* (49) have published a meta-analysis to evaluate the evidence supporting safety and effectiveness of intra-articular injective treatments for ankle lesions ranging from osteochondral lesions of the talus (OLT) to OA. Twenty-four studies (21 for OA and 3 for OLT) were included on hyaluronic acid (HA), platelet-rich plasma (PRP), saline, methylprednisolone, botulinum toxin type A (BoNT-A), mesenchymal stem cells, and prolotherapy. The authors support the safety of intra-articular treatment for ankle OA and OLT, being the HA the unique intra-articular therapy with some evidence in terms of better results vs placebo for the treatment of ankle OA.

Surgical treatment joint-preserving procedures

Arthroscopic joint debridement

It plays a relatively limited role in the treatment of ankle OA, as it is mainly confined to cases with early signs of OA (30). It reduces pain and improves function in patients with clinical signs of anterior impingement, both bony and soft tissue impingement, and is very effective in the excision of intra-articular loose bodies (50). It can also prove useful when performing cartilage repair techniques if there are localized osteochondral lesions. So, in carefully selected cases, arthroscopy can retard the disease progression and delay the need for subsequent surgical interventions. Diagnostic arthroscopy recently assumed an important place with respect to the decision-making of whether to perform joint-preserving or joint-sacrificing surgery (30, 50).

Joint distraction arthroplasty or arthrodiastasis

It involves implanting a fixed or hinged external fixator between the tibia and talus while applying a distraction force to the ankle joint, either alone or in combination with other joint techniques (chondroplasty, osteochondral holes, microfractures, hyaluronic acid or PRP injections, etc.) (51). It is mainly indicated for young patients (under 45 years) with advanced post-traumatic ankle OA, with no malalignment, and those who still have mobility. The external fixator should remain in place for at least 3 months to obtain a beneficial effect on the cartilage. This technique has proven to be valuable in reducing pain in up to 70% of cases throughout the first 5 years; however, the results decline over time and the improvement is only hypothetical, as studies have not found any evidence that joint distraction leads to marked chondral regeneration (52).

Osteotomies around the ankle

This is the only universally accepted joint-preserving procedure. Osteotomies are indicated in cases of ankle malalignment (up to 70% of post-traumatic ankle OA manifests a varus ankle) (52); the rationale is to transfer the axis of force transmission from the most to the least damaged portion of the joint and osteotomies are performed above the ankle joint (supra-malleolar), below this joint line (inframalleolar) or both. It has been shown to reduce pain in between 70 and 75% of cases and even defers the need for definitive procedures such as arthrodesis or total ankle arthroplasty (TAA) (52, 53, 54). The main indication for an osteotomy is asymmetric OA with at least 50% healthy cartilage in the tibiotalar joint, which should be confirmed by means of a preoperative MRI or intraoperative arthroscopy (52). The procedure has both general and specific contraindications. Among others, the general contraindications include acute or chronic infection (with or



Figure 4
Varus osteoarthritis treated by medial opening supra-malleolar ankle osteotomy.

without osteomyelitis), severe circulatory insufficiency, and neuropathies (52). The specific contraindications are severe OA of the entire joint and the patient’s objection to the postoperative unloading protocol and rehabilitation. There is some controversy about the limits for supra-malleolar osteotomies. Tanaka *et al.* suggest that stage 3B ankle OA is no longer a candidate for joint-preserving surgery due to the poor results obtained, preferring to opt for ankle arthrodesis or replacement arthroplasty (28). A varus deformity can be treated by means of a medial opening wedge osteotomy (Fig. 4) or lateral closing wedge osteotomy, the former being the most used option (54). Valgus ankle deformities are more commonly corrected by performing a medial closing wedge osteotomy combined with a fibular osteotomy (53). In cases with intra-articular varus or valgus asymmetric OA, extraarticular techniques have poorer outcomes and higher rates of recurrence. In such cases, an oblique intra-articular osteotomy (known as plafondplasty) of the tibia has been described, showing low rates of recurrence, substantial postoperative pain relief, functional improvement, and a possible slowing of the degenerative process (55). Another relevant point is the treatment of malunited malleolar fractures. Reidsma *et al.* (56) report good or excellent results in the majority of patients indicating that reconstructive surgery is effective in most and that the beneficial effects can last for up to 27 years after the procedure.

Joint-sacrificing surgical treatments: total ankle arthroplasty and ankle arthrodesis

This is indicated in cases of advanced, end-stage OA (stages 3B and 4 in the Takakura-Tanaka Classification) or after failure of joint-preserving techniques.

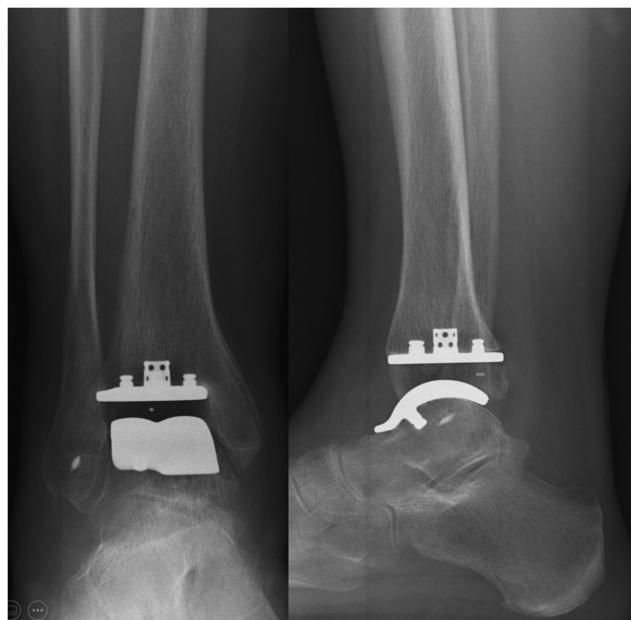


Figure 5
Total ankle replacement and lateral ligament repair in a patient with advanced ankle osteoarthritis and lateral instability.

Total ankle arthroplasty

Over the past decade, TAA surgery has evolved as an alternative to ankle arthrodesis in select patients with ankle arthritis (57, 58). These include adult patients with primary, post-traumatic, and inflammatory arthritis who have moderate or severe pain, loss of mobility, and loss of function of the involved ankle. Patients with previous hindfoot fusion or significant arthritic change in neighboring joints are also considered good candidates for replacement (58). The indications for TAA were very strict up to a few years ago, but they have become more flexible with time and thanks to the incorporation of the newest designs. Indications currently include patients with end-stage OA (post-traumatic, inflammatory, etc.), sedentary lifestyles, the elderly (above 55 years at present), low functional requirements, and preserved joint mobility (Fig. 5). Indication for TAA is also well accepted when there is a contralateral ankle arthrodesis or ipsilateral major OA or previous fusion of the neighboring joints (subtalar and talonavicular joint in particular), because the preserved motion of TAA may be protective against further degeneration while providing equivalent pain relief (57, 58). The complications associated with TAA vary from 13.5 to 54.5%. Some examples include superficial and deep infections, wound dehiscence, intra- and postoperative fractures (mainly of the malleoli), aseptic loosening, polyethylene fracture, postoperative pain, stiffness, heterotopic calcifications, bone cysts, soft tissue impingement, neurovascular lesions, and deep vein thrombosis, many of which may require reoperation



Figure 6
Open ankle arthrodesis by lateral approach using the fibula itself as a local bone graft.

(4, 59). On the other hand, there are some absolute contraindications for TAA such as an active infection, major peripheral arterial disease, Charcot neuroarthropathy, or unhealthy/low-quality soft tissue coverage. Relative contraindications include tobacco consumption, morbid obesity, ankle ankylosis, younger age (under 50 years, controversial), severe lower limb malalignment, avascular necrosis of the talus (above 50%), and osteoporosis (59, 60). Unlike total knee and total hip arthroplasty, in severe malalignment deformity cases, bony and soft tissue realignment procedures might be needed to restore a more normal mechanical axis (57, 61). Although the age itself is an important factor to be considered, it has been published that at medium-term, ankle replacement is at least as effective in patients under the age of 50 as in those aged 50 or older (62).

Ankle arthrodesis

Traditionally, arthrodesis was the favored treatment for end-stage ankle OA. The aims are to achieve a stable,

Table 2 Indications for ankle arthrodesis.

<ul style="list-style-type: none"> - Idiopathic end-stage osteoarthritis (OA) of the ankle (Tanaka 3B, 4) - Post-traumatic ankle OA (80% of total) - Inflammatory arthritis - Young and active patients* - Avascular necrosis of the talus[^] - Infectious sequelae - Congenital malformations - Neurological foot with malalignment - Failed total ankle arthroplasty (TAA) ^^

*Classic indication currently under debate: there are good results of TAA in patients under 55 years of age. ^In severe necrosis (>75% of the total talus) tibiototalcalcaneal (TTC) arthrodesis may be necessary to provide stability. ^^In cases of severe bone stock loss during TAA revision surgery, TTC arthrodesis with allograft is the technique of choice.

Table 3 Contraindications for ankle arthrodesis.

Contraindications for ankle arthrodesis	
Absolute contraindications	
-	Open physis
Relative contraindications	
-	Active infection
-	Peripheral arterial insufficiency
-	Active smoking
-	Contralateral ankle arthrodesis (consider TAA)
-	Ipsilateral subtalar osteoarthritis (consider TAA or tibiototalcalcaneal fusion)

pain-free, and plantigrade foot, and it is the preferred technique in physically active patients with high functional requirements (63, 64). It can be performed through a conventional open technique using different approaches (lateral transfibular with a fibular autograft, anteromedial and anterolateral mini-open, or the classic anterior approach preserving the malleoli) and different types of osteosynthesis (anterior plate, lateral plate, double plate, crossed screws, etc.) (Fig. 6). The main indications, contraindications, and ideal position for ankle arthrodesis (AA) are described in Tables 2, 3, and 4 (64). Although it is well-known classic technique, the main concerns are the overload of adjacent joints and nonunion (Fig. 7). Adjacent-joint overload is normal since these joints are specifically responsible for compensating for the absence of ankle movement. Therefore, subtalar and talonavicular OA commonly develops following an ankle arthrodesis, even though the latter is not always clinically significant (63). Arthroscopic AA has imposed itself as the technique of choice or gold standard treatment in patients with soft tissues in a poor condition due to previous surgeries (which is very common in ankle OA), although a series of contraindications have been described (Table 5) (65). Various studies have compared open and arthroscopic fusion; while they offer similar rates of nonunion and fusion times, the hospitalization period is shorter (and it can even be performed on an outpatient basis) and the functional improvement is clearly superior with arthroscopic techniques, although these differences seem to even out after 1 year of follow-up (64, 65).

Tibiototalcalcaneal arthrodesis

Tibiototalcalcaneal (TTC) arthrodesis is another procedure available for the treatment of degenerative disease in the ankle and hindfoot. The goal is to fuse the subtalar and tibiotalar joints, usually performed with a retrograde nail or plate and screws (66). TTC is indicated in attempts to salvage a failed total ankle replacement, in case of the loss of talar or

Table 4 Ideal position of ankle arthrodesis.

<ul style="list-style-type: none"> - Neutral flexion - Slight (5°) of hindfoot valgus - 5–10° of external rotation - Talus slightly posterior (5 mm) under the axis of the tibia
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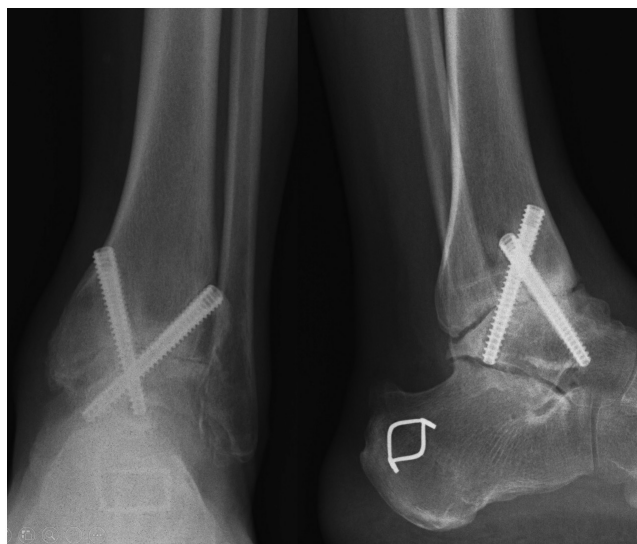


Figure 7
Ankle arthrodesis nonunion.

distal tibial bone stock, severe hindfoot instability, morbid obesity, severe progressive collapsing foot deformity, and Charcot neuroarthropathy, among others (Fig. 8 and Table 6) (66, 67). The procedure can be performed via minimally invasive techniques; however, complications have been reported to occur in up to 25% of the cases, particularly with early nail designs, the most noteworthy being proximal fractures around the nail, nonunion (often asymptomatic), infections, neurovascular lesions, and rotational alterations. The contraindications for TTC arthrodesis are a healthy subtalar joint, poor bone stock, active infection, and severe distal tibia deformities (67).

Total ankle arthroplasty vs ankle arthrodesis

Veljkovic *et al.* compared 238 patients (88 TAA, 100 open fusions, and 50 arthroscopic fusions) and reported similar clinical and functional outcomes (62). Shih *et al.* published a meta-analysis in which they did not find any significant differences in terms of pain, functionality, alignment, and satisfaction among patients treated by means of TAA and AA (68). Despite the undeniable design improvements and growth in the use and indication for TAA, AA remains

Table 5 Contraindications for ARTHROSCOPIC ankle arthrodesis.

Contraindications for ARTHROSCOPIC ankle arthrodesis	
Absolute contraindications	
-	Loss of bone stock of talus (avascular necrosis, tumor, and infections)
-	Significant anteroposterior translation of the talus
-	Active infection
Relative contraindications	
-	*Severe varus/valgus deformities >15°.
-	**Morbid obesity

*Currently, arthroscopic techniques can overcome severe deformities. **Could produce a higher rate of nonunion.



Figure 8
Tibiototalcalcaneal arthrodesis with retrograde nail using the fibula itself as an autograft after post-traumatic osteoarthritis secondary to pilon tibial fracture.

the most frequent surgery all over the world for end-stage ankle OA, as there is still concern about implant survival and the learning curve in TAA (61, 69). Additional studies of outcomes provide support for the performance of ankle replacement surgery in patients with OA, but most authors agree that a careful evaluation of the patient is important when selecting patients for a TAA procedure (69, 70). With this regard, Krause *et al.* published a review outlining the decision-making process for TAA in terms of major and minor criteria (71). Age, cause of arthritis, deformity, instability, ankle motion, and adjacent joint arthritis were all considered major considerations when selecting the appropriate procedure for a patient (71).

In general, TAA and AA are both associated with pain reduction and similar functional outcome in the mid term (68). The main problem with TAA is the greater rate of reoperations or revision surgeries in comparison with AA,

Table 6 Indications for tibiototalcalcaneal arthrodesis.

-	Subtalar joint osteoarthritis
-	Failed tibiotalar arthrodesis
-	Failed total ankle arthroplasty with bone stock loss
-	Morbid obesity
-	Severe malalignment
-	Severe instability
-	Avascular necrosis of the talus greater than 50%.
-	Charcot neuroarthropathy
-	Loss of bone stock of talus and/or distal tibia secondary to infection, tumour resection or post-traumatic.

whereas the main issue with AA is adjacent-joint overload and gait pattern alterations. Putting aside these concerns, TAA seems to be superior to AA with respect to gait pattern normalization, less overload of adjacent joints, and show marked improvement in the quality of life and function (70).

Talar body replacement

In the last 5 years, there has been a special interest in the development of total talar prostheses (72), indicated in avascular necrosis of the talus, failed fixation of talar fractures, and advanced ankle OA. Although many studies have shown better function than partial talar prostheses, there is a need for long-term studies to determine its long-term efficacy (73).

Bipolar allograft

Designed with the idea of replacing the ankle joint with a fresh total allograft (fixed to the distal tibia and talus with screws), it is a novel and complex procedure. Clinical outcomes are highly variable, and a 2015 systematic review proved that although the results appear promising (73), the lack of statistical power and inconsistent documentation made it difficult to determine the superiority of any one intervention compared with another for the treatment of ankle arthritis (73).

ICMJE Conflict of Interest Statement

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