Correction of Sagittal Plane Deformity of the Distal Tibia

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KEYWORDS

• Supramalleolar osteotomy • Distal tibia deformity • Localized ankle osteoarthritis • Anterior ankle arthritis • Posterior ankle arthritis • Sagittal deformity

KEY POINTS

- Sagittal distal tibia deformities produce a greater change in tibiotalar joint contact areas than with valgus or varus deformities.
- Talar anterior or posterior translation occurs secondary to a distal tibia sagittal deformity and worsens the asymmetric joint overload and secondary cartilage damage.
- Distal tibial angle and talar position relative to the tibial axis should be always obtained to evaluate the deformity severity and the amount of correction needed.
- Anterior distal tibia closing or opening wedge osteotomies are the recommended treatment options for posterior or anterior ankle arthritis, respectively.
- Fibular osteotomies should be generally added to the tibia osteotomy to help with talar repositioning.

INTRODUCTION

The sagittal plane alignment of the distal tibia is not frequently analyzed, and its normal parameters are commonly forgotten. As Drs Paley and Herzenberg described years ago, seen from the lateral aspect, the middiaphyseal line of the tibia in the sagittal plane passes through the lateral process of the talus, when the plantar aspect of the foot is in 90° in relation to the tibia[1] (**Fig. 1**). Another commonly measured angle is the anterior distal tibial angle (ADTA), whose normal value is 80° (**Fig. 2**).[1]

Two different scenarios can be observed in sagittal plane deformities of the distal tibia. One scenario refers to the classic antecurvatum and recurvatum deformities, where due to a posttraumatic physeal damage or a malunited tibia fracture, a secondary anterior or posterior displacement of the talus relative to the tibial axis is seen, with no ADTA alteration. In these cases a supramalleolar apex of deformity will be found, consistent with a previous skeletal damage. Localized ankle arthrosis can coexist depending on the time elapsed since the original trauma (initially no ADTA change is seen). The second scenario, much more frequent, is observed when an asymmetric

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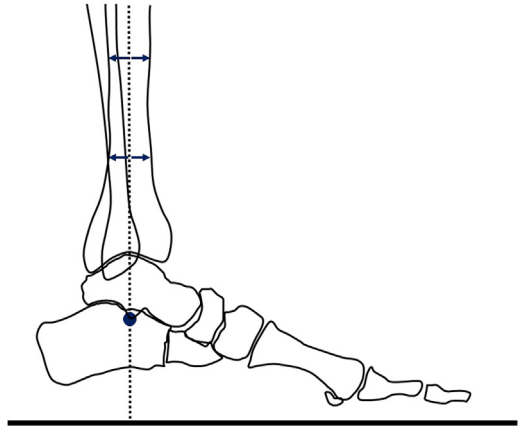

Fig. 1. The distal leg, showing a normal sagittal alignment. The axis of the tibia is represented as an intermittent dot line following the center of the diaphysis of the distal tibia, intersecting the anterolateral process of the talus, shown as a dot.

ankle joint arthritis is present compromising either the anterior or posterior aspects of the ankle joint. In these cases, a decrease in joint space is observed, with ADTA alteration and a consequent anterior or posterior displacement of the talus relative to the tibia axis. In these cases, an intraarticular apex of deformity will be found. Both scenarios share the sagittal plane deformity of the ankle consisting in a malalignment between the tibia and the talus: in one case due to a posttraumatic malunited distal tibia (antecurvatum or recurvatum deformities) and in the other case due to loss of cartilage in the anterior or posterior aspect of the ankle joint.[2]

In this article, we will use the term "anterior ankle arthritis" to refer to patients with an anterior displacement of the talus relative to the tibia, with a mechanical overload of the anterior aspect of the ankle joint, with or without changes in the anterior joint space or ADTA values. The term "posterior ankle arthritis" will refer to patients with a posterior displacement of the talus relative to the tibia, with a mechanical overload of the posterior

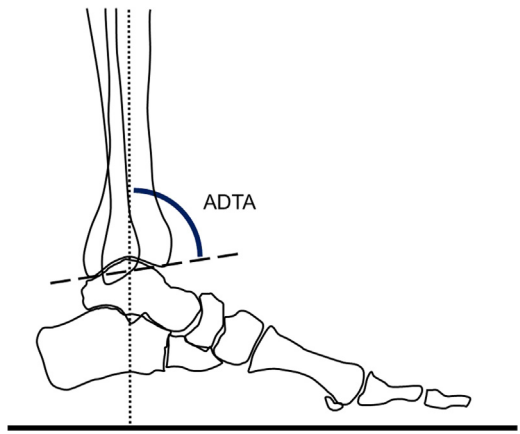

Fig. 2. The distal leg, showing the tibia axis represented as an intermittent dot line. The distal tibia articular surface is represented by a dashed line. The ADTA angle is measured anteriorly between the 2 previously mentioned lines.

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aspect of the ankle joint, with or without changes in the posterior joint space or ADTA values. We will analyze the biomechanical changes happening in ankle sagittal plane malalignments, with their clinical consequences and present alternatives of treatment.

BIOMECHANICAL BACKGROUND

In cadaveric studies malunited tibia fractures show significant changes when greater than 15° of deformity is applied to the distal tibia.[3] Anterior and posterior bow deformities produce a greater change in tibiotalar joint contact areas than with valgus or varus deformities of the tibia.[4] These facts highlight the importance of identifying sagittal plane malalignments of the ankle joint.

Ankle arthrosis is usually posttraumatic in origin, explaining the frequent asymmetric presentation, as cartilage damage will manifest where most of the energy and destruction occurred.[5] Ankle joint pressure changes depending on the damaged area of the ankle, for example, the center of pressure shifts posterolaterally in ankle fractures with interosseus membrane damage.[6] Another fact to remember is that the bone resistance of the tibia and talus is not uniform on its surface, with the tibia showing greater subchondral resistance in its posteromedial aspect than in the anterolateral one.[7] Whenever there is an asymmetric damage on the ankle joint, besides the concurrent ligament damage, the talus will tend to shift to the damaged cartilage area. This will create either a coronal plane or a sagittal plane malalignment, depending on where the joint damage/deformity is located. Sagittal ankle malalignment is common in end-stage ankle arthrosis, with up to 56% of the cases presenting either anterior or posterior displacement of the talus in relation to the tibia.[8]

The most referred angle of the distal tibia in the sagittal plane corresponds to the ADTA, whose normal value is 80°.[1] The lateral process of the talus can be considered to represent the axis of rotation of the ankle on a lateral ankle radiograph, although this is not exact, as the ankle joint acts as a truncated cone, with an axis passing through both malleoli, thus having a dynamic axis of rotation. The distance between the tibial axis and the center of rotation of the ankle therefore can be measured and will represent the sagittal alignment of the ankle in relation to the tibia.[9] A comparison between 3 different ways of measuring the alignment of the talus in relation to the tibia in the sagittal plane has been published.[9] The tibial axis to talus ratio (TT), which corresponds to the ratio into which the midlongitudinal axis of the tibial shaft divides the longitudinal talar length, is the measure that tolerates the better perturbations of ankle positioning. The longitudinal talar length is defined as a line parallel to the floor, beginning at the intersection between the posterior subtalar joint and the posterosuperior cortex of the calcaneus, ending at the vertical projection of the most anterior aspect of the talus[9] (**Fig. 3**). The average normal value for the TT ratio (expressed as a percentage) has been reported to be 34 $\pm$ 2.[8] In a consequent study the TT ratio was shown to be a reliable radiographic measure to determine the position of the talus relative to the tibia, regardless of the condition of the ankle surface.[10]

CLINICAL DIAGNOSIS AND RADIOLOGICAL CHARACTERISTICS

Patients with sagittal plane deformities of the distal tibia will present clinically with arthritic symptoms, resembling any patient with localized ankle arthritis. Initially they will present with ankle pain associated with changes in physical activity, differences in footwear, changes in body weight, and so forth. The pain may begin immediately after physical activity and subside in the following hours or persist for hours or days

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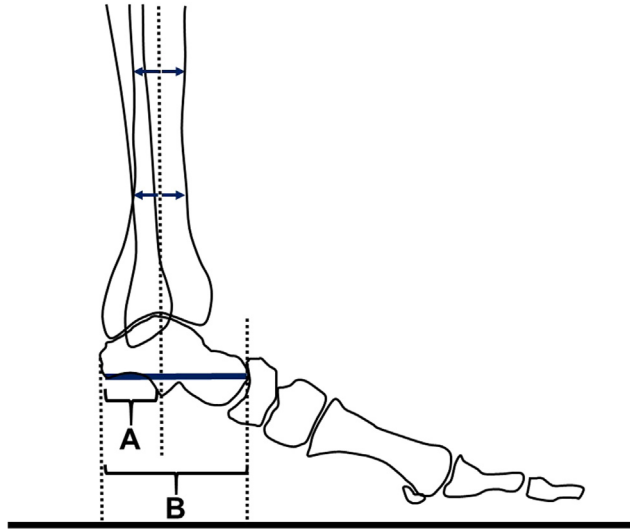

Fig. 3. The distal leg, showing the tibia axis represented as an intermittent dot line. The longitudinal talar length is represented by a horizontal continuous line beginning at the most posterior aspect of the subtalar joint and ending at the most distal aspect of the talus (its most distal aspect if projected vertically to the floor). The tibia axis divides the longitudinal talar length line into two. The TT ratio, generally expressed as a percentage, is obtained dividing distance "A" (distance along the longitudinal talar length *line* beginning at the most posterior aspect of the subtalar joint and ending at the intersection of the tibial axis and the longitudinal talar length *line*) over "B" (longitudinal talar length) and multiplied by 100.

after completing the physical activity. With worsening arthritis, pain may become continuous during the day. Recurvatum is less tolerated than procurvatum deformities because the articular surface of the talus is not well covered with the tibia, leading to pressure concentration in the anterior aspect of the ankle joint (Fig. 4). Procurvatum of the distal tibia should be less destructive for the ankle, as the talus is well covered by the mortise.[5] Having said this, procurvatum may be more painful for patients as a result of anterior ankle impingement. Two sagittal plane malalignment examples are provided in Fig. 5.

The study of patients with ankle malalignment should consider standing long leg radiographs, in addition to ankle radiographs. Patients in early stages of sagittal plane deformities may have joint angles within normal values but will have ankle pain in the area affected by previous trauma, due to a mechanical overload. In these cases, an MRI or a nuclear medicine test such as single-photon emission computed tomography will provide information supporting the idea of an ankle joint overload (Fig. 6). In more advanced stages of localized osteoarthritis, radiological alterations will already be seen consisting in changes in the joint space, angulation of the joint line, sclerosis or osteophytes, bone cysts, or already formally advanced osteoarthritis.

We must analyze the degree of arthrosis and radiological indices such as the ADTA, lateral distal tibial angle, talar tilt, tibiotalar angle, and any other deformity present always using the apex of deformity concept. Because we are discussing sagittal plane deformities, the ADTA angle and the TT ratio should be altered. The frontal plane should always be evaluated as well. The recommended method is using the mechanical axis deviation to obtain the lateral distal tibial angle.

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Fig. 4. Lateral ankle radiograph of a patient with a recurvatum ankle deformity. There is a clear deformity at the distal tibia due to an old distal tibia fracture. Note the uncoverage of the talus anteriorly, which leads to overload and arthritis in that area.

There are no specific classifications for ankle sagittal plane malalignments. To the best of our knowledge, the only classification for localized ankle arthritis that considers sagittal ankle position is the one published by Knupp, where on top of the analysis given to the coronal plane malalignment, a modifier is added using a letter. If there is no sagittal plane malalignment, a letter c (centered) is added to the main group. If there is any sagittal malalignment, a letter e (extruded) is added.[11]

TREATMENT

A traditional limit to use joint preserving surgery in ankle osteoarthritis is the presence of at least 50% of the talar surface still covered by cartilage. This theoretic limit is only valid for coronal plane deformities, so there is no clear limit to choose to preserve an ankle joint where there is mainly a sagittal plane deformity. Our preference is to always correct sagittal plane malalignments irrespective of the cartilage condition, considering it more important compared with coronal ankle deformities. The preferred surgery consists in a supramalleolar osteotomy of the tibia (SMOT).

ANTERIOR ANKLE ARTHRITIS

Our objective should be to correct the ankle alignment to the best we can. The coronal correction is being explained elsewhere in this issue, so we will focus on the sagittal correction. In anterior ankle arthritis, we will either find an ADTA angle less than 80°, or

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Fig. 5. Lateral radiographs of 2 clinical cases with ankle sagittal malalignment. (*A*) A case with anterior ankle arthritis, with anterior displacement of the talus relative to the tibia and anterior ankle arthrosis with a concurrent decrease of the ADTA angle. (*B*) A case with posterior ankle arthritis, with posterior displacement of the talus relative to the tibia, with an increase of the ADTA angle.

a TT ratio less than 30, or both. When planning an SMOT to correct this malalignment, we recommend using digital software to aid in the correct preoperative planning (**Figs. 7** and **8**). A correct measurement of the ADTA needs to be performed in these cases considering the removal of anterior distal tibia osteophytes to draw the joint line correctly.

If the anterior ankle arthritis case presents with an obvious extraarticular distal tibia deformity due to a malunited fracture or previous physeal damage, without any decrease in anterior joint space, the ADTA will be normal and the TT ratio will be abnormal. In these cases the apex of the deformity will be extraarticular in the distal tibia metaphysis, where the SMOT must be planned.

Most of the anterior ankle arthritis cases present with a decrease in anterior joint space, anterior distal tibia osteophytes, and abnormal ADTA and TT ratio values. In these cases, there is an intraarticular apex of deformity, and therefore, the SMOT cannot be performed at the apex of the deformity. When an SMOT is performed outside the apex, the so-called third rule of osteotomies occurs. This rule mandates that a secondary translation of the distal segment occurs when an angular correction is performed outside the deformity apex. This secondary translation occurs in the direction of correction (posterior translation in cases of operated anterior ankle arthritis), which is desirable in osteoarthritic cases. It further helps with mechanical axis correction and therefore does not need to be corrected.[12] Recovering normal angular values should not be our goal in osteoarthritic cases, as we must overcorrect the alignment, pushing the weight-bearing axis line away from the damaged cartilage. There are no

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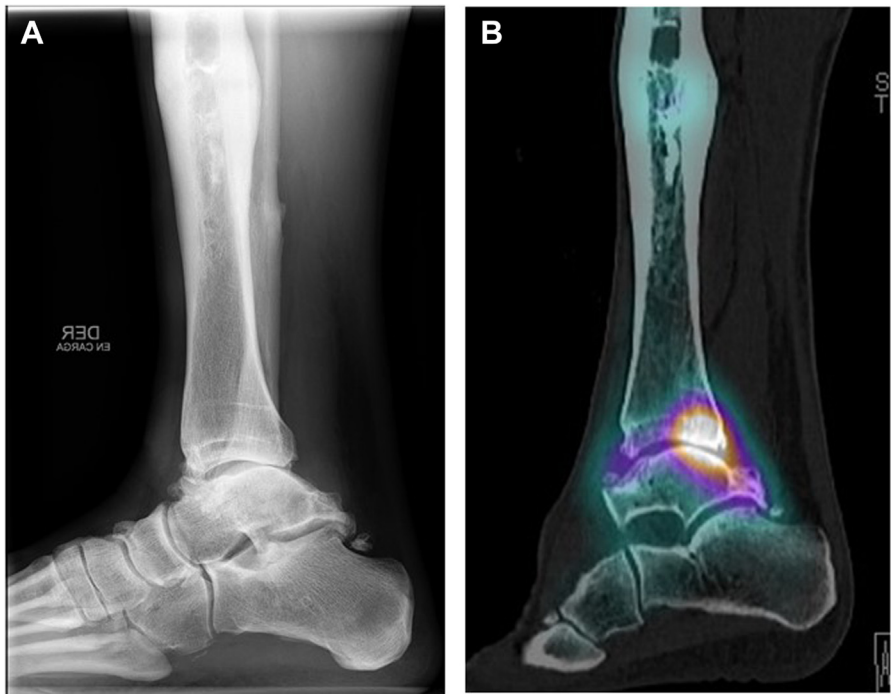

Fig. 6. Lateral ankle radiograph of a sagittal plane malalignment case. (*A*) The posterior displacement of the talus relative to the tibia, with some osteophytes present in the anterior aspect of the talus. (*B*) The same case but with an SPECT-CT image, where the posterior overload is represented by an intense yellow color.

specific recommendations relative to the amount of correction, but we recommend staying within 5° of normality to avoid creating anterior ankle impingement. For example, an anterior ankle arthritis case with an ADTA of 73° should therefore be overcorrected to 85°.

The most recommended osteotomy for anterior ankle arthritis is an anterior opening wedge osteotomy for angular corrections under 10° and a dome osteotomy for corrections greater than 10°. We recommend always adding a fibular osteotomy at the level of the syndesmosis, to aid in the correction of the TT ratio. We have seen in our experience that adding a fibular osteotomy helps the talus to relocate under the tibia, especially if there is a malunited fibula or malunited syndesmosis. A posterior distal tibia closing wedge osteotomy is also an option for deformities of 10° or less, especially if contracted soft tissues are present.

A special consideration must be given to severe recurvatum deformities, due to the posterior soft tissue contractures generally found. After performing the SMOT, the ankle will remain in plantar flexion due to posterior soft tissue contractures. Components that must be released include the posterior capsule, posterior tibial tendon, Achilles tendon, and posteromedial neurovascular sheath.

Technique

Tibial osteotomy

An anterior ankle incision is recommended, generally used also for coronal plane deformity treatment. Any anterior distal tibia osteophyte needs to be resected.

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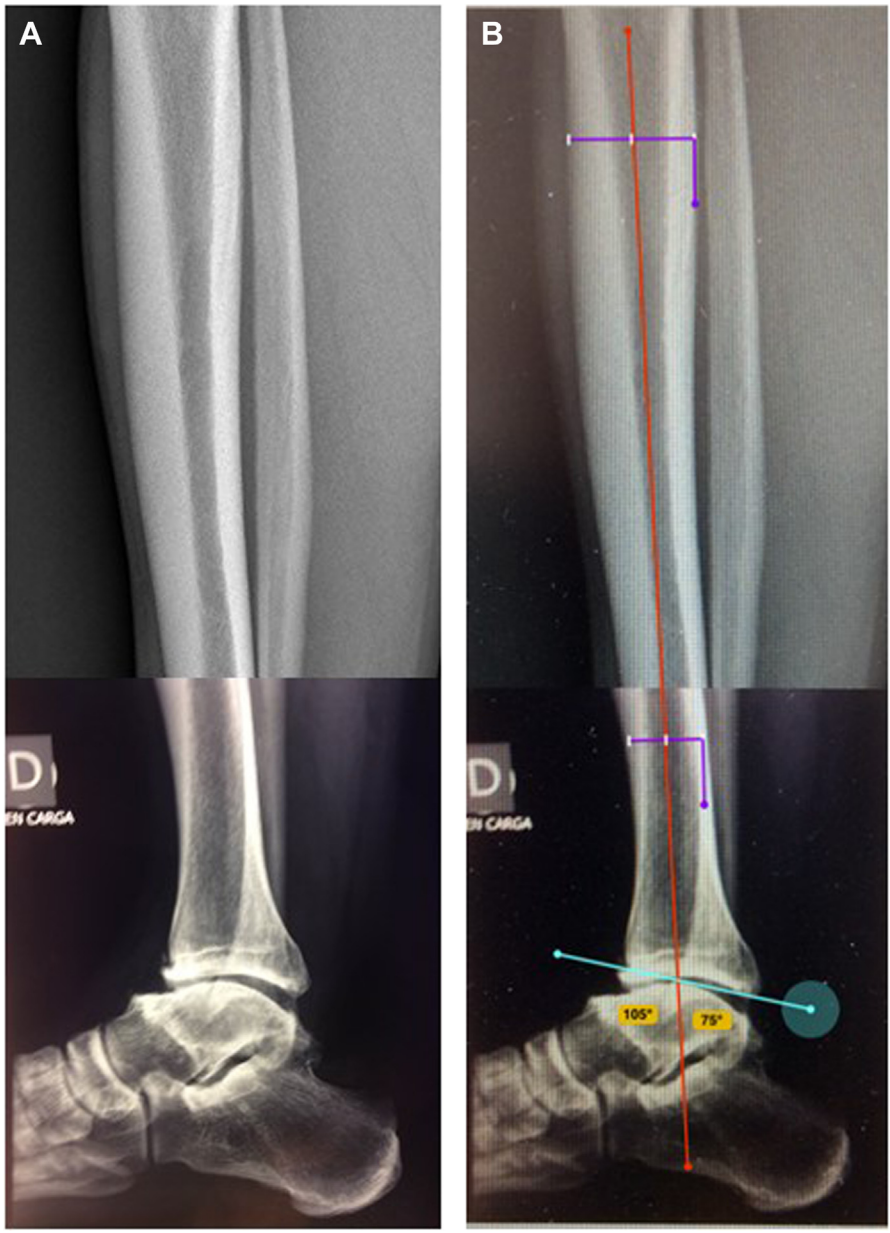

Fig. 7. (*A*) Lateral radiograph of an anterior ankle arthritis case. Preoperative planning is paramount in order to achieve the best results. (*B*) The digital measurement of the ADTA angle, in this case, 75°.

Through this approach, an anterior distal tibia opening wedge osteotomy can be performed. After protecting medial and lateral soft tissues and performing minimum periosteum dissection, an incomplete transverse distal tibia osteotomy is performed, approximately 5 cm proximal to the joint surface (Fig. 9). It can be performed using

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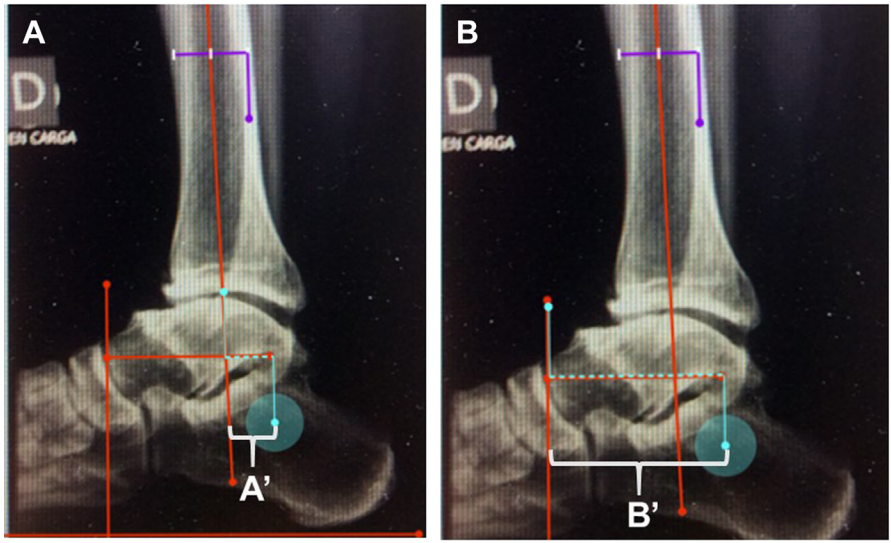

Fig. 8. Preoperative planning of the same case shown in Fig. 6, where the calculation of the TT ratio is exemplified. (*A*) The first distance to be measured, which corresponds to A′, that is, the distance measured along the longitudinal talar length line between the most posterior aspect of the subtalar joint and the intersection of the tibial axis with the longitudinal talar length line. (*B*) The distance B′, which corresponds to the longitudinal talar length. The TT ratio is obtained with the following formula: TT ratio: A/B*100. In this case, the TT ratio was 25.

a saw blade but in an intermittent manner and using constant cooling. The size of the opening wedge (h) is calculated with the same rule as for coronal plane correction, which considers the angle to be corrected (theta) and the width of the tibia at the osteotomy level (w) (formula: tan theta = h/w).[13] If we are correcting an anterior ankle arthritis case with an ADTA of 73°, the maximum overcorrection we could calculate would be to leave the ADTA in 85°. Using the formula, correcting 12° of the ADTA, with a tibia width of 32 mm, the wedge height size would be 6.8 mm.

An easy way to remember the SMOT wedge size needed for arthritic cases is to equal the deformity severity to the wedge size in millimeter (mm); for example, ADTA 73° is a 7° deformity (normal ADTA 80). That means a 7 mm wedge is required, and this calculation already includes the overcorrection needed. As the reader can conclude, a 6.8 mm wedge (obtained from the equation calculation previously shown) is not clinically different from a 7 mm wedge. We recommend using bone autograft if possible, obtained from the iliac crest. If this is not possible, the use of structured allografts is adequate.

When correcting anterior ankle arthritis combined with severe recurvatum deformities, we recommend performing a medial dome osteotomy (Fig. 10). Although technically more complex, a medial dome allows for an easier angular correction when estimating the necessary shift of the distal tibial fragment. If there is not any arthrosis or change in anterior ankle joint space, we recommend only to consider the supramalleolar apex of deformity and perform a medial dome SMOT centered on the supramalleolar apex. If there is already anterior ankle arthrosis, which is more frequent, we recommend using the intraarticular apex as the apex of deformity correction. For planning, a 4-hole third tubular plate is used. It is fixed with a pin at the medial malleolus through its first hole. Then, using it as a compass, multiple drill holes are performed

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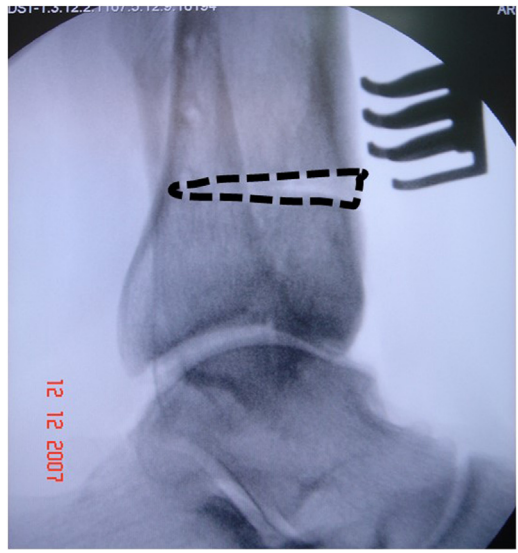

Fig. 9. Intraoperative fluoroscopy of an anterior ankle arthritic case. An incomplete transverse distal tibia opening wedge osteotomy has been performed. The size of the wedge is calculated with the same rule as for coronal plane correction, that is, 1.2° of correction for every 1 mm wedge size.

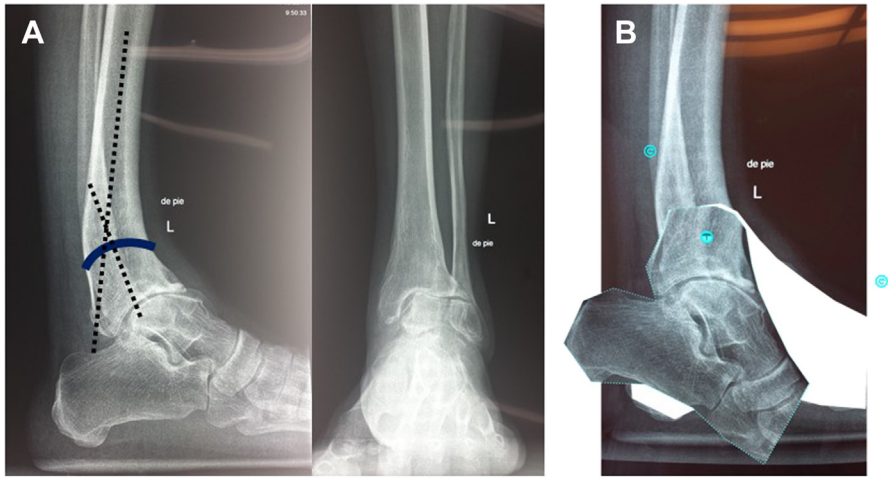

Fig. 10. Radiographic views of an anterior ankle arthritis case with a severe recurvatum deformity. (*A*) The measurement of the apex of the deformity (follow the intersection of the *dotted lines* representing the proximal and distal tibia axes) and consequent planning of a medially based dome SMOT. In the anteroposterior view, a mild varus deformity can also be seen. (*B*) The digital planning of a medial dome SMOT, where after the deformity correction, we can assume how difficult it will be to lengthen the posterior soft tissue contractures to achieve a neutral dorsiflexion.

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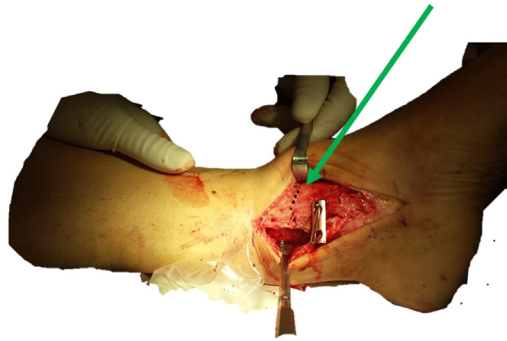

Fig. 11. Intraoperative view of the same clinical case shown in the previous images. Patient is laying supine; proximal is at the left-hand side of the picture. A medial approach was performed, and a medial dome osteotomy is being performed. Please note theone third semitubular plate at the distal tibia, which was used as a compass to "draw" with multiple perforations a medial dome SMOT on the tibia. These multiple holes were then connected with an osteotome.

using its fourth hole. After drilling, the osteotomy is completed with a conventional osteotome (Fig. 11). When performing the dome osteotomy (performed from a medial distal tibia approach), as there is a broad bone contact area, there is no need in using bone graft, but the correction must be tailored intraoperatively. Checking on fluoroscopy the distal fragment must be angulated until the desired correction is achieved. Fixation is performed with small fragment locked plates.

When correcting a sagittal plane deformity generally we also encounter coronal plane deformities. These deformities need a biplanar osteotomy, which are more

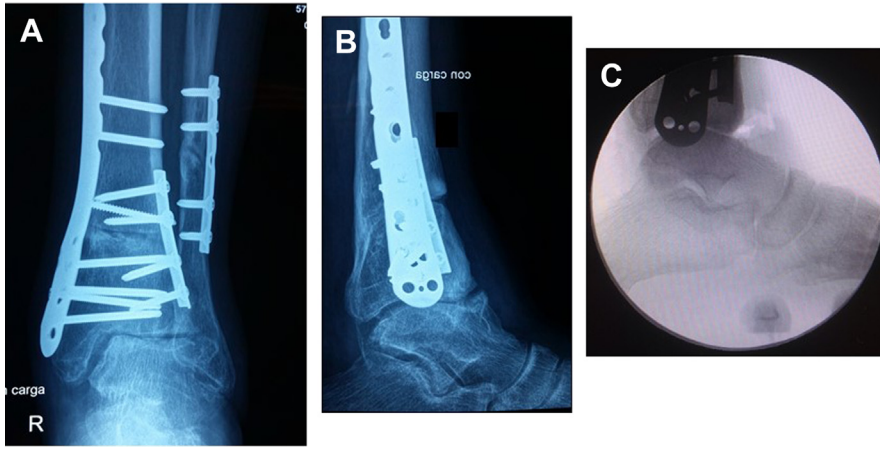

Fig. 12. Postoperative radiographs of the same patient presented in the previous figures. (*A*) The anteroposterior view of the ankle. As a correction in the sagittal and coronal plane was performed, 2 plates were used to fix the tibia. (*B*) The lateral view, where a complete correction of the recurvatum deformity was achieved. Note also the distal talar osteophytes that developed within 1 year, due to an incomplete posterior ankle soft tissue release. (*C*) The revision surgery where besides the removal of the talar osteophytes, an extensive release of posterior soft tissue was performed.

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unstable than single-plane osteotomies. Our recommendation is to fix these biplanar osteotomies with 2 plates, ideally orthogonally placed (Fig. 12).

Fibular osteotomy

The fibula is osteotomized at the level of the syndesmosis, making sure to have enough distal fibula to be fixed later with a locking plate. The osteotomy is generally a short oblique one, resembling a Weber B fracture; this will allow an easier reorientation of the talus. A common mistake when fixing the fibula is to anatomically reduce the fragments and apply the plate. If we are correcting the TT ratio, anatomic reduction of the fibular osteotomy is not desired, as we will most probably lose all sagittal translation correction. Therefore, the fibula must remain nonreduced, and it has to be fixed with a locking plate, without interfragmentary compression. In this way we will hold the talus in the desired position.

If intraoperatively after correcting the ADTA angle and resecting the anterior tibial osteophytes, the talus seems to be too close to the anterior lip of the tibia, a talar neck plasty may be a solution to avoid future anterior ankle impingements.[5]

POSTERIOR ANKLE ARTHRITIS

In posterior ankle arthritis, we will either find an ADTA angle more than 80°, or the TT ratio higher than 38, or both (Figs. 13 and 14). Similar considerations must be given to

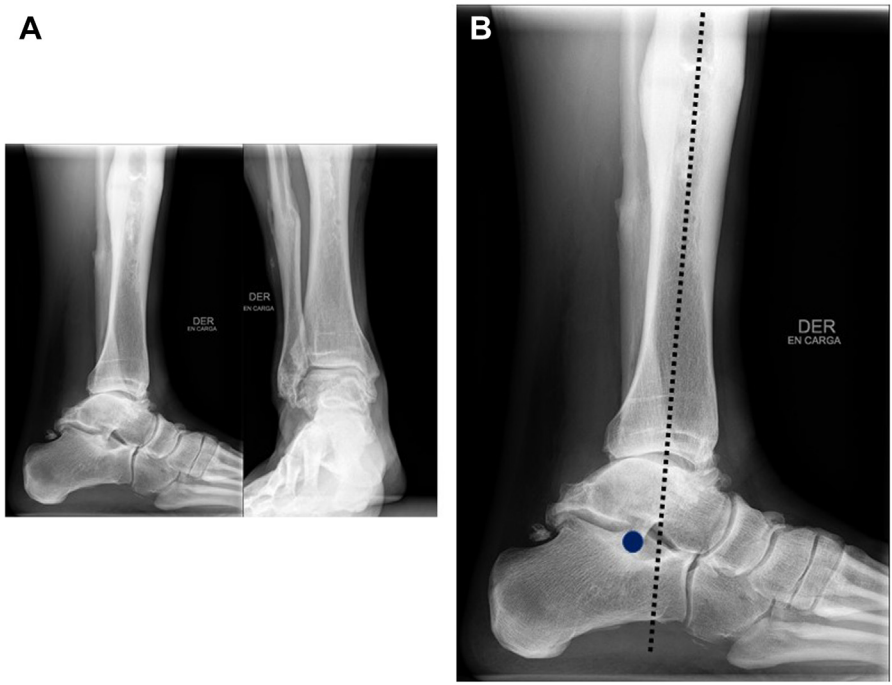

Fig. 13. Radiographic views of a posterior ankle arthritis case. (*A*) The lateral and anteroposterior view, with a clear sagittal malalignment (note the posterior position of the talus relative to the tibia). Please note that there is no significant coronal plane malalignment. (*B*) The posterior displacement of the talus relative to the tibial axis (represented by the *dotted line*). The tibia axis does not intersect the center of rotation of the ankle represented by the blue dot (located at the anterolateral talar process).

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the preoperative planning, position of the apex of deformity, and desired amount of correction as already mentioned for anterior ankle arthritis.

In this case, we will indicate an SMOT using an anterior closing wedge rather than a posterior opening wedge, which is more technically challenging. The fibula must be osteotomized as already commented for anterior ankle arthritis (Fig. 15). In these cases, we have not seen soft tissue retractions as an additional element to be considered.

Technique

Tibial osteotomy

An anterior ankle incision is recommended, generally used also for coronal plane deformity treatment. Through this approach, an anterior tibial closing wedge can be performed, with the same calculations performed given for the anterior ankle arthritis cases. For deformities greater than 10°, a dome osteotomy is recommended using a direct distal tibia medial approach.

In posterior ankle arthritis we have seen a bigger role of a malunited fibula or syndesmosis in creating or keeping the posterior translation of the talus. The final fibular position must allow the correction of the TT ratio. Sometimes, a corrective osteotomy of the fibula should be performed forcing the distal fibula anteriorly so the talus can be anteriorized, fixing the fibula in the corrected position to hold the talus in place. The

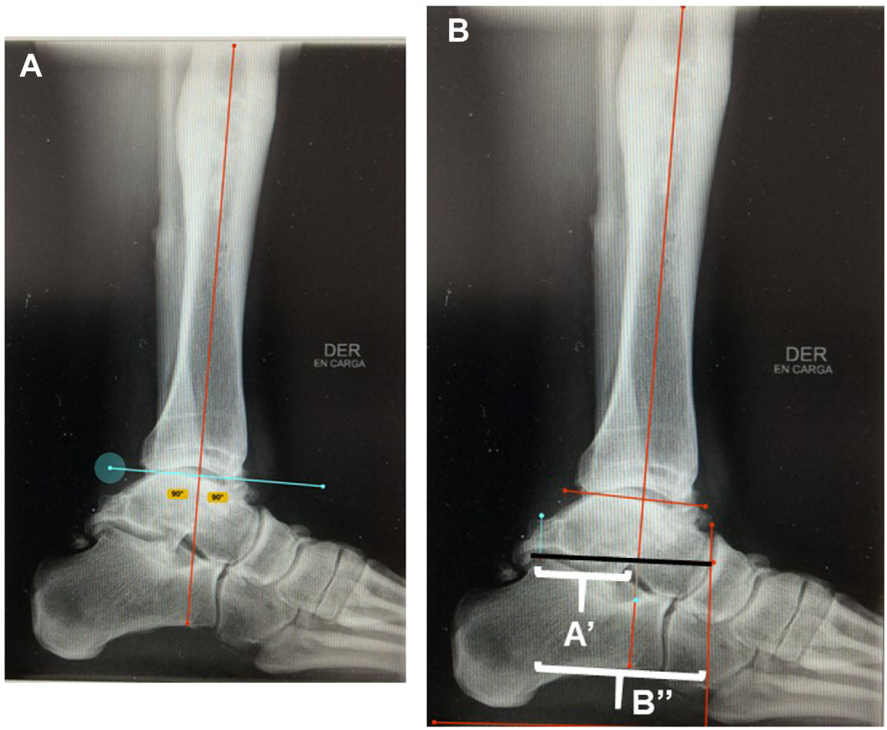

Fig. 14. Radiographic views of the same case presented in the previous figure. Preoperative planning is being performed. (*A*) The ADTA angle, which in this case is 90°. (*B*) The calculation of the TT ratio, obtained from dividing A′ over B″ and multiplying by 100. In this case, the TT ratio was 45.

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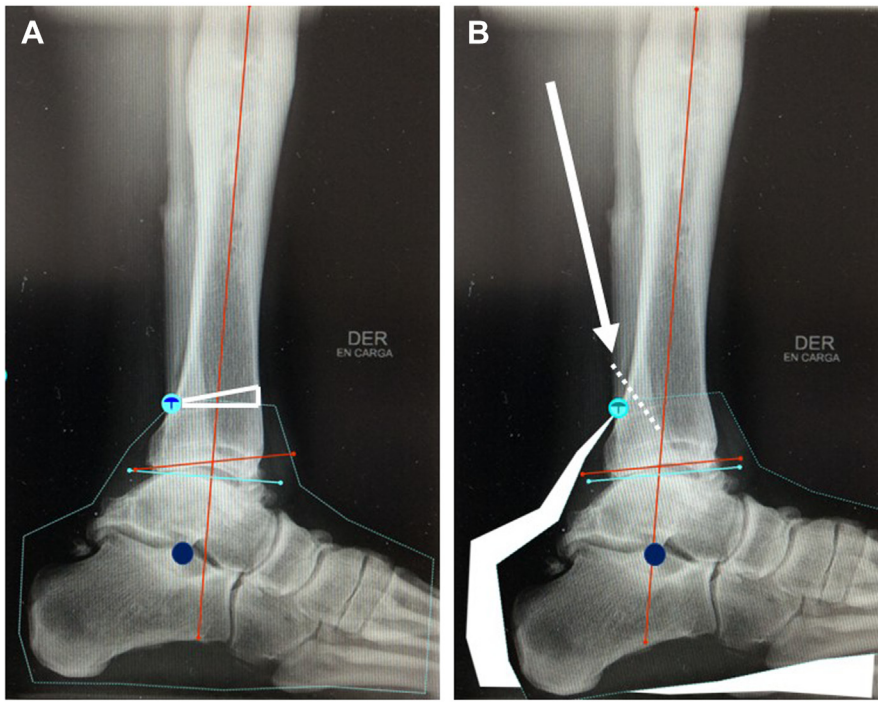

Fig. 15. Preoperative planning of the same case presented in the 2 previous figures. (*A*) A planned SMOT with an anterior closing wedge. Note the incorrect intersection of the center of rotation of the ankle (*blue dot*) and the tibia axis (*red line*). (*B*) The planned correction after removing the anterior tibial wedge. Note the correct intersection of the center of rotation of the ankle (*blue dot*) and the tibia axis (*red line*). To aid in the correction of the talar position, a fibular osteotomy must be added, allowing the talus to move forward. The fibular osteotomy is represented by a white dotted line and indicated by a white arrow.

incisura fibularis may have changed in shape, and therefore although we may see a correct reduction of the fibula in the incisura, the talar reduction may not be adequate. Therefore, we recommend using the talar reduction under the tibia and not the syndesmosis reduction to decide where to fix the fibula. It may happen in these cases that an apparent malreduction of the syndesmosis is needed to achieve a good correction of the TT ratio. A locking plate is needed to help maintain the talar position (Fig. 16).

RESULTS

For anterior ankle arthritis, an anterior opening wedge SMOT is the technique of choice, with good published results.[2,14] In the largest study published about anterior ankle arthritis, Scheidegger showed good results in 39 patients using either an SMOT with an opening wedge or a dome technique. The cumulative survival rate was 67% at 36 months, where 23% of the patients were converted to total ankle replacement or fusion.[15] No results have been published relative to posterior ankle arthritis.

In our experience over our last 20 cases of SMOT dealing with combined coronal and sagittal plane deformities, posterior ankle arthritis cases seem to have less

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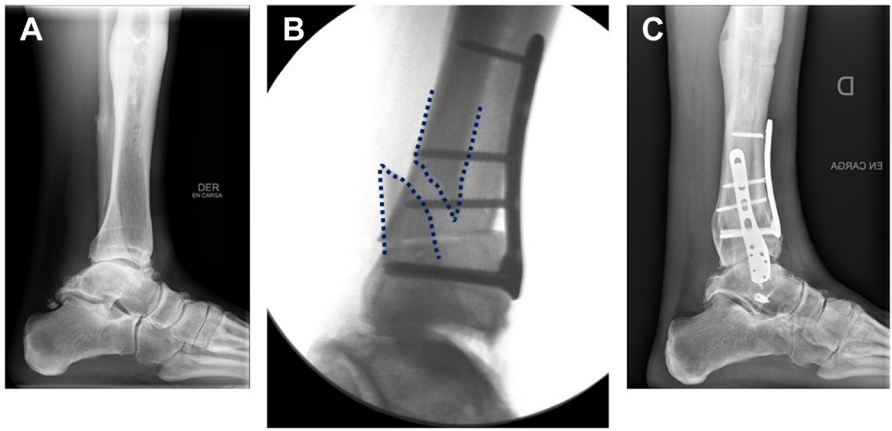

Fig. 16. Lateral radiographs of the same case presented in the previous figures. (*A*) The preoperative view with the visible sagittal ankle malalignment. (*B*) The intraoperative view after performing the SMOT with an anterior tibia closing wedge. Note the fibular contour after the fibula osteotomy, represented by the dotted lines following the proximal and distal fibular fragments. This relative "malposition" of the fibular osteotomy must be maintained and fixed with a locking plate, in order to secure the talar position. (*C*) The postoperative lateral view after the correction.

satisfactory results, due to the presence of syndesmotic damage or malunion, hindering a good result due to prolonged pain and stiffness. Our main SMOT technique for sagittal plane deformities considers adding or subtracting an anterior distal tibial wedge, which is easily combined with coronal plane corrections, using the same anterior approach. If the sagittal plane deformity prevails over the coronal deformity and presents with a magnitude of 10° or more, we prefer a medial approach to perform a medial Dome osteotomy. The medial dome SMOT is straightforward to perform, with an excellent bone-to-bone contact. In this way, we address the main deformity on its own plane, allowing an easier intraoperative correction tailoring. Smaller corrections of coronal plane deformities are possible through a medial dome, affecting some cancellous bone laterally or medially.

SUMMARY

For posterior ankle arthritis, an anterior closing wedge osteotomy is the recommended treatment option. An anterior opening wedge osteotomy is recommended for anterior ankle arthritis. If the deformity is greater than 10° in severity, a medial dome osteotomy is recommended. Special care must be taken to adequately plan the correction, in order to achieve a corrected angular position of the distal tibia and a correct centering of the talus under the tibia.

CLINICS CARE POINTS

- Anterior and posterior bow deformities produce a greater change in tibiotalar joint contact areas compared with valgus or varus deformities of the tibia.[4]
- Sagittal ankle malalignment is common in end-stage ankle arthrosis, with up to 56% of the cases presenting either anterior or posterior displacement of the talus in relation to the tibia.[8]

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- Radiographically, the middiaphyseal line of the tibia in the sagittal plane passes through the lateral process of the talus when the plantar aspect of the foot is in 90° in relation to the tibia. Another commonly measured angle is the ADTA, whose normal value is 80°.[1] The TT ratio was shown to be a reliable radiographic measure to determine the position of the talus relative to the tibia, regardless of the condition of the ankle surface.[10]
- Anterior and posterior ankle arthritis have been characterized, with consequent changes in the ADTA angle and in the position of the talus relative to the tibia.[2]
- For anterior ankle arthritis, an anterior opening wedge SMOT is the technique of choice, with good, published results.[2,13]

DISCLOSURE

The authors have nothing to disclose.

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