Correction of the Valgus Ankle with a Joint Sparing Supra-Malleolar Osteotomy

The Modified Wiltse Technique

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KEYWORDS

- Orthopaedic surgery • Valgus ankle deformity • Joint-sparing surgical treatment
- Wiltse osteotomy

KEY POINTS

- The reconstitution of normal anatomy in the presence of a valgus ankle deformity is complicated by the position of the Center of Rotation and Angulation (CORA), soft tissue limitations, and complexities related to achieving stable distal fixation.
- The Wiltse osteotomy correctly uses "osteotomy rule two" to reconstitute normal angular- and maintaining mechanical alignment.
- The reproduction of the preplanned "Wiltse Triangle" on the distal tibia allows for highly accurate correction, inherent stability, and coronal plane adaptability.

INTRODUCTION AND HISTORICAL OVERVIEW

The valgus ankle is a common cause of pain, deformity, and disability in the pediatric, adult, and geriatric population due to impaired ankle and/or foot mechanics.[1–3] The "valgus ankle" could present as a relatively simple coronal plane deformity or as a more complex multiplanar deformity around the ankle joint. The deformity might be situated supramalleolar, within the ankle joint or even the hindfoot. Additional deformities, joint instability, contractures, muscular imbalance as well as loss of motion within the ankle joint and/or the foot could further complicate the management thereof.[4]

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Foot Ankle Clin N Am 27 (2022) 91–113
https://doi.org/10.1016/j.fcl.2021.11.004
foot.theclinics.com

Longitudinal studies evaluating the long-term outcome and sequela of valgus ankle malalignment are lacking.[2,5] Confounding factors of existing evidence include patient selection bias, a multitude of causes, slow deformity progression, early utilization of treatment, as well as the added complexities of the ankle joint anatomy and biomechanical considerations.[2] Additionally, the ankle is situated in close proximity to the foot that can either cause ankle deformities or structurally and functionally adapt to a valgus ankle, thereby rendering subtalar joint malposition and/or stiffness.[6]

Although several retrospective studies imply that mild to moderate valgus malalignment around the tibiotalar joint does not cause significant ankle arthritis and/or other secondary long-term sequelae,[2,7–9] other authors recommend early surgical correction for valgus deformities as little as 5°.[2,10] However, basic science studies,[2,11,12] the profound effect of fibular malalignment on the ankle mortise,[2,13] the risk of progression of valgus angulation[13,14] support early, aggressive correction.[2,6] In addition, the secondary effect on foot mobility and deformities and the known advantages of joint-sparing procedures, combined with mechanical axis realignment further suggest that an early and customized approach to those patients is beneficial in the long term.[15]

Surgical correction of a predominant coronal plane valgus supra-malleolar deformity without inherent contraindications for joint-sparing osteotomies can be achieved by different types of varus angulating osteotomies.[3,14,15]

- Medial closing wedge osteotomies
- Lateral opening wedge osteotomies
- Focal dome osteotomies.
- Minimally invasive Gigli saw osteotomies (frame assisted correction)

Each osteotomy has distinct advantages and disadvantages to consider when planning which osteotomy to use[5,10,15,16] (**Table 1**).

A multitude of stabilizing and fixation methods after performing a supramalleolar varus angulating osteotomy are available and determined by various factors:

- Patient preference, anxieties, or tolerance especially when external frame application is considered
- The physiologic age, functional demands and etiology of the valgus ankle in individualized patients
- The quality of the soft tissue envelope, vascular compromise, and presence of previous or current infection
- The need to simultaneously address leg length discrepancies
- The severity of the deformity
- The inherent stability of the specific osteotomy
- The presence or absence of protective sensation, for example, children with myelomeningocele.

Stabilizing and Fixation techniques include[15]:

- Kirschner-wires: frequently used in the pediatric population due to the potential for accelerated union in inherently stable osteotomies
- External fixators: typically used in multiplanar deformities, poor soft tissue, and/or loss of length
- Plate fixation: gold standard of fixation in the adult population when using acute corrections

The Wiltse Osteotomy, a modification of the wedge resection osteotomy, is a viable alternative for the treatment of valgus coronal plane deformities in and around the

Table 1
Advantages and disadvantages of different osteotomies for the correction of ankle valgus deformities[5,10,15,16]

Approach	Advantages	Disadvantages
Opening wedge	Straightforward preoperative planning	Delayed union
	Simple intraoperative technique	Soft tissue compromise
	Adds length	Unintentional mechanical axis translation (osteotomy rule 3)
Closing wedge	Straightforward preoperative planning	Loss of length
	Simple intraoperative technique	Unintentional mechanical axis translation (osteotomy rule 3)
	Inherent stability	
	Soft tissue friendly	
Dome	Inherent stability	Moderate technical complexity
	Maintaining mechanical axis (osteotomy rule 2)	Inability to address multiplanar deformities
	Length neutral	
Wiltse	Accurate preoperative planning	Moderate technical complexity
	Inherent stability	Inability to address multiplanar deformities
	Length neutral	
	Maintaining mechanical axis (osteotomy rule 2)	
	Applicable to large deformities	

tibiotalar joint.[17] Leon Wiltse, in 1972, observed that a simple wedge resection osteotomy causes mechanical axial malalignment with secondary medial translation of the tibiotalar joint and a prominent medial malleolus. By the resection of a triangular bone segment combined with a rotation of the distal fragment, he achieved mechanical axis realignment and an ankle with a more "normal appearance."[17] He additionally performed an oblique fibula osteotomy that maintained the integrity of the syndesmosis and allowed rotation of the ankle complex when correction the deformity.[17]

While not explicitly stated, Wiltse achieved the compensatory and corrective translation when an osteotomy is performed a distance away from the center of rotation of angulation (CORA) thus successfully and correctly using rule 2 of osteotomies (compensatory translation within the osteotomy site) and preventing osteotomy rule 3 (**Figs. 1** and **2**).[15,18]

Frequently used osteotomies for the treatment of a valgus ankle include medial closing wedge or lateral opening wedge osteotomies, performed proximal to the center of rotation of angulation. Although angular correction is achieved, a compensatory medial mechanical axis deviation with a prominent medial malleolus occurs (**Fig. 3**).

The dome osteotomy adheres to rule 2 and can simultaneously achieve angular correction as well as maintaining mechanical axis alignment (**Fig. 4**).[15,18]

When the predominant coronal plane valgus deformity is situated close to the ankle joint and/or within the hindfoot or is of considerable magnitude, it is frequently not possible to perform your osteotomy at the CORA and stabilizing your osteotomy

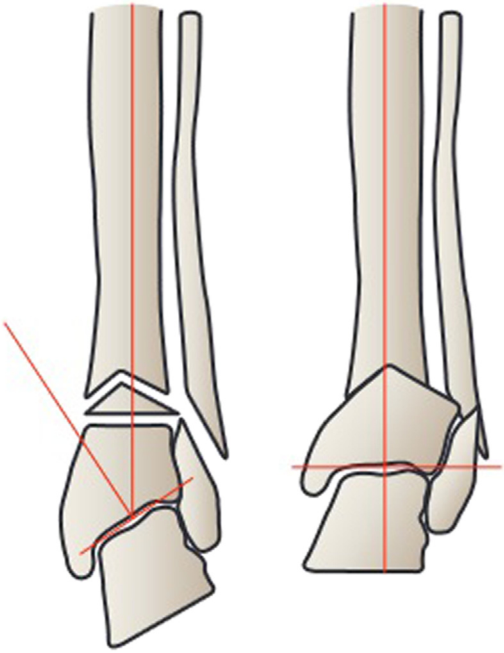

Fig. 1. The Wiltse osteotomy: excision of a triangular tibial bone segment and oblique osteotomy of the fibula. Rotation and translation of the distal tibial fragment within the apex of the triangle achieve normalization of the ankle. Correct utilization of rule 2 of osteotomies by the Wiltse technique corrects the valgus angulation as well as the mechanical axis of the ankle.

without compromising the tibiotalar joint or the physis in a child. The Wiltse osteotomy is an excellent alternative to achieve mechanical realignment (angulation and translation) even though the deformity is situated close to the ankle joint. Additional secondary advantages are inherent stability of the osteotomy, as well as early mobilization. The distal tibial and fibular physis is not compromised and the tibia-fibular relationship and syndesmoses remain unchanged. Additionally, the Wiltse osteotomy renders itself to allow accurate preoperative planning and templating and is adaptable to allow relative ease of intraoperative adjustment.

The goal of this article is to outline the indications/contraindications, preoperative and preprocedure planning, surgical technique, postoperative care, and surgical outcomes of the Wiltse Osteotomy.

INDICATIONS AND CONTRAINDICATIONS FOR THE WILTSE OSTEOTOMY

Indications:

- Developmental and congenital valgus deformities around the ankle
- Mild to moderate osteoarthritis and pain or local osteoarthritis predominantly situated in the lateral pillar of the ankle mortise
- Severe osteoarthritis combined with a large valgus deformity whereby mechanical realignment is indicated for preparation for a future total ankle arthroplasty
- Malunited distal tibial fractures around the supramalleolar area and/or extending intraarticular

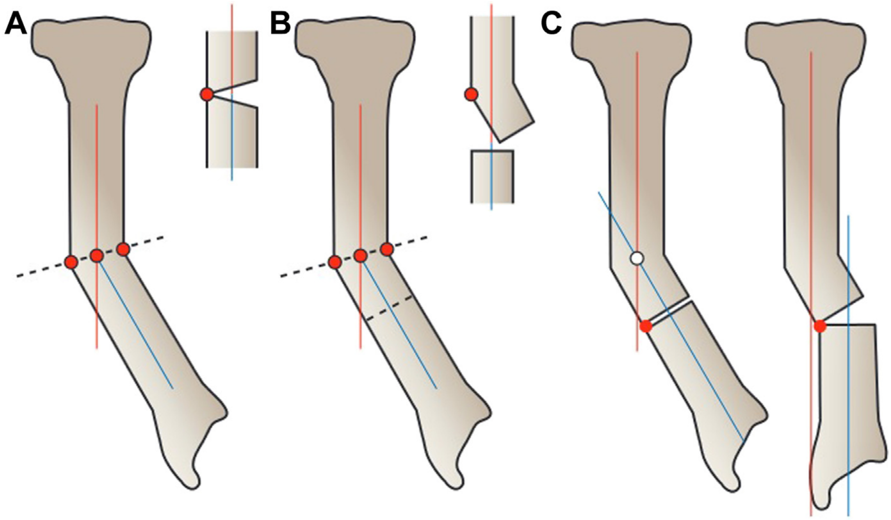

Fig. 2. The “rules of osteotomies” as popularized by Paley and colleagues (*A*) Osteotomy rule 1: The osteotomy is performed at the location of the center of rotation of angulation (CORA) and only requires angulation for reduction. (*B*) Osteotomy rule 2: The osteotomy is performed at a location other than the CORA, but the angulation correction axis (ACA) is located at the CORA, thus angulation around the site of the deformity and translation at the osteotomy is required for correct reduction of alignment. The Wiltse osteotomy frequently uses rule 2 to obtain a normal mechanical axis. (*C*) Osteotomy rule 3: The osteotomy is created away from both the CORA and ACA and will result in a secondary deformity – the ankle joint and the knee joint will be parallel, but a secondary translation deformity will be created.

- Malunited valgus ankle and/or subtalar arthrodesis
- Fixed abnormal valgus deformity of the subtalar joint and the surgery around the foot is contraindicated due to host, soft tissues, or certain congenital abnormalities

Contraindications:

- Multiplanar deformities in and around the ankle joint whereby the main deformity is in the sagittal plane
- Deformities less than 10° whereby the medial translation is neglectable (relative contraindication)
- Varus deformity

PREOPERATIVE PLANNING

A comprehensive clinical assessment, radiographic evaluation, and templating of a patient with an ankle valgus deformity is critical and is frequently complicated by the following factors and considerations:

Clinical Examination

- Etiology: The valgus ankle can be caused by developmental and congenital abnormalities, malunited distal tibia fractures, osteoarthritis, or postoperative sequelae of arthrodesis of the foot and/or ankle.[15] Host factors, for example, the skeletally immature patient with congenital abnormalities or poor local biology, needs to be carefully assessed

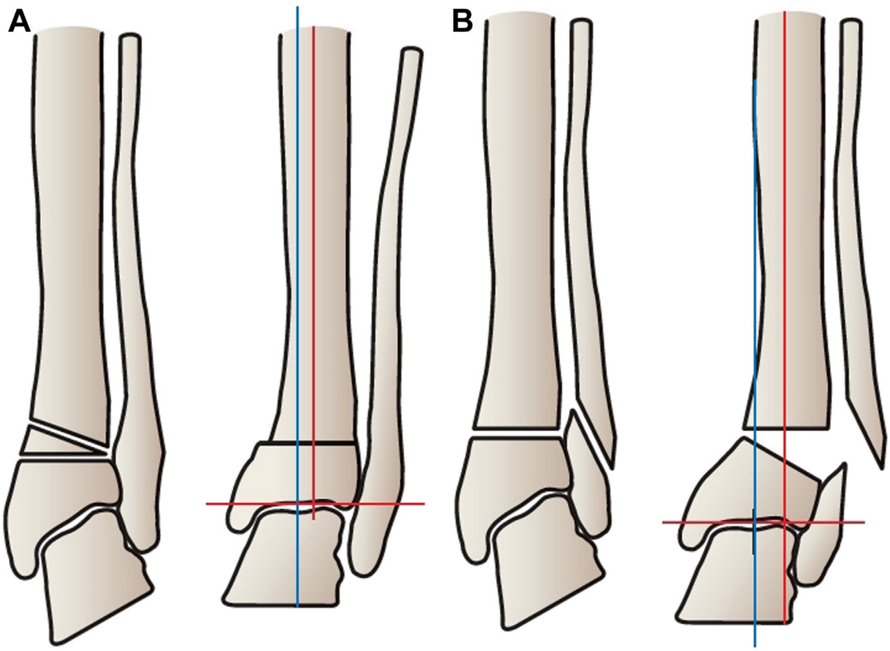

Fig. 3. Closed (*A*) and open (*B*) wedge osteotomies of a coronal plane valgus deformity in or around the ankle joint will result in a medial translational deformity, illustrating the concerns related to rule 3 of osteotomies.

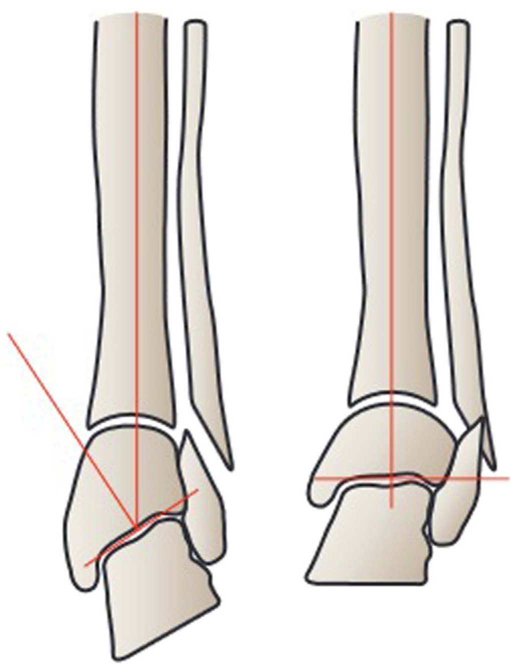

Fig. 4. The dome osteotomy allows for angular correction and maintains the mechanical axis.

- The future effect of growth on the deformity and the "at risk" anatomic position of the distal tibia and fibula physis
- Previous operations performed in and around the ankle and the affected lower limb
- Additional lower limb malalignment above or below the ankle. Severe rotational abnormalities should be clinically noted and measured as this will have a profound effect on the radiological evaluation and preoperative planning and templating.
- Poor mobility, contractures, and/or instability of the hip, knee, ankle, and/or subtalar joint. The range of movement of the ankle and the presence and type of Achilles tendon contracture should be assessed. The Silfverskiöld test should be performed to determine the need for a gastrocnemius slide (fractional lengthening of the gastroc-soleus complex)
- Muscular and tendinous imbalance due to congenital, traumatic, or degenerative causes
- A compromised soft tissue envelope in and around the ankle
- Previous surgical or posttraumatic scars that could compromise a standard surgical approach to the supramalleolar area.
- Neurovascular compromise
- Active or previous infection
- The magnitude and location of the deformity
- Presence or absence of compensating motion or deformity of adjacent joints, especially the subtalar joint. Should the subtalar joint be rigid and unable to accommodate the valgus correction, additional realignment foot osteotomy procedures may be required.

Preoperative Radiological Planning

Standardized radiological assessment is critical to enable the surgeon to detect and anticipate any additional deformities of the affected and unaffected lower limb via structured deformity analysis.[18] The presence of posttraumatic or procedural nonunions, previous hardware, and osteomyelitis or previous sequelae of septic arthritis needs to be noted. Radiographic evaluation of the ankle valgus deformity enables exact deformity location, the magnitude of the coronal, sagittal and axial deformity, and the integrity of the ankle joint and the fibular anatomy. Anatomically correct plain radiographs are also essential for preoperative templating and planning of the Wiltse Osteotomy.

Recommendations for radiographs depend on etiologic and host factors, with the typical workup including[18]:

- Full-length standing antero-posterior (AP) radiographs of both lower extremities
- AP radiograph of the ankle that includes the tibia (weight bearing)
- Lateral radiograph of the ankle that includes the tibia (weight bearing)
- AP, lateral, and mortise views of the ankle
- AP and lateral weight-bearing radiographs of the foot
- Hindfoot alignment views if clinically indicated

Magnetic resonance imaging (MRI) and/or computed tomography (CT) is usually not required but a CT scan for 3D printing of the deformity and a custom cutting block may be indicated.

Basic deformity analysis is conducted according to the method described by Paley and colleagues[19] to identify any additional malalignment deformities in the affected limb. Specifically exclude large sagittal plane deformities around the affected ankle that would contraindicate the use of a Wiltse Osteotomy.

Step 1: Basic Deformity Analysis of the Ankle Joint Using the AP Radiograph (Including the Distal Tibia)

- Insert the mid-diaphyseal longitudinal line to obtain the anatomic axis of the tibia (Fig. 5)
- Insert the ankle joint orientation line along the flat subchondral line of the tibial plafond and identify the ankle joint center (mid-width of the located talus or mid-width of the tibia and fibula) (Fig. 6)
- Draw and measure the normal LDTA angle (use the contralateral normal side or the accepted norm of $\pm$ 89°) (see Fig. 6)
- The abnormal joint orientation angle of the ankle (lateral distal tibial angle - LDTA) is measured (in this case identifying the magnitude of the valgus coronal plane deformity) (Fig. 7)
- The site of the valgus deformity is represented by the point whereby the anatomic axis line of the tibia and the longitudinal line of the normal LDTA transect. This may be located proximal, within, or distal to the ankle joint. The magnitude of the deformity that needs to be corrected to restore the normal LDTA is measured (see Fig. 7).

Step 2: Osteotomy Planning and Templating

- The Wiltse osteotomy planning is based on constructing a scalene "Wiltse Triangle". This triangle in which all 3 sides have different lengths and all 3 angles differ is influenced by the magnitude of the valgus deformity.
- The overarching aim for constructing the "Wiltse Triangle" is to determine the site of the osteotomy, to incorporate the deformity angle, and to define the correct placement of the apex of the triangle, thus predetermining the correct translation and restoring the mechanical axis. The base of the triangle is the leg perpendicular to the mechanical axis of the tibia (Fig. 8) By convention we place this base

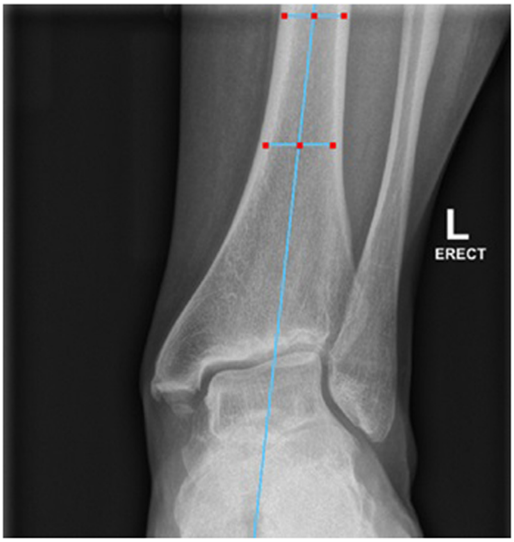

Fig. 5. Step 1 of preoperative templating: the mid-diaphyseal longitudinal line to obtain the anatomic axis of the tibia is inserted.

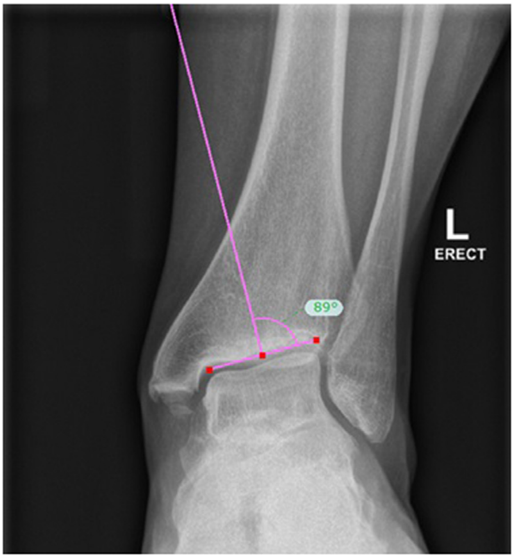

Fig. 6. The normal lateral distal tibial angle (LDTA) – 89°.

line just above the syndesmosis but as closely as possible to the articular surface to maintain and protect the integrity of the ankle mortise.

- The lateral base angle (LBA) is equal to the magnitude of the measured deformity in degrees, enabling correction of the angular deformity (**Fig. 9**).

Step 3: The Calculation of the Medial Base Angle

- The medial flare angle (MFA) is calculated by drawing a line parallel to the anatomic axis and traversing the base osteotomy line at the medial cortex. An additional angle line is drawn along the medial flare toward the area whereby the base osteotomy line crosses the aforementioned parallel line (**Fig. 10**)
- Calculation of the MBA - Accurate measurement of this angle allows the medial flare of the medial distal tibia to fit snugly on the superior medial leg of the osteotomy, thus replicating normal medial ankle anatomy.

90° – (MFA + LBA) = MBA of the Wiltse triangle (**Fig. 11**)

The MBA line and the LBA line are extended to form the apex of the triangle. This angle's value is not important but the position within the tibia is essential to enable the accurate lateral translation of the distal fragment to maintain the mechanical axis. The Wiltse triangle is now complete (**Fig. 12**).

Preoperative templating of your chosen fixed-angle fixation plate is recommended.

SURGICAL TECHNIQUE & OUTCOMES

The patient is placed supine on a padded radiolucent table after which general anesthesia is used together with a regional, ultrasound-guided popliteal nerve block. Alternatively, according to host-specific preferences and/or risk factors, spinal/epidural anesthesia is used to provide intra and postoperative analgesia.

A bump is placed under the ipsilateral hip to rotate the lower limb with the patella facing anteriorly and a padded thigh tourniquet is applied to provide a bloodless field. The extremity is prepped above the level of the knee to assess limb alignment.

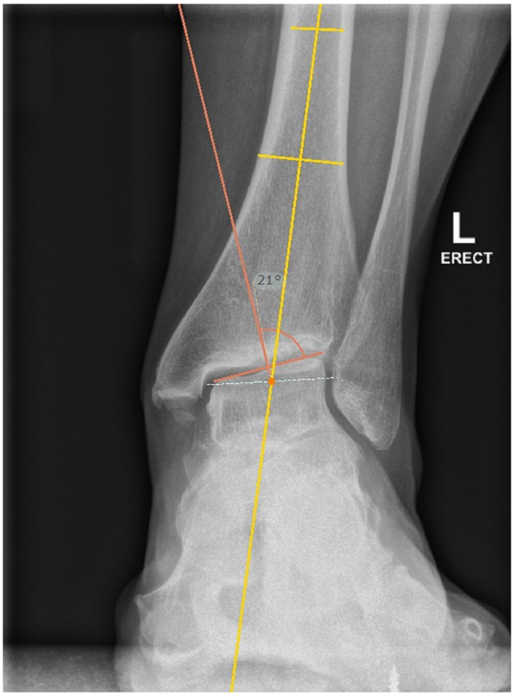

Fig. 7. Step 1 of preoperative templating: The magnitude of the valgus deformity is measured at 21°.

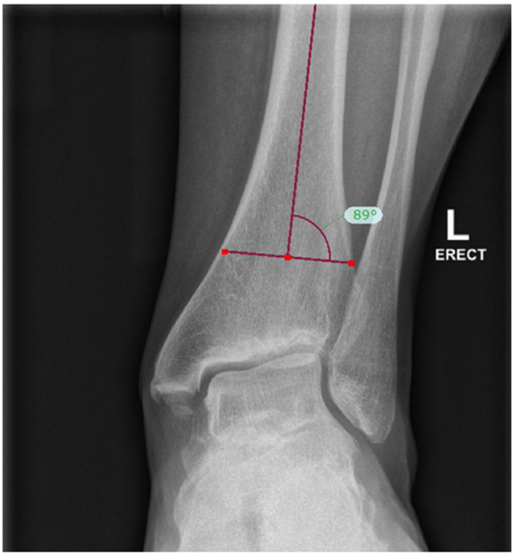

Fig. 8. Step 2 of preoperative templating: the transverse line represents the base of Wiltse's triangle and is situated immediately proximal to the syndesmosis.

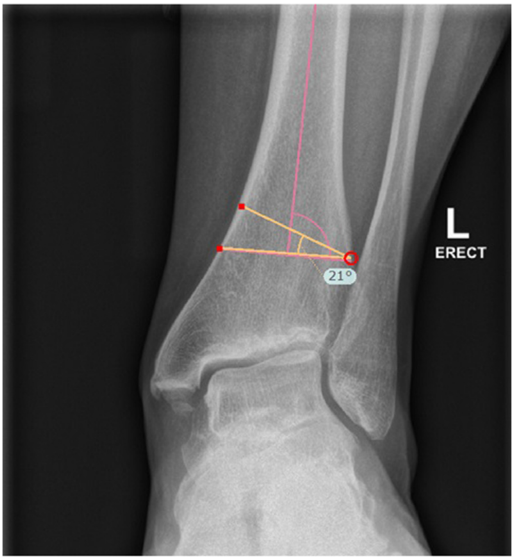

Fig. 9. Step 2 of preoperative templating: The lateral base angle (LBA) as indicated measuring 21°.

Fluoroscopy with sterile sleeves should be available from the start of the procedure to ensure correct positioning of the limb, to aid with the accurate placement of the Wiltse Triangle, performing the tibial and fibular osteotomies, evaluation of restoration of the normal mechanical axis, and correct and accurate fixation of the osteotomy (Fig. 13).

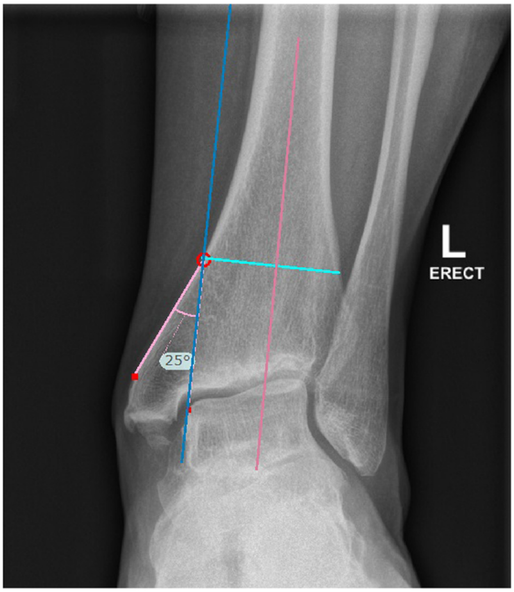

Fig. 10. Step 3 of preoperative templating: the medial flare angle (MFA) is calculated at 25°.

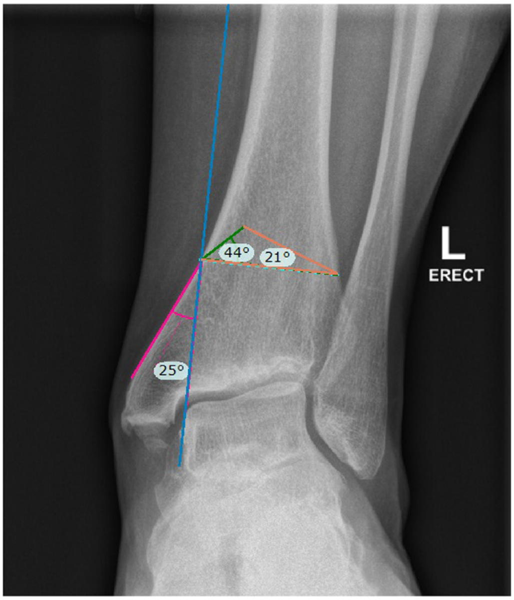

Fig. 11. Step 3 of preoperative templating: The Medial Base Angle (MBA) is calculated by subtracting the sum of the medial flare angle (MFA) and lateral base angle (LBA) from 90°: 90° – (25° + 21°) = 44°.

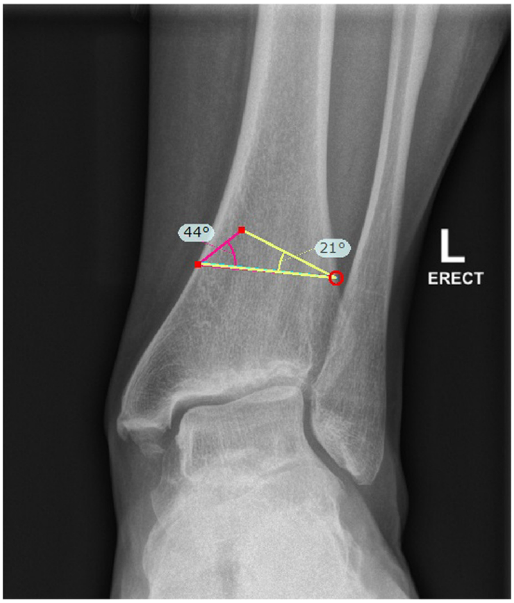

Fig. 12. Step 3 of preoperative templating: the Wiltse triangle is now completed.

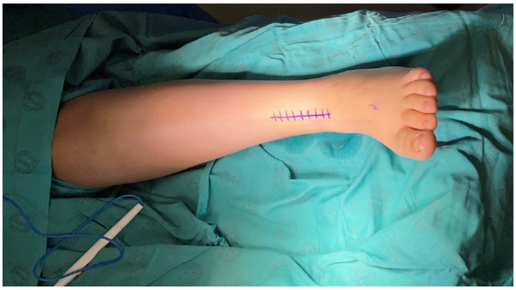

Fig. 13. Standard intraoperative positioning and incision.

A standard anterior surgical ankle approach is used to expose the distal tibia with a separate lateral fibula approach with safe skin bridges being used to expose the distal fibula. The structure most at risk during the standard anterior ankle approach is the anterior neurovascular bundle and should be protected.

The incision can be extended distally to the level of the ankle joint to enable excision of the capsule, synovium, or osteophytes around the ankle joint and/or proximally to aid with the osteotomy cuts placement or the seating of a custom cutting block.

Three options can be considered intraoperatively to accurately reproduce the preplanned Wiltse Triangle:

1. Drawing the Wiltse osteotomy on transparent paper and superimposing this over the fluoroscopy image to guide Kirchner-wire placement (Fig. 14).
2. Using a sterilized triangle set to guide K-wire placement (Fig. 15).
3. Using a 3-dimensional (3D) printed, patient-specific cutting jig: CT scan data from the patient are used to construct a 3D digital model of the anterior surface of the distal tibia. The Digital Imaging and Communication in Medicine (DICOM) data generated by medical CT scanners is converted into 3D Computer Assisted Drawing (CAD) data that can be used to manipulate the bone structure digitally and to design and print the custom cutting jig. Slots are created to act as exact cutting guides for the saw blade, thus mimicking the Wiltse triangle (Fig. 16).

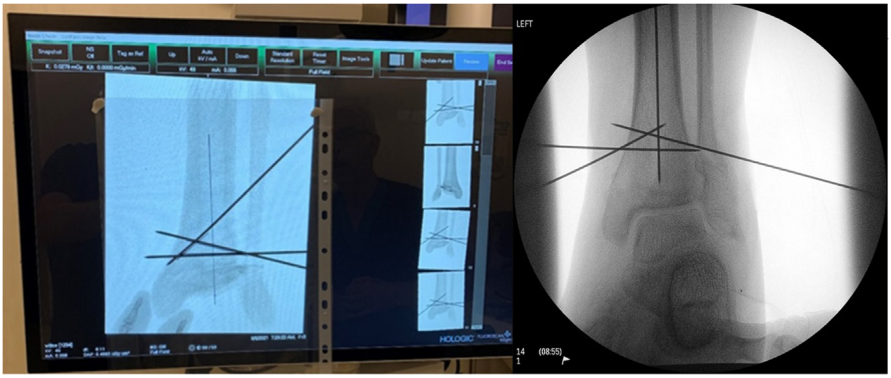

Fig. 14. Surgical technique option 1: superimposing the preplanned Wiltse triangle on the fluoroscopy screen guiding Kirchner-wire placement.

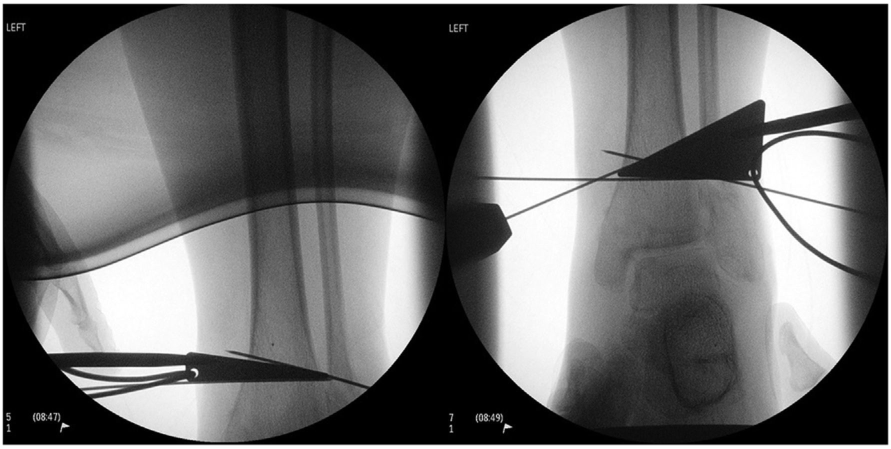

Fig. 15. Surgical technique option 1: sterilized triangle set to enable accurate K-wire placement to reproduce the Wiltse triangle.

The current preferred method in our unit is using sterilized triangles to guide the insertion of K-wires and completing the osteotomies with an oscillating saw. Under fluoroscopic guidance, the level of the base of the osteotomy is marked on the proximal border of the syndesmosis after which a 1.8-mm wire is inserted perpendicular to the anatomic long axis of the tibia at the lateral cortical border of the tibia. The LBA is replicated by placing a K-wire under fluoroscopic guidance from lateral-distal to medial-proximal crossing the 1st wire at the lateral tibial border. The MBA is replicated by placing a K-wire under fluoroscopic guidance from medial-distal to lateral-proximal. Subsequently, a triangle is formed. A K-wire can be placed in an anterior–posterior plane at the apex of the Wiltse triangle, to aid in performing an accurate osteotomy.

An oscillating saw is used to perform the cuts along each wire, taking care to disrupt the integrity of the medial and lateral cortex and to stay in the sagittal plane. An

Fig. 16. Surgical technique option 3: a 3D printed, patient-specific cutting jig reproducing the Wiltse triangle.

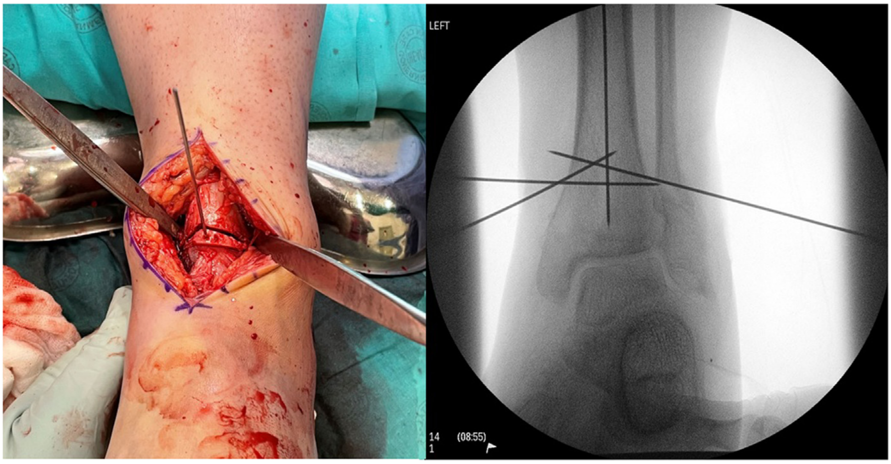

Fig. 17. Surgical technique: reproducing the Wiltse triangle via the sterile triangle technique.

oscillating saw blade with specific dimensions of 44x10 × 0.9 mm is recommended. The removed bony triangle is retained in case a supplemental bone graft is indicated (Fig. 17). A standard lateral fibula surgical approach is used to expose the distal fibula. A long oblique osteotomy is performed from proximal-medial to lateral-distal taking care to maintain the integrity of the syndesmosis (Fig. 18).

The distal tibial segment is slightly distracted, then rotated and laterally translated to enable the distal transverse tibial surface to keystone on the lateral proximal triangular surface and the medial malleolus flare to fit onto the medial proximal triangular surface. This creates a stable reduction (Fig. 19).

The mechanical axis, deformity correction, and translation should be evaluated. An advantage of this osteotomy is the ability to increase or decrease the translation to further restore the anatomic axis. An increase in lateral translation is obtained by lateral inferior translation of the distal tibial segment with the resultant medial gap filled with bone graft. In turn, a decrease in lateral translation is obtained by removing bone from the medial border. The resultant osteotomy will remain stable in both these adjustments (Fig. 20).

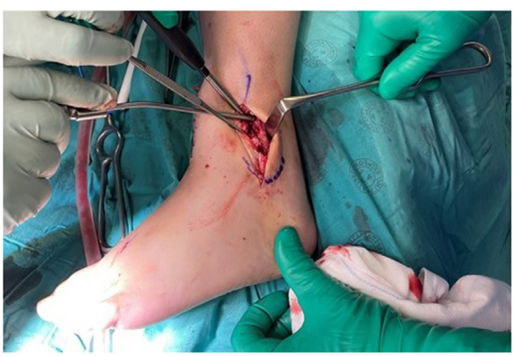

Fig. 18. Oblique fibula osteotomy.

Fig. 19. Surgical technique: the Wiltse triangle is completed and removed and the oblique fibula osteotomy performed - completion of the stable Wiltse osteotomy.

The lateral distal fibula prominence may be removed if indicated and is frequently the case with large deformities and the proximal fibula can be shortened in the same plane as your oblique osteotomy if adequate bone contact needs to be facilitated (**Fig. 21**).

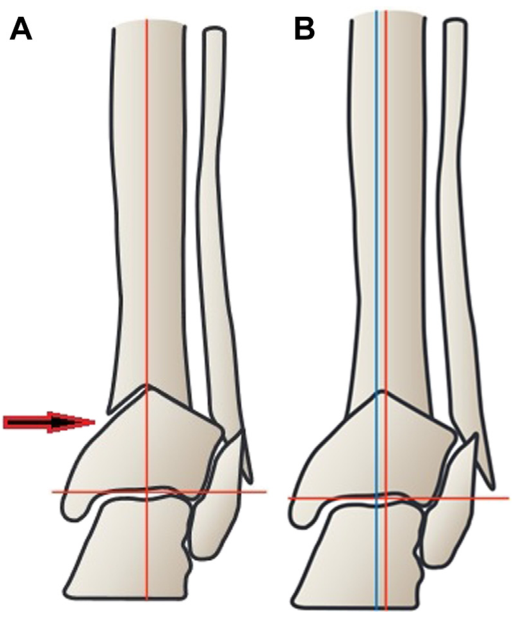

Fig. 20. Surgical technique: (*A*) Bone is removed from the medial border of the triangle, with subsequent (*B*) medial translation of the talus and anatomic axis.

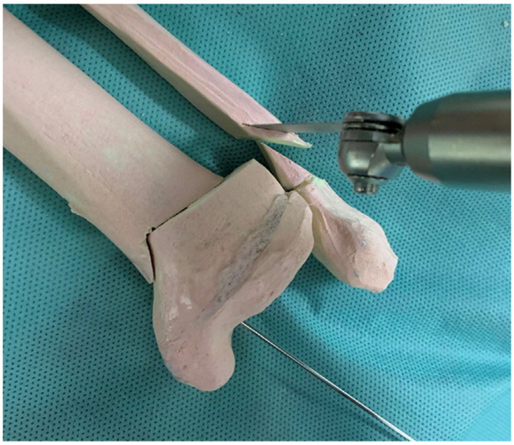

Fig. 21. Surgical technique: shortening of the fibula enables stable lateral fixation.

Routinely, the tibia is stabilized with a low-profile, fixed-angle T-plate. Fibula fixation can either be performed via intramedullary K-wire fixation or a low-profile, fixed-angle plate. External fixation can be considered due to host factors (Fig. 22).

POSTOPERATIVE CARE

A well-padded below-knee backslab is applied in the operating room. Strict elevation is prescribed for the immediate postoperative period. Early range of motion exercises of the hip and knee is initiated immediately postoperatively. A wound inspection is performed at 2 weeks and a walking cast is applied.

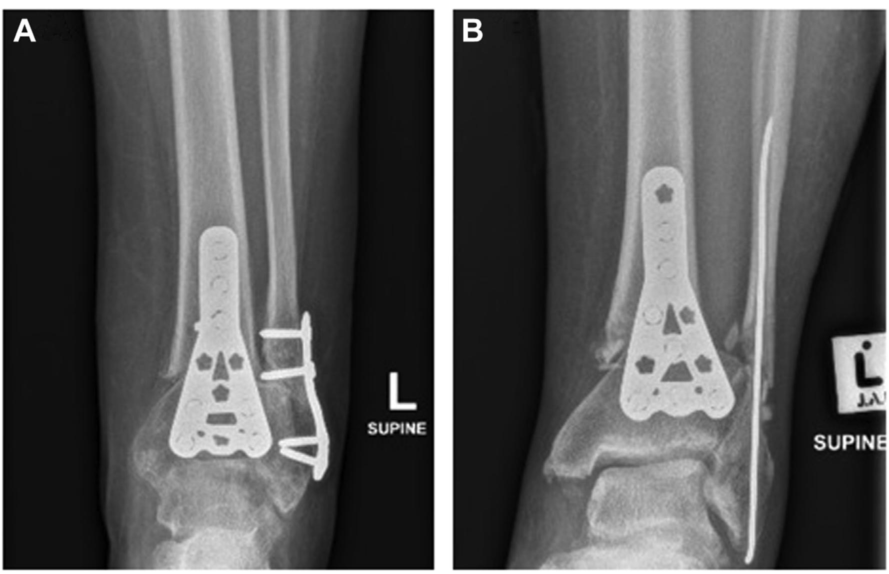

Fig. 22. Surgical technique: low-profile, fixed-angle plate for tibial fixation. Fixation options for the fibula using a (*A*) low-profile, fixed-angle plate, or a (*B*) intramedullary K-wire.

Fig. 23. Preoperative clinical photos indicating a valgus deformity of the ankle.

Subsequently, 6 weeks of toe-touch weight-bearing is prescribed with the cast being removed after this period. A moon boot is prescribed if sufficient evidence of radiographic healing is present. Partial weight-bearing for 6 weeks is then allowed, followed by full weightbearing and early resistance training. At 12 weeks osseous healing is confirmed, and resistance training is added to the exercise regime. Due to the inherent stability of the osteotomy and fixed-angle plate fixation, a more aggressive rehabilitation program can be used.

AUTHORS' EXPERIENCE

Case 1

A 55-year-old woman sustained a right ankle fracture after falling from a flight of stairs. She was treated conservatively in a below-knee cast for 6 weeks and a subsequent moonboot for 2 months. Despite extensive rehabilitation, her ankle pain and swelling persisted. She presented with anterolateral ankle pain and a progressive valgus ankle (**Fig. 23**). The range of motion was comparable to the contralateral side. Standard

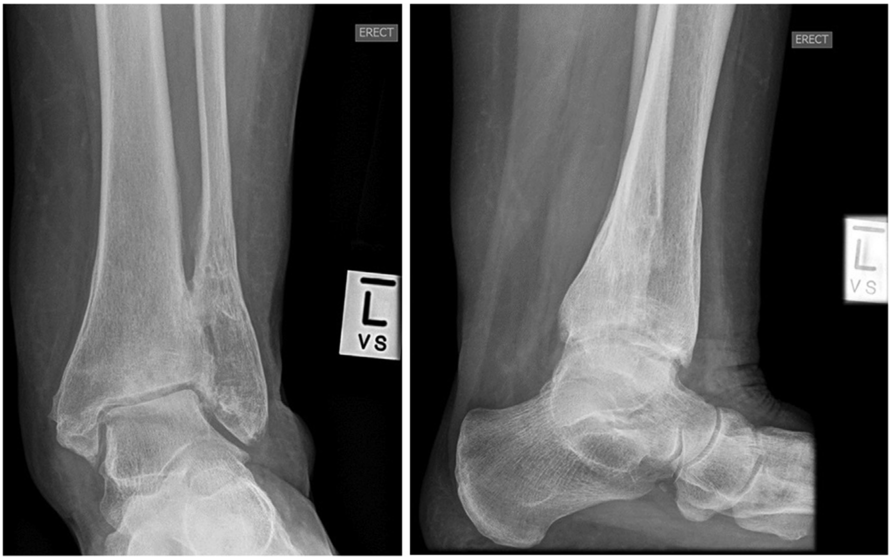

Fig. 24. Standardized preoperative x-rays reveal a 13° valgus deformity within the ankle joint.

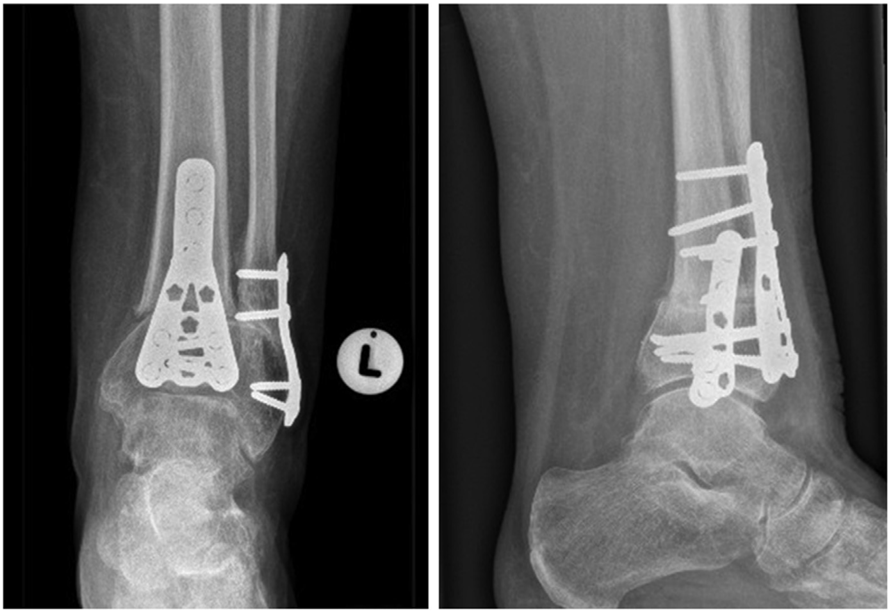

Fig. 25. Postoperative x-rays confirming the realignment of the mechanical axis.

Fig. 26. Postoperative clinical photos indicating a corrected mechanical axis.

Fig. 27. Preoperative clinical photos indicating a mild valgus deformity of the ankle with a compensatory cavus deformity of the foot.

radiographs demonstrated a 13° intraarticular valgus deformity (**Fig. 24**). A Wiltse osteotomy was performed, correcting the valgus deformity and maintaining the mechanical axis (**Fig. 25**). At the 1-year follow-up, she reported no pain or discomfort in the ankle joint and active participation in her preinjury activities (**Fig. 26**).

Case 2

A 25-year-old female involved in a pedestrian-vehicle accident sustained a bimalleolar, left ankle fracture. She was treated conservatively in a below-knee cast and presented 6-months postinjury with progressive ankle deformity and significant anterolateral mechanical ankle pain. On examination, she had an acceptable range of motion with a valgus deformity of the ankle and a flexible, compensatory cavus

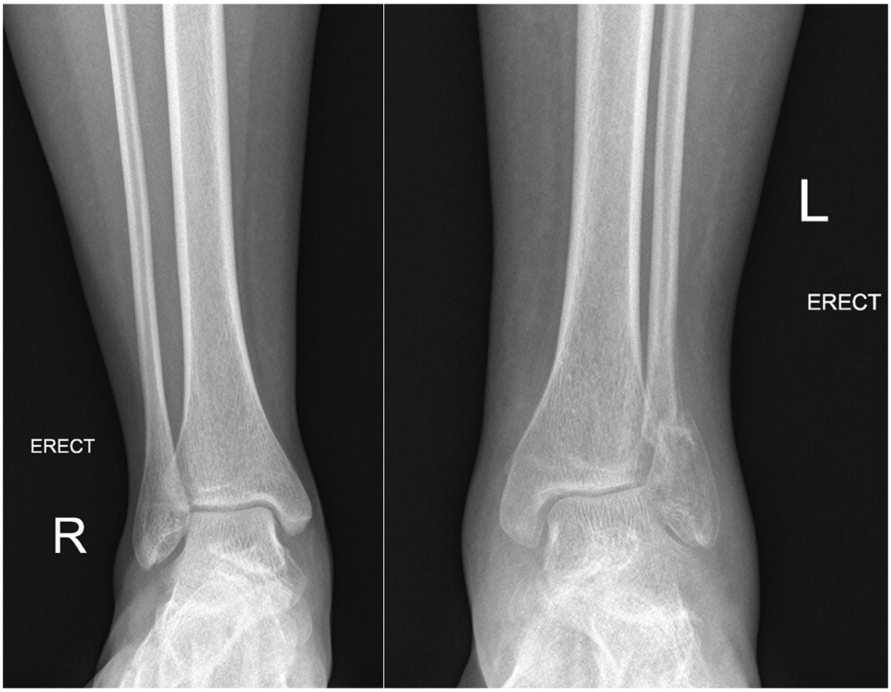

Fig. 28. Standardized preoperative x-rays reveal a 13° valgus deformity within the ankle joint (no translatory deformity was present).

Fig. 29. Intraoperative x-ray confirm realignment of the mechanical axis.

deformity of the foot (**Fig. 27**). Preoperative x-rays revealed a 13° valgus deformity within the ankle joint with no translatory deformity (**Fig. 28**). A Wiltse osteotomy was planned and performed. Postoperative x-rays confirm realignment of the mechanical axis (**Fig. 29**).

Clinical overview

The authors performed, on average, 2 to 3 Wiltse osteotomies per year over the past 15 years. Of these patients, no nonunions were reported, all maintained their corrected intraoperative mechanical axis, and no metal hardware failure was observed. All patients had adequate pain relief. One patient experienced postoperative progression of symptomatic osteoarthritis and pain, whereafter a successful fusion was performed.

As this is an anecdotal review of the authors' experience, no functional scores were measured.

SUMMARY

The reconstituting of normal anatomy in the presence of a valgus deformity is complicated by the position of the CORA and the soft tissue limitations. The Wiltse osteotomy correctly uses osteotomy rule 2 to accurately reconstitute normal angular- and maintaining mechanical alignment. Due to the inherent stability of the Wiltse osteotomy, this procedure can be used in a wide range of patients, including the pediatric population.

CLINICS CARE POINTS

- Careful patient selection with a significant distal valgus deformity (isolated coronal plane deformity).
- Meticulous preoperative planning using adequate, standardized x-rays – "Plan the operation and operate the plan."

- Perform accurate anterior–posterior cuts with the patella facing forward, thus preventing an oblique osteotomy due to the sloping distal tibial anatomy
- Review and address the lateral fibula prominence after performing the Wiltse Osteotomy and consider additional shortening of the fibula.
- Objectively measure your corrected anatomic axis intraoperatively (templating)

ACKNOWLEDGMENTS

Our sincere gratitude to Dr Marilize Burger for her invaluable aid in the editing and formatting of the article and to Dr Ryno du Plessis and Prof Nando Ferreira for aiding with the mathematical design and planning of the "Wiltse Triangle." The authors would like to thank Mr Marius Vermeulen (CEO of Aditiv Solutions (Pty) Ltd.) and Mr Devon Hagedorn-Hansen (Technical Manager: Stellenbosch Technology Centre - Laboratory for Advanced Manufacturing) for their aid in the design and printing of the cutting jigs. TraumaCad software was used in measuring, calculating, and demonstrating the Wiltse Triangle and osteotomy. Lastly, our thanks to Dr Mark Meyerson who contribute so much in the field of foot and ankle surgery and who saw the potential of the Wiltse osteotomy.

DISCLOSURE

The authors have nothing to disclose.

REFERENCES

1. Gibson V, Prieskorn D. The Valgus Ankle. Foot Ankle Clin 2007;12(1):15–27.
2. Bluman EM, Chiodo CP. Valgus Ankle Deformity and Arthritis. Foot Ankle Clin 2008;13(3):443–70.
3. Barg A, Pagenstert GI, Horisberger M, et al. Supramalleolar osteotomies for degenerative joint disease of the ankle joint: Indication, technique and results. Int Orthop 2013;37(9):1683–95.
4. Valderrabano V, Paul J, Monika H, et al. Joint-preserving surgery of valgus ankle osteoarthritis. Foot Ankle Clin 2013;18(3):481–502.
5. Krause F, Veljkovic A, Schmid T. Supramalleolar Osteotomies for Posttraumatic Malalignment of the Distal Tibia. Foot Ankle Clin 2016;21(1):1–14.
6. Barg A, Pagenstert GI, Leumann AG, et al. Treatment of the Arthritic Valgus Ankle. Foot Ankle Clin 2012;17(4):647–63.
7. Merchant T, Dietz F. Long term follow-up after fractures of the tibial and fibular shafts. J Bone Joint Surg Am 1989;71:599–606.
8. Puno RM, Vaughan JJ, Stetten ML, et al. Long term effects of tibial angular malunion on the knee and ankle joints. J Orthop Trauma 1991;5(3):247–54.
9. Valderrabano V, Horisberger M, Russell I, et al. Etiology of ankle osteoarthritis. Clin Orthop Relat Res 2009;467(7):1800–6.
10. Pagenstert GI, Hintermann B, Barg A, et al. Realignment surgery as alternative treatment of varus and valgus ankle osteoarthritis. Clin Orthop Relat Res 2007;462:156–68.
11. Ting AJ, Tarr RR, Sarmiento A, et al. The role of subtalar motion and ankle contact pressure changes from angular deformities of the tibia. Foot Ankle Int 1987;7(5):290–9.

12. Knupp M, Stufkens SAS, Van Bergen CJ, et al. Effect of supramalleolar varus and valgus deformities on the tibiotalar joint: A cadaveric study. Foot Ankle Int 2011;32(6):609–15.
13. Thordarson D, Motamed S, Hedman T, et al. The effect of fibular malreduction on contact pressures in an ankle fracture malunion model. J Bone Joint Surg Am 1997;79(12):1809–15.
14. Stamatis ED, Cooper PS, Myerson MS. Supramalleolar osteotomy for the treatment of distal tibial angular deformities and arthritis of the ankle joint. Foot Ankle Int 2003;24(10):754–64.
15. Siddiqui NA, Herzenberg JE, Lamm BM. Supramalleolar Osteotomy for Realignment of the Ankle Joint. Clin Podiatr Med Surg 2012;29(4):465–82.
16. Dabis J, Templeton-Ward O, Lacey AE, et al. The history, evolution and basic science of osteotomy techniques. Strateg Trauma Limb Reconstr 2017;12(3):169–80.
17. Wiltse LL. Valgus deformity of the ankle: a sequel to acquired or congenital abnormalities of the fibula. J Bone Joint Surg Am 1972;54(3):595–606.
18. Paley D. Osteotomy rules. In: Herzenberg JE, editor. Principles of deformity correction. First edition. Berlin Heidelberg: Springer; 2002. p. 102–12.
19. Paley D. Principles of deformity correction. First edition. Berlin Heidelberg: Springer; 2002.