Joint Preserving Surgery for Valgus Ankle Osteoarthritis

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KEYWORDS

- Joint-preserving surgery • Valgus ankle osteoarthritis
- Supramalleolar osteotomy of the tibia (SMOT)

KEY POINTS

- Valgus ankle osteoarthritis (OA) is a complex deformity with multiple etiologies.
- Joint-preserving surgery (JPS) of ankle OA avoids sacrificing reconstructions of the ankle joint.
- Medial closing-wedge supramalleolar osteotomy of the tibia (SMOT) is the primary procedure in JPS for valgus ankle OA.

INTRODUCTION

Valgus ankle osteoarthritis (OA) is a complex deformity with numerous etiologies that can be classified as posttraumatic, degenerative, congenital, and neurologic. Posttraumatic entities are considered the most common causes of ankle OA.[1] However, the degenerative factor via chronic posterior tibial tendon (PTT)/muscle dysfunction remains the most common cause of valgus ankle deformity.[2,3] Patients with valgus ankle OA typically present with different symptoms and signs depending on the causative factor, chronicity level, and the number of etiology entities existing in a particular case. These etiologies often begin with lateral ankle pain, calcaneofibular impingement, medial ankle pain with instability, restricted range of motion (ROM), and joint and limb dysfunction. The early identification of valgus ankle OA pathology provides surgeons with a window of opportunity to avoid joint-sacrificing surgeries (eg, total ankle arthroplasty and ankle arthrodesis) and allows them to use joint-preserving surgery (JPS) that equally distributes the load within the ankle joint, reduces pain, and restores function—especially in the younger population.

Valderrabano and colleagues defined JPS for their group by changing the load axis from the osteoarthritic side to the healthy side of the joint, thereby restoring the parallelism of the joint in the frontal plane and providing stability.[4] In JPS, it is very important to appropriately analyze the etiology and biomechanics of the case since neglecting or

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not recognizing all pathobiomechanical issues might deteriorate the condition and lead to end-stage ankle OA in the long-term.[4,5]

ETIOLOGY OF VALGUS ANKLE OA

Valgus ankle OA can be classified based on the clinical etiology, level of deformity, severity, and tissue initiating the deformity (eg, bone, ligament, muscle, or combined).[2,3,6] Regarding the clinical etiology grouping, the most common cause of ankle OA is posttraumatic (80% of cases) and often due to lower leg fractures. Although grade IV PTT/muscle insufficiency is the most common cause of degenerative valgus ankle OA, primary ankle OA may also start with valgus ankle OA.[3,7] To simplify the etiology, we attempt to classify valgus ankle OA as posttraumatic, degenerative, congenital, or neurologic (**Box 1**). Furthermore, a classification of ankle OA based on the level of the deformity is also presented in **Box 1**.

Biomechanics of Valgus Ankle Osteoarthritis

A valgus ankle/hindfoot OA shows typically a valgus hindfoot, lateralized mechanical lower leg axis, reduced contact area in the joint with subsequent increased joint reaction forces, lateral joint overuse with increased peak forces, medial ligament ankle complex deficiency, and fibulotalar/calcaneal impingement.

Box 1
Etiologies of Valgus Ankle Osteoarthritis

Posttraumatic Etiologies
- Fibular malunion (shortening, external rotation)
- Valgus malunion of tibial shaft fractures
- Valgus malunion of tibial plafond fractures
- Valgus malunion of talus and calcaneus fractures
- Chronic medial ankle ligament insufficiency (after acute deltoid ligament injury or part of rotational chronic ankle instability (lateral and medial ankle instability))
- Chronic syndesmotic injury
- Avascular necrosis of talus

Degenerative Etiologies
- Posterior tibial tendon dysfunction (grade IV)
- Primary ankle osteoarthritis
- Rheumatoid osteoarthritis
- Charcot osteoarthropathy

Congenital Etiologies
- Tarsal coalition
- Excessive tibial external rotation
- Fibular hemimelia

Neurologic Etiologies
- Stroke
- Central and peripheral nerve disorders
- Hereditary motor sensory neuropathy
- Spina bifida
- Cerebral palsy

Deformity Levels of Valgus Ankle Osteoarthritis
- Supramalleolar deformity: mDTAA $\geq$ 92° and CORA supramalleolar
- Intraarticular deformity: mTTA $\geq$ 4° and CORA intraarticular
- Inframalleolar deformity: mDTAA and mTTA normal, but HAA greater than 10°

Altering the mechanical axis of the lower leg or hindfoot leads to an unequal distribution of load in the ankle joint (ie, an overload of the lateral compartment of the tibiotalar joint) and an overloading of the medial ankle ligaments with consecutive medial ligament complex deficiency, resulting in a vicious circle.[2] In a cadaver study by Knupp and colleagues, incongruent valgus ankle malalignment shifted the pressure to the posterolateral ankle compartment.[8,9] This aspect was also proven by a radiological study using single-photon emission computed tomography (SPECT-CT) in patients with valgus ankle OA. In the SPECT-CT images, the valgus malaligned ankles showed significantly greater uptake in the lateral areas than in the medial ankle regions.[10]

In the area of in vivo biomechanics, Nüesch and colleagues found the following kinematic and kinetic changes in patients with asymmetric ankle OA when compared to a healthy control: at least 25% lower sagittal ankle ROM, at least 15% lower peak dorsiflexion movement, at least 40% lower ankle power, and less gastrocnemius medialis and soleus muscle activity in electromyogram around push-off.[11]

Furthermore, as per fractures with bone loss, alterations of the contact surface area in the ankle joint increase pathologic joint reaction forces.[12] Pathologic changes in subchondral density and mineralization that occur in the asymmetric arthritic ankle area as a compensatory effect to the chronic load can be reversed by corrective supramalleolar osteotomy, as proven by Egloff and colleagues in a study using CT-osteoabsorptiometry (CT-OAM).[13] However, calcaneal osteotomy alone has only a minor effect on the pressure distribution of the ankle joint.[14] The effect of the fibula in controlling ankle stability should not be neglected as the shortening and the external rotation might play a major role in disrupting the contact area in the tibiotalar joint.[15]

Clinical Assessment

A good clinical assessment starts with a meticulous history evaluation that includes the history of trauma or ankle instability, past treatment and surgical history, and comorbidities such as neurologic disorders, diabetes mellitus, or any inflammatory disease. A proper history and physical examination are crucial to analyze the etiology of valgus ankle OA.

Standing examination: The evaluation of shoes and insoles is important to obtain indirect information regarding the amount of hindfoot/ankle deformity and the quality of the conservative treatment performed. Hindfoot/ankle alignment, old scars, and muscle atrophy are assessed with the patient standing via inspection of the whole leg, lower leg, hindfoot, and foot from all sides (ie, front, back, and side). Evaluation of limb length discrepancy should also be performed. Assessment of the gait and hindfoot/ankle with painful asymmetric limping, possible arch collapse, ligament ankle instability, and neuromuscular dysbalance is also part of good documentation. Furthermore, a thorough evaluation of the signs of PTT insufficiency is important to confirm or rule out this entity (eg, the “too many toes” sign, single and double heel raise test). The reverse Coleman block test is important to rule out forefoot-driven deformity and assess the flexibility of the deformity.[16,17]

Sitting examination: While the patient is sitting, the following examination points should be addressed: evaluation of skin condition; documentation of all tenderness points; measurement of active and passive ROM of the ankle joint, subtalar joint, and Chopart joint; assessment of lateral and medial ankle instability; evaluation of muscle power around the ankle (ie, posterior tibial muscle, peroneal muscle, anterior tibial muscle, gastrocnemius/soleus muscles). Furthermore, the Silfverskiöld test is important to evaluate a possible triceps surae contracture that may need to be addressed at the time of surgery.

Finally, a neurovascular examination is also a crucial part of the orthopedic assessment.

IMAGING

Conventional Weight-bearing Radiography is the basic level of imaging in valgus ankle OA. In our institution, the following weight-bearing x-rays are defined as the standard radiological status: standing anteroposterior (AP) view of the ankle joint (mortise view), standing hindfoot view (Saltzman view), lateral view of the foot, and dorsoplantar view of the foot. In severe lower leg, knee, and leg deformities, lower limb radiography of both legs is advisable to accurately define the center of rotation and angulation (CORA).

In valgus ankle OA, the *AP ankle view/mortise* allows the confirmation of a reduction in joint space of the lateral ankle joint, reduction of space in the lateral gutter with a talofibular impingement,[3,18] and a medial increase in clear space, which suggests the involvement of the deltoid ligament.[3]

In the AP ankle view/mortise view, these angles can be measured. The medial distal tibial articular angle (mDTAA) is normally 92.4° ± 3.1 (range, 88–100), whereas an mDTAA value of greater than 92° is considered a valgus ankle OA with supramalleolar deformity.[19] In the mortise view, the midline tibiotalar angle (MTTA) can also be measured. An average normal MTTA value is 88.7° ± 5.1 (range, 77–104), whereas greater than 90° is considered a valgus ankle OA.[20] Furthermore, in the mortise view, the medial talar tilt angle (mTTA) can clarify the congruency status of the tibiotalar joint (incongruent >4°, suggesting instability of the ankle joint[21]).

Syndesmotic integrity can be measured (1 cm above the tibial plafond) in the AP view using the following variables: The width of the tibiofibular clear space with a normal range of less than 6 mm; tibiofibular overlap with a normal value of greater than 1 mm in the mortise view and greater than 6 mm in the AP view.[22]

Fibular length is also evaluated in the mortise view based on disruption of the parallelism of the tibiotalar line (talar tilt), disruption of Shenton's line, and disruption of the dime sign/Weber circle at the tip of the fibula/lateral talar process.[23–25]

In the *hindfoot alignment view* (Saltzman view), an inframalleolar deformity can be detected. In this view, the hindfoot valgus angle (HVA) can be measured as the angle between the anatomic axis of the tibia and the axis of the calcaneus. A physiologic HVA has a value of 0 to 5°valgus. Pathologic HVAs are greater than 10°.[26]

In the weight-bearing *AP foot view*, an important angle is the talonavicular coverage angle, which should be smaller than 7° in a plantigrade foot.[27] Furthermore, the AP talar-first metatarsal angle also describes a medial collapse in a flatfoot deformity (normally 7.7° ± 8.2).[28]

The weight-bearing *lateral foot views* are valuable in assessing the sagittal deformity of the ankle as well as the hindfoot and midfoot involvement of the deformity. The tibia lateral surface angle has a normal value of 81° to 82°.[29] The lateral talar-first metatarsal angle depicts the amount of flatfoot deformity. Notably, an angle greater than 4° convex downward is considered pes planus.[30]

MRI represents the second line of imaging for the evaluation of the cartilage, ligaments, syndesmosis, tendons, and soft tissues in the ankle joint and hindfoot. In addition, weight-bearing MRI can provide further information to improve diagnostic accuracy.[31,32]

CT scan helps to better evaluate the bone condition of the lower leg, ankle, and hindfoot—especially in fracture-related cases. Weight-bearing CT (WBCT) scans of the foot and ankle have improved the understanding of deformities and the real orientation of the bone and the joint, which provides a better understanding of the pathology, especially in complex cases.[33,34]

The authors performed *SPECT-CT* to evaluate the extent of degenerative changes and the biological activity of valgus ankle OA to localize hot spots, which is very important for the planning of JPS.[10,35] Knupp and colleagues used weight-bearing radiographs, conventional CT, bone scintigraphy, and SPECT-CT in patients with valgus or varus ankle OA.[10] In SPECT-CT images, the valgus ankles showed significantly greater uptake in the lateral areas than in the medial regions. The results of the present study showed that SPECT-CT is a unique radiographic tool that allows the simultaneous analysis of the structure and metabolism of degenerative changes of the tibiotalar joint.[10] Besides information about the ankle joint, SPECT-CT can provide diagnostic information about additional co-entities such as other OA in the foot joints, stress fractures, and tarsal coalitions.[32,36]

TREATMENT

Conservative Treatment

Classic conservative treatment aims to achieve pain reduction and increase of function. This type of treatment consists of adaptation of physical activity, painkillers, viscosupplementation (orally or by joint infiltration), platelet-rich plasma (PRP), physiotherapy, and orthotics (eg, insoles, stabilizing shoes). Conservative treatment should be attempted for 3 to 6 months before a possible surgery. Physiotherapy programs typically involve stretching the foot evertors and strengthening the invertors and contracted calf muscles. In addition, orthosis plays a major role in conservative treatment. Notably, it is important to adjust solid insoles with a well-padded medial arch support to appropriately varisate the hindfoot and ankle.

The use of oral glucosamine sulfate has been expanded to cover ankle OA because it is a safe chondroprotective agent.[37] Moreover, intraarticular injection with hyaluronic acid might help to reduce ankle pain and is one of the treatment options for ankle OA.[38] Effectiveness and improvement were observed using multiple rating scales, including that of the American Orthopedic Foot and Ankle Society (AOFAS; 50.7 ± 13.8–79.9 ± 13.8) and visual analog scales (VAS; 5.7 ± 1.2–2.7 ± 1.6).[39]

PRP injection should not be neglected—especially in valgus ankle OA—because of its multiple effects as an anti-inflammatory and analgesic agent, which help to delay the destruction process.[40,41] Notably, physicians must support nonoperative management. However, conservative treatment does not increase the deformity and degenerative changes because a process delay reduces the opportunity for and outcome of JPS. Increasing pain severity and instability is an alarming sign that suggests the need to accelerate surgical intervention (if indicated).

Joint Preserving Surgery (JPS)

JPS represents a variety of surgical methods used to retain the natural joint and extend its survivorship by improving its biomechanics and biology (eg, a partial arthritic joint can be transformed from a pathobiomechanical to an almost normal biomechanical joint). The most important factor for JPS in valgus ankle OA is that the tibiotalar cartilage must be intact in more than half of the intraarticular area. The goal is to restore the anatomic alignment, de-load the osteoarthritic area, improve joint congruency, and achieve joint ankle stability to reach a pain-free ankle with a plantigrade, flexible, functional ankle/hindfoot/foot and postpone or avoid end-stage full-ankle OA. In the ankle OA timeline, the window of opportunity to perform JPS is narrow. Therefore, early patient presentation and timely surgery can avoid the rapid progression to full ankle OA, thereby avoiding a total ankle arthroplasty or ankle arthrodesis.

Technically, JPS may have the following surgical content: osteotomies (supramalleolar, hindfoot/calcaneal, malleolar, mid-/forefoot), ankle ligament surgery (lateral, medial, syndesmosis), tendon surgery (PTT, peroneal, etc.), and osteo-/chondral surgery.

The indications for JPS for valgus ankle OA include painful asymmetrical lateral ankle OA with preserved medial half of tibiotalar cartilage, conserved ankle motion (>20° ROM), and patient age less than 60 years (relative indication).

The JPS contraindications generally include poor patient health conditions such as the presence of multiple comorbidities, severe vascular deficiency or neurologic disability, and severe systemic disorders. In addition, factors that could affect compliance and postoperative rehabilitation should be considered. Caution should also be exercised in patients with noncompliance, vitamin D3 insufficiency, immunosuppression, and tobacco use.[2,6,42] These factors can lead to complications such as infections, malunions/nonunions of the bony corrections, and failed JPS surgery.

Radiological Preoperative Planning

Many x-ray measurement guidelines for angles around the ankle joint are available in the literature. The purpose of these guidelines is to facilitate a proper diagnosis to identify and localize the deformity level and augment the clinical diagnosis (see the Imaging section in this article). Measuring these angles will help surgeons in preoperative assessment, surgical planning, and postoperative evaluation. Good preoperative planning of the JPS is crucial for good surgical outcomes (**Box 2**).

Ankle Arthroscopy

Diagnostic and therapeutic ankle joint arthroscopy is part of ankle JPS and helps at the beginning of JPS to intraoperatively assess the valgus ankle OA intraarticularly and judge chronic ankle instability (medial, lateral, and syndesmotic) as well as bony ankle impingement.[43,44] As we shift the load to the medial part of the ankle in JPS, evaluating the joint condition before the osteotomy is crucial. A simple and common classification used to judge the cartilage is the Outerbridge classification: grade 0, no cartilage damage; grade 1, cartilage softening; grade 2, cartilage damage with the stripping of superficial cartilage layers; grade 3, deep cartilage ulceration without visible subchondral bone; grade 4, visible subchondral bone.[45]

The therapeutic use of ankle arthroscopy before JPS might help to remove possible loose bodies, shave osteophytes anteriorly, or perform arthroscopic cartilage repair techniques.

Box 2
Rules for optimizing the surgical intervention of joint preserving surgery for valgus ankle osteoarthritis

1. Perform a solid preoperative analysis and define the primary cause of osteoarthritis
2. Correct the alignment with slight overcorrection (2°–5°) to substantially de-load the osteoarthritic ankle area
3. Correct the largest deformity entity first, then address any proximal deformity before any distal one
4. First address the bony deformities, then the soft tissue pathologies

Supramalleolar Osteotomy of the Tibia (SMOT)

The goals of the supramalleolar osteotomy of the tibia (SMOT) procedure are to realign the ankle/hindfoot and restore the mechanical axis to avoid or delay a possible joint-sacrificing procedure. Proven by multiple studies, asymmetric ankle OA can be improved by the SMOT procedure.[46–48] This is in addition to the clinical and radiological outcomes showing a promising result.[49] The SMOT is a powerful tool that optimizes the lower limb alignment in the presence of coronal, sagittal, and rotational deformity of the tibia.[50] In this type of osteotomy, the goal is to reduce pain and improve function. Even in the case of a suboptimal outcome, the patient and surgeon would not have caused harm by realigning the lower leg/ankle/hindfoot for possible future joint-sacrificing surgery (eg, total ankle arthroplasty, ankle arthrodesis). For the treatment of lateral valgus ankle OA, a medial closing-wedge SMOT is indicated, especially for cases with tibial plafond lateral damage, intraarticular ankle valgus OA, pathologic mDTAA >92°, or a supramalleolar tibia CORA deformity. Furthermore, a medial closing-wedge SMOT is part of the treatment for a valgus ankle OA with post-traumatic shortened fibula after fibular fracture malunion/nonunion or a valgus ankle OA with a chronic syndesmotic instability or chronic medial ankle instability.

Medial Closing-Wedge SMOT Technique

The patient is placed in a supine position with a thigh tourniquet for homeostasis and heel flush with the end of the operation table. A 15-cm incision is performed on the medial distal tibia. As the structures at risk include the saphenous vein and nerve, they must be identified and gently retracted. A sharp incision of the medial distal tibia periosteum is performed. Hohmann retractors are inserted around the tibia to protect the soft tissue structures anteriorly and posteriorly. For intraoperative osteotomy guidance, two K-wires are placed under fluoroscan guidance from the medial side to represent the wedge to be medially resected. The required amount of correction/angular degrees, which is preoperatively calculated from weight-bearing x-rays, can be roughly used as millimeters in the medial tibial wedge resection. In AP views, the surgical goal is to overcorrect the medial distal tibial joint surface angle by 2° to 5° over the physiologic normal average angle.[21] The formula proposed by Warnock ($\tan\alpha = h/W$) facilitates preoperative planning for the possible medial closing tibial wedge size calculation, where α is the angle to be corrected, H is the wedge height in millimeters, and W is the tibial width.[51] Regarding the K-wires, it is important to place the tip of both K-wires laterally proximal to the incisura fibularis because, distal of it, the SMOT could endanger syndesmotic stability. Approximately, the proximal K-wire is more or less perpendicular to the tibia, whereas the distal K-wire is more or less parallel to the joint line or talus surface, depending on the case. Using an oscillating saw and continuous irrigation to avoid thermal injury, the medial closing-wedge osteotomy is performed. The lateral part of the osteotomy is gently weakened by using an osteotome. The preservation of the lateral tibial cortex and periosteum is important because this helps the healing process of the osteotomy and enhances osteotomy stability.[4,5,52] With compressive K-wire-forceps (or by hand), the osteotomy can be gently closed and compressed on acceptable level. We recommend using a robust anatomic angular stable medial tibia plate with compression options (as oblong eccentric holes) to compress the osteotomy on a micro level (Anatomic APTUS Medial Supramalleolar Tibia Osteotomy Plate, Medartis, Switzerland; **Figs. 1** and **2**). If the osteotomy breaks on the lateral cortex, this can be left unaddressed if the medial tibial plate is of good quality and the patient is compliant. If the lateral osteotomy tibia cortex breaks with a significant shift, we recommend augmenting the SMOT fixation with a second additional ventral or lateral tibia plate. During the SMOT procedure, it is

Fig. 1. Case of Joint preserving Surgery by Supramalleolar Osteotomy of the Tibia (SMOT) for Valgus Ankle Osteoarthritis with a Lateral Talar Osteochondral Lesion. A 28-year-old male with chronic painful asymmetric posttraumatic lateral ankle osteoarthritis with a multicystic osteochondral lesion (OCL) on the lateral talus (*A–E*). Preoperative angles: mDTAA 97°, TTSA 96°, mTTA 1°, and HAA 8°. Previous surgeries: St. after ankle arthroscopy and retrograde drilling of the lateral OCL talus 2 years ago; St. after ankle arthroscopy, medial-sliding-calcaneus-osteotomy, and AMIC lateral talus OCL 1 year ago. We performed a medial closing-wedge supramalleolar tibial osteotomy SMOT (Anatomic APTUS Medial

important to control the rotational and sagittal plane of the distal fragment. If simultaneous correction occurs in the sagittal plane, one should consider anterior or posterior wedge cutting (depending on the deformity on the sagittal plane) for the required amount to achieve the optimum sagittal alignment required, while also considering the downsizing of the recurvatum and antecurvatum to reduce the anterior or posterior impingement of the ankle joint and allow an optimal pressure distribution in the ankle joint.[53,54] After the final intraoperative x-rays, the medial tibial soft tissues are closed with drainage to avoid a possible lower leg hematoma.

Possible additional surgeries include:

- *Fibular osteotomy*: An additional fibular osteotomy is required in cases with a shortened or external malrotated fibula (eg, after a fibular or lower leg fracture). Furthermore, an unreduced talus after restoring the mDTAA angle could indicate the need for fibular lengthening osteotomy.[21] After SMOT, the optimal fibular length adds value to the ankle joint by supporting, inverting, and medially shifting the talus, which provides strain reduction on the deltoid.
- *Ankle ligament reconstruction*: Medial ankle ligament complex reconstruction (ie, deltoid, spring ligament): In cases with medial ankle instability, medial ankle ligament complex reconstruction via the shortening or enhancement of the deltoid/spring ligament is required. If this entity is unclear preoperatively, the medial ligament complex can be judged manually or under fluoroscopic evaluation (stress view) after SMOT plate fixation by balance testing the medial and lateral ligaments. In some cases, lateral ligament reconstruction must also be performed (rotational ankle instability: medial and lateral ankle ligament instability combined).
- *Posterior tibial tendon reconstruction*: In PTT insufficiency, a PTT surgery that involves shortening or augmentation of the PTT via an FDL-tendon transfer must be added to the SMOT.
- *Calcaneal osteotomy*: In cases of remaining hindfoot valgus (inframalleolar deformity), a calcaneus osteotomy or varisating subtalar arthrodesis of the arthritic subtalar joint is required. In the case of a calcaneal osteotomy, the surgeon must differentiate between a medial sliding calcaneal osteotomy or lateral lengthening calcaneal osteotomy—especially the latter if a forefoot abductus is present.
- *Cotton osteotomy*: If valgus ankle OA is combined with a medial arch/midfoot collapse, a cotton osteotomy at the medial cuneiform must be added.
- *Gastrocnemius recession/Strayer procedure*: This procedure is indicated for patients with a tightness of the calf muscle as a cause of their hindfoot valgus and equinus contracture.
- *Osteochondral reconstructive ankle surgery*: Only osteochondral defects need to be addressed (eg, with arthroscopic procedures or an Autologous Matrix Induced Chrondrogenesis [AMIC]-Membrane technique), whereas chondral lesions can be healed by the simple deloading effect of the SMOT.

Supramalleolar Tibia Osteotomy Plate, Medartis, Switzerland), re-do of AMIC cartilage reconstruction of the lateral talus (debridement OCL, spongiosaplasty from ipsilateral tibia; Chondro-Gide Membrane, Geistlich Surgery, Switzerland), and lateral ankle ligament reconstruction. Six months after final SMOT surgery, the patient is pain-free and x-rays show a healed osteotomy and a physiologic position of the ankle joint with an mDTAA of 88° (*F–I*).

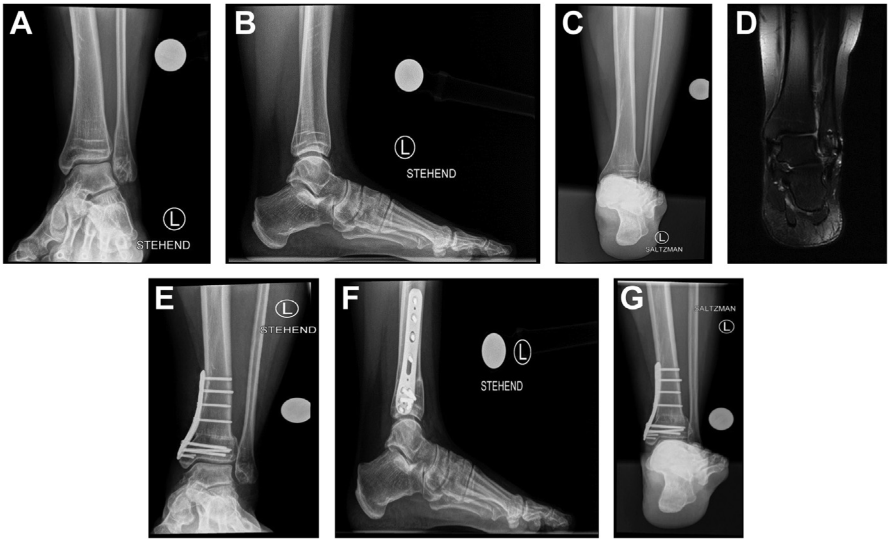

Fig. 2. Case of Joint Preserving Surgery (JPS) by Supramalleolar Osteotomy of the Tibia (SMOT) for Valgus Ankle Osteoarthritis. Preoperative weight-bearing AP (*A*) and lateral (*B*) radiographs of the ankle and Saltzman view (*C*) demonstrating valgus ankle deformity, posttraumatic chronic painful lateral ankle cartilage degeneration (*D*) with a lateral osteochondral lesion (OCL) of the talus with medial and lateral chronic ankle instability and pes valgus. Postoperative weight-bearing AP (*E*) and lateral (*F*) radiographs of the ankle and Saltzman view (*G*) after the following surgeries: diagnostic ankle arthroscopy, debridement and abrasion of the lateral talus OCL, supramalleolar medial closing tibial osteotomy SMOT (Anatomic APTUS Medial Supramalleolar Tibia Osteotomy Plate, Medartis, Switzerland), medial ankle ligament surgery, and lateral ankle ligament surgery with an ipsilateral semitendinosus tendon graft.

Post-treatment of the medial closing-wedge SMOT: The patient must be immobilized and maintain a 15 kg partial weight-bearing for 8 weeks (eg, using a lower leg/ankle/foot walker). We recommend immediately performing postoperative physiotherapy to improve ankle motion and reduce the swelling of the soft tissues via lymphatic drain massage. Practically, full weight bearing is only allowed if the SMOT is radiologically healed.

Fibular Osteotomy

Valgus ankle OA possibly requires fibular osteotomy, the goal of which is to restore anatomic ankle alignment, improve joint congruency at the tibia plafond of the ankle, and reduce the risk of chronic medial ankle instability. Notably, fibular osteotomy restores the fibular length and talus position in the mortise view.[55,56] In a cadaver study, Stufkens and colleagues clarified the augmentation and restriction effects of fibular osteotomy above the syndesmosis on the SMOT.[8] They showed that adding a fibular osteotomy to the SMOT directly above the syndesmosis was helpful for reaching the desired load, which reveals the restriction and augmentation effect of the fibula.

The evaluation of fibular length is performed preoperatively in the weight-bearing mortise view or WBCT by disrupting the parallelism of the tibiotalar line (talar tilt), Shenton's line, or dime sign/Weber circle at the tip of the fibula/lateral talar.[23–25,57]

Although multiple types of fibular osteotomies have been described in the literature, there is no consensus in the literature regarding the realignment osteotomy for the malunited fibula.[58] We prefer the Z-shaped fibular osteotomy with or without fibular rotational wedge resection unless the rotation deformity is less than 10°; if the malrotation is over 10°, an oblique osteotomy is preferred.[25,57]

Fibular-lengthening Osteotomy Surgical Technique: Z-shaped fibular osteotomy is performed using an oscillating saw under Hohmann protection. It is important to perform the z-part with sufficient length to have a good bridge area after fibular elongation. After restoring the desired length, wedge removal osteotomy in the horizontal part of the osteotomy is performed for external rotation correction. The osteotomy is then fixed by an angular stable plate with an AP screw in the z-bridging area.

It is important to perform the osteotomy above the level of the syndesmotic ligament to avoid iatrogenic instability of the ankle joint. A cadaver study showed that sectioning of the anterior inferior tibiofibular ligament alone increases the tibiofibular space by up to 10 mm and 20° of varus tilt and 40° of rotational instability if the osteotomy is performed below the level of syndesmosis.[23,59] Furthermore, the laxity of the syndesmotic ligament should be evaluated before and after osteotomy. On the other hand, scarring in the syndesmotic should be removed to restore the correct fibular length.[24] It is recommended to fill the gap with bone grafts if the gap is too large.

DISCUSSION

Ankle OA does not always involve full tibiotalar degeneration. Malaligned valgus or varus ankle OA is quite often.[1] Valgus ankle OA has a typical etiologic profile: posttraumatic, degenerative, congenital, or neurologic and can be supramalleolar, intraarticular, or inframalleolar (see **Box 1**). The treatment of valgus ankle OA should follow the same treatment pathway as ankle OA in general: conservative treatment, JPS, total ankle arthroplasty, and ankle arthrodesis. After a solid conservative treatment for 3 to 6 months, JPS might be required to avoid a total ankle arthroplasty or even an ankle arthrodesis. Deloading the osteoarthritic joint area while simultaneously optimizing the joint load is a crucial part of JPS. The content of JPS depends on the underlying etiology of the valgus ankle OA: osteotomies, ligament reconstruction, tendon surgery, and osteochondral surgery. The most powerful osteotomy for valgus ankle OA is SMOT, which is performed as a varisating medial closing-wedge osteotomy. If the deformity is not only intraarticular or supramalleolar, a calcaneal or midfoot bony surgery might be required as an inframalleolar correction.

Stamatis and colleagues showed a satisfactory result in 12 patients with SMOT: improvement of AOFAS score from 53.8 to 87 and no progression in ankle OA over 2 years.[60] Furthermore, Knupp and colleagues reported the effect of SMOT on 92 patients with asymmetric ankle OA with a mean follow-up of 3.6 years. None of the patients suffered nonunion and the healing period did not exceed 12 weeks. In addition, the AOFAS hindfoot and VAS scores improved significantly.[61] Moreover, Pagenstert and colleagues proved that JPS for valgus ankle OA has a good outcome. In their study, pain visual analog scale scores decreased from 6.6 ± 1.5 preoperatively to 2.4 ± 1.6 points after treatment (P<.0001). In addition, the AOFAS hindfoot score increased from 43 points (range, 16–67) preoperatively to 84 points (range, 63–100; P<.0001).[5] The literature also suggests that JPS improves the ability to perform sports by reducing pain and increasing the function of the ankle joint.[62] In an *in vivo* biomechanics study, Nüesch and colleagues showed that JPS improved the function of patients through a 25% average increase in AOFAS score in addition to a 50% reduction in pain. Moreover, there were no significant differences in muscle activation in the long-term when compared with the control group. This is especially valuable for younger patients because the improvement of function and pain reduces the need for (or could delay) joint-sacrificing ankle procedures.[11] In addition to pain reduction and functional outcomes, Ayyawsawmy reported significant improvements to radiological parameters including the tibial articular surface ankle and talar tilt angle (TT).[63]

In cases where the JPS result was suboptimal or did not provide the desired pain relief, the JPS served as a good presurgery for the next step in the timeline-treatment/pathway of ankle OA, which is total ankle arthroplasty. Wood and colleagues found that the failure rate for total ankle arthroplasty was lower in ankles that were well aligned than in ankles with over 15° preoperative valgus or varus deformity.[64]

Notably, complications from supramalleolar osteotomies are possible. Wound healing complications and infections have a reported incidence of up to 22%, whereas malunion or nonunion occurred in up to 22% of cases.[65] OA progression is one of the most common complications after JPS for ankle OA.[4,5,62] In a series of 22 patients who underwent SMOT for valgus ankle OA with a mean follow-up of 4.5 years, 2 patients (9%) developed progressive OA.[5] In a more recent report of 56 patients who underwent SMOT for valgus ankle OA, 4 patients (7%) had to undergo a secondary TAA or ankle fusion because of the progression of ankle OA. This is in addition to 4% who had delayed union and another 4% who had delayed wound healing.[49] Undercorrection of the varisation osteotomy is considered one of the risk factors for ankle OA progression.[5,6] Espinosa and colleagues considered the persistence of pain beyond 12 months after the surgery as an indication of failure and categorized the failure factors into surgery-related failures, global OA of the joint (progression), and infection.[66]

SUMMARY

Valgus ankle OA is a complex problem with multiple etiologies that can either be isolated or superimposed on top of other medical or musculoskeletal disorders. Proper medical history, physical, and preoperative radiological examinations are crucial in deciding on surgery and planning the surgical approach. JPS, especially the varisating medial closing-wedge SMOT with solid plate fixation, has been consistently associated with good outcomes for patients with valgus ankle OA. To further improve JPS for valgus ankle OA, further clinical and biomechanical studies are required to address the long-term clinical and functional outcomes and complications.

DISCLOSURE

Victor Valderrabano: Consultant of: Medartis, Geistlich Surgery.

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