



# Peri-talar re-alignment osteotomy for joint preservation in asymmetrical ankle osteoarthritis

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- Various types of re-alignment surgery are used to preserve the ankle joint in cases of intermediate ankle arthritis with partial joint space narrowing.
- The short-term and mid-term results after re-alignment surgery are promising, with substantial post-operative pain relief and functional improvement that is reflected by high rates of patient satisfaction.
- In this context, re-alignment surgery can preserve the joint and reduce the pathological load that acts on the affected area.
- Good clinical and radiological outcomes can be achieved in asymmetrical ankle osteoarthritis by understanding the specific deformities and appropriate indications for different surgical techniques.

**Keywords:** asymmetrical ankle osteoarthritis; peri-talar osteotomy; joint-preserving surgery

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## Introduction

Osteoarthritis (OA) of the ankle occurs in approximately 1% of the population, and the majority of patients have developed secondary arthritis due to fractures around the ankle joint.<sup>1</sup> Primary degenerative arthritis, with no history of trauma or underlying disease, constitutes a relatively small proportion of ankle arthritis.<sup>1</sup> Ankle arthritis has low prevalence compared with knee or hip arthritis, but once it progresses, it can lead to pain, dysfunction and abnormal gait.<sup>2</sup>

The treatment for ankle arthritis varies according to the cause and severity of the cartilage degeneration. For example, arthroscopic debridement, spur excision or ligament reconstruction have been attempted for early-stage degenerative arthritis with minimal talar tilt. However, these approaches give unpredictable results in cases of more advanced ankle arthritis.<sup>2</sup>

Total ankle arthroplasty or arthrodesis are performed for end-stage ankle arthritis. Ankle arthrodesis provides pain relief, although it also results in the loss of joint movement and possible degenerative arthritis in the adjacent joints. Total ankle arthroplasty can preserve ankle movement, although the common requirement for additional surgery<sup>3,4</sup> and the unknown long-term result has limited its widespread use.

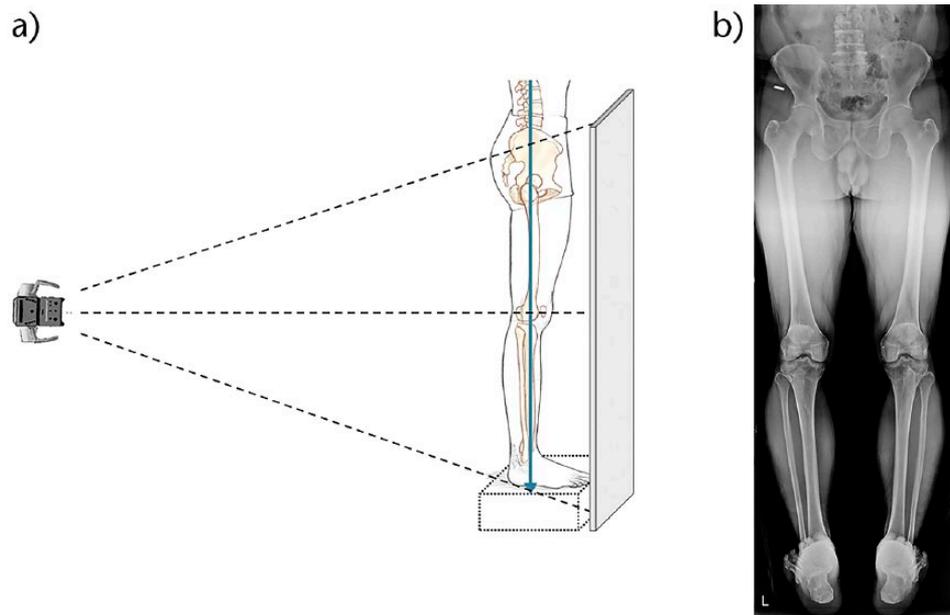
Therefore, various types of re-alignment surgery are used to preserve the ankle joint in cases of intermediate-stage ankle arthritis with partial joint space narrowing, and the short-term and mid-term results after re-alignment surgery are promising, with substantial post-operative pain relief and functional improvement that is reflected by high rates of patient satisfaction.<sup>5-7</sup>

This review aims to examine the indications, results and complications that are associated with current re-alignment surgery for asymmetrical ankle arthritis.

## Rationale of re-alignment surgery for asymmetrical ankle OA

Asymmetrical arthritis is defined as ankle arthritis with varus or valgus talar tilt. Thus, the patient's weight is borne by a small area, and additional pressure on that small area further aggravates the degenerative process. This pathological pressure on the subchondral bone<sup>8</sup> and living cartilage causes circumscribed joint degeneration, cartilage wear and debris in the joint,<sup>9</sup> which is the source of painful synovitis.<sup>10</sup>

Malalignment in the coronal plane also causes varus or valgus instability according to the direction of the talar tilt, which further aggravates the talar tilt due to insufficiency of the lateral or medial ligamentous structures. Thus, asymmetrical ankle arthritis appears to generate a vicious cycle;<sup>11</sup> reducing the load on the most severely affected area and transferring the load to an area with more normal cartilage are the principal aims in re-alignment surgery. The other reasons to perform re-alignment surgery are talus containment in the ankle mortise and better



**Fig. 1** Whole lower limb radiograph encompassing the hip, knee and heel: a) radiographic method; b) radiographic appearance.

congruity between the ankle mortise and the talus, which can be accomplished by narrowing the width of the ankle mortise or osteotomy of the tibial plafond.<sup>12,13</sup> Therefore, osteotomies that are performed at the distal tibia may have different effects and results.

Degenerated articular cartilage cannot regenerate itself, although coverage of the denuded area after re-alignment surgery using regenerated fibrocartilage has been reported in the knee.<sup>14</sup> Furthermore, plain radiography has been used to detect restoration of the normal joint space after re-alignment, and this even occurs in ankles with severe talar tilt ( $> 15^\circ$ ). However, the longevity of the results from joint re-alignment surgery is unknown, although our experience indicates that the joint may be maintained for  $\geq 15$  years.

### Radiographic assessment

Evaluation of the whole limb alignment as well as regional alignment at the ankle and hindfoot is essential for assessment of the ankle arthritis. It is difficult to assess the direction of asymmetrical weight-bearing load on the ankle joint on full-length lower limb radiographs, including the hip and the ankle joint because the weight-bearing axis distal to the ankle joint is not shown. Therefore, it is essential to take a whole limb radiograph encompassing the hip and the heel (Fig. 1).<sup>15</sup>

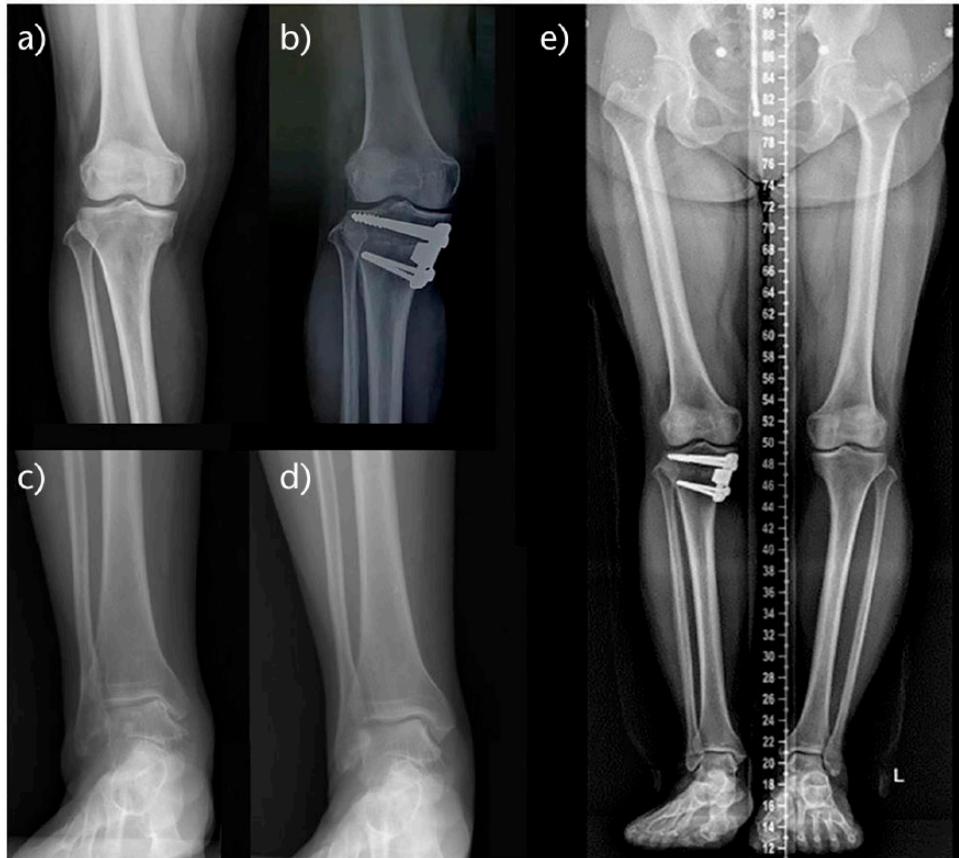
Re-alignment surgery principally addresses the asymmetrical ankle in the coronal plane, which makes the anteroposterior (AP) view the most important image for pre-operative and post-operative assessment. Furthermore,

there are several important radiological parameters of the ankle joint on the coronal plane. First, the tibial axis and tibial plafond form the medial distal tibial angle, the tibial axis and talus form the tibio-talar angle, and the tibial plafond and talar dome form the talar tilt angle.<sup>16,17</sup> Talus centre migration is another parameter that has been suggested for assessing the location of the talus relative to the tibial axis.<sup>12</sup> The position of the talus relative to the tibial axis is important for pre-operative planning and post-operative evaluation because the medial or lateral translation of the talus on pre-operative radiographs necessitates lateral or medial translation of the talus respectively during re-alignment surgery.

The lateral radiograph is regarded as less important in determination of joint re-alignment surgery for ankle arthritis because the principal object of re-alignment surgery is the correction of asymmetrical arthritis in the coronal plane. However, failure of currently suggested joint re-alignment procedures may necessitate more comprehensive normalisation of the ankle including restoration of normal alignment in the sagittal plane as well as the coronal plane.

Radiological parameters on the lateral radiograph of the ankle joint include an angle between the tibial axis and tibial plafond<sup>18</sup> and parameters to assess the position of the talus relative to the tibial axis, such as lateral talar station or tibio-talar ratio.<sup>19</sup>

Hindfoot alignment is described in only a few articles on ankle arthritis. Lateral impingement after distal tibial osteotomy has been reported. Angulation of the hindfoot is a known cause of coronal plane deformity of the talus



**Fig. 2** Pre-operative and post-operative weight-bearing radiographs showing correction of varus osteoarthritis at the knee and ankle joints by high tibial opening wedge osteotomy: a) pre-operative knee anteroposterior (AP) view; b) post-operative knee AP view; c) pre-operative ankle AP view; d) post-operative ankle AP view; e) post-operative whole limb radiograph.

and residual hindfoot malalignment may be a cause of deterioration after re-alignment surgery.<sup>16,17</sup> Hindfoot alignment is assessed either by angulation or translation relative to the tibial axis.<sup>12,16,17</sup> The author's measure of an angulation of hindfoot alignment is defined by the angle between the tibial axis and calcaneal axis. Translation of hindfoot alignment is measured by dividing the width of the calcaneus medial to the tibial axis by the calcaneal width at its widest portion.

### Re-alignment surgical procedures

Choosing the appropriate type of osteotomy for treatment of a specific deformity can optimise outcomes. High tibial osteotomy may be applicable for the ankle deformity when there is a varus deformity of the tibial plafond and degenerative arthritis of knee and ankle (Fig. 2). However, most authors have performed peri-talar osteotomies for joint preservation in asymmetrical ankle arthritis. Common joint preservation surgical procedures are described below.

### Asymmetrical varus ankle arthritis

#### *Osteotomy at the distal tibia: supramalleolar osteotomy (medial open-wedge distal tibiofibular osteotomy)*

After supramalleolar osteotomy of the tibia and fibula, the tibial plafond is angulated into valgus and the talus is translated laterally (Fig. 3). Usually both tibia and fibula are osteotomised. If only the tibia is osteotomised and angulated into valgus, the intact fibula will block the translation of the distal tibial fragment.

However, tibia-only osteotomy without fibular osteotomy may be indicated when there is widening of syndesmosis or ankle mortise which requires narrowing of the width of the mortise with minimal lateral translation. The necessity for lateral ligament reconstruction is controversial. However, the authors do not perform any ligament reconstruction when they perform supramalleolar osteotomy.

The authors aim for the centre of the talus<sup>12</sup> to be located on the tibial axis or slightly laterally after supramalleolar osteotomy. The average medial distal tibial angle should be 93° after supramalleolar osteotomy.



**Fig. 3** Pre-operative and post-operative weight-bearing radiographs of a valgus ankle corrected by supramalleolar osteotomy.

#### *Osteotomy at the distal tibia: indications*

Supramalleolar osteotomy is designed to shift the weight-bearing axis to the lateral side of the ankle joint and unload the medial side, and it is expected to correct distal tibial slope and medial talar translation as well. At the same time, lateral translation and valgus angulation of the hindfoot can result when a medial opening-wedge osteotomy is used. Indications, contra-indications and special risks of

supramalleolar osteotomy based on previous studies<sup>6,15,16</sup> are described in Table 1.

#### *Osteotomy at the distal tibia: clinical outcomes*

Good results have been reported after supramalleolar osteotomy targeted at primary ankle OA.<sup>16,19,20</sup> Takakura et al<sup>20</sup> performed distal tibial osteotomy for the moderate varus ankle OA patients and reported good or excellent results in 15 out of 18 cases. According to our report, American Orthopedic Foot and Ankle Society (AOFAS) score improved from 62.3 to 82.1 after supramalleolar osteotomy for primary varus ankle arthritis.<sup>16</sup>

Supramalleolar osteotomy is also known to be effective for post-traumatic varus malalignment. Graehl et al<sup>21</sup> reported good results in seven out of eight cases, Cheng et al<sup>22</sup> reported good results on osteotomy targeted for primary and secondary moderate ankle arthritis patients.

#### *Osteotomy at the distal tibia: complications*

Critical complications such as nonunion or malunion rarely occur after supramalleolar osteotomy. Loss of correction or undercorrection/overcorrection may occur and delayed union can also occur.

#### *Distal tibial oblique osteotomy: characteristics and indications*

Distal tibial oblique osteotomy makes the width of the ankle mortise narrower without disruption of the syndesmosis (Fig. 4). This osteotomy transfers weight-bearing load to the lateral side of the ankle joint and improves the

**Table 1.** Indications, contraindications and special risks of re-alignment supramalleolar osteotomy for asymmetrical varus ankle osteoarthritis (OA)

Supramalleolar osteotomy	Osteotomy distal to syndesmosis (mortise plasty)	Osteotomy of tibial plafond (plafondoplasty)
<p><b>Indications</b></p> <ul style="list-style-type: none"> <li>Asymmetric varus ankle OA with minimal talar tilt and a partially preserved lateral tibiotalar joint.</li> <li>Osteochondral lesions on the talar aspect of the tibiotalar joint.</li> <li>Corrections of post-traumatic deformities after lower leg fracture.</li> <li>Hindfoot re-alignment before or with ankle joint-sacrificing procedures.</li> </ul> <p><b>Contraindications</b></p> <p><b>Absolute contraindications:</b></p> <ul style="list-style-type: none"> <li>End-stage ankle OA.</li> <li>Unmanageable hindfoot instability.</li> <li>Acute osteomyelitis or infection.</li> <li>Severe vascular and/or neurological deficiency.</li> </ul> <p><b>Relative contraindications:</b></p> <ul style="list-style-type: none"> <li>Advanced age.</li> <li>Patients with poor general condition who are unable to perform post-operative non-weight-bearing rehabilitation.</li> <li>Insulin-dependent diabetes.</li> <li>Altered bone quality due to medication.</li> <li>Large cysts.</li> <li>Osteopenia or osteoporosis.</li> <li>Rheumatoid OA.</li> </ul> <p><b>Special risks</b></p> <ul style="list-style-type: none"> <li>Intra-operative injury of neurovascular structures and/or tendons.</li> <li>Wound-healing problems or infections.</li> <li>Undercorrection or overcorrection.</li> <li>Loss of correction.</li> <li>Delayed union or nonunion.</li> </ul>	<ul style="list-style-type: none"> <li>Asymmetric varus ankle OA with a wide ankle mortise, due to medial malleolar erosion, and a partially preserved tibiotalar joint.</li> <li>Corrections of medial translation of the talus with asymmetric varus ankle OA.</li> </ul>	<ul style="list-style-type: none"> <li>Intra-articular varus ankle OA.</li> <li>Tibial plafond incongruity after intra-articular fracture.</li> </ul> <p><i>This avoids creating a secondary translational deformity (unlike supramalleolar osteotomy).</i></p>



**Fig. 4** Pre-operative and post-operative weight-bearing radiographs of a varus ankle corrected by distal tibial oblique osteotomy.

containment of the talus. It is specifically indicated for an ankle with widened ankle mortise caused by marked erosion of the medial malleolus.

*Distal tibial oblique osteotomy: clinical outcomes*

According to Ahn et al,<sup>12</sup> the AOFAS score improved from 78.4 before surgery to 89 in 18 patients with an osteoarthritic ankle in varus. Visual analogue scale score was improved from 6.7 to 2.7. Kobayashi et al<sup>23</sup> also reported good results after distal tibial oblique osteotomy.

*Osteotomy through the tibial plafond (plafondoplasty): characteristics and indications*

Mann et al<sup>24</sup> performed osteotomy to correct a deformed tibial plafond in varus ankle arthritis (Fig. 5). We think this kind of osteotomy may accelerate cartilage degeneration in primary ankle OA, so it is better for post-traumatic OA patients with malunion of an intra-articular fracture.

*Osteotomy through the tibial plafond (plafondoplasty): clinical outcomes*

Mann et al<sup>24</sup> reported outcomes of 19 tibial plafond osteotomies for ankle arthritis, in which AOFAS score improved to 78 from 46 pre-operatively. They assessed 15 ankles as successful in which the ankle became stable after surgery. They wrote that there was no change in the slope of the tibial plafond on AP and lateral radiographs. Talar tilt angle improved from 18° pre-operatively to 10° post-operatively.

*Osteotomy at the foot*

Geometrically proximal re-alignment achieves larger correction than distal re-alignment. Re-alignment distal to



**Fig. 5** Pre-operative and post-operative weight-bearing radiographs of osteoarthritis of the ankle with a valgus deformity corrected by plafondoplasty.

the ankle joint has been reported by several authors.<sup>25-28</sup> Lateral translation or lateral closing-wedge calcaneal osteotomy has been the main method employed, and various bone or soft-tissue procedures were performed at the time of calcaneal osteotomy. This approach may be applicable when there is minimal tilt and no deformity on the tibial side. The re-alignment at the foot also failed to achieve large correction of the talar tilt although there was clinical improvement in most patients.

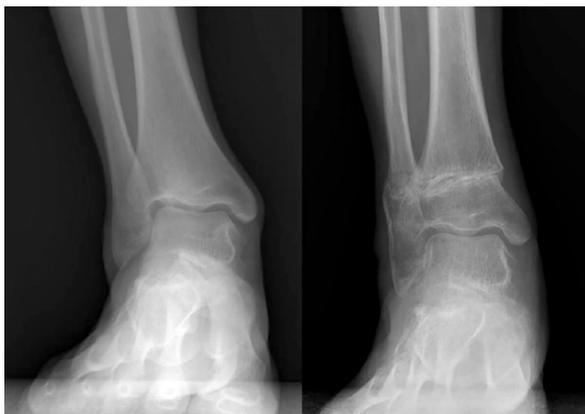
*Other approaches for correction of coronal plane alignment*

Only limited correction can be achieved with re-alignment surgery in the foot due to the small size of the tarsal bones. Thus, when there is a fixed deformity hindfoot, arthrodesis should be performed for re-alignment. Hintermann et al<sup>29</sup> reported that hindfoot arthrodesis is useful as one of the important methods of ankle re-alignment, which might decelerate or halt progression of the ankle arthritis.

There are few reports about the effect of static balancing (ligament repair)<sup>30</sup> or dynamic balancing (tendon transfer, etc.)<sup>18</sup> on ankle asymmetrical arthritis.<sup>31</sup> However, ankle arthritis with large talar tilt is difficult to salvage with any method. Recently, Park et al<sup>32,33</sup> reported satisfactory correction of severe talar tilt with triple arthrodesis and muscle balancing. The difference from previous reports may have been the de-rotation of the internally rotated talus by tendon transfer.

**Asymmetrical valgus ankle arthritis**

The causes of asymmetrical arthritic valgus ankles can be divided into two main aetiological and morphological groups.<sup>34</sup> One is characterised by osseous valgus deformity of the tibial plafond. This can be caused by post-traumatic ankle OA or primary valgus ankle OA.<sup>35</sup> Patients with malunited fibular fracture with a shortened and



**Fig. 6** Pre-operative and post-operative radiographs of a varus ankle corrected by a plafondoplasty.

externally rotated fibula may present with asymmetrical valgus ankle arthritis.<sup>36,37</sup> Another category of asymmetrical valgus ankle arthritis is associated with hindfoot valgus, with or without insufficiency of the deltoid ligaments.<sup>34,38</sup> Often, both tibial side valgus and hindfoot valgus co-exist.

Joint preservation surgery for valgus ankle arthritis primarily aims to correct the aetiological deformity. Distal tibial osteotomy has been performed for valgus deformity of the tibial plafond. Fibular osteotomy is used for malunion of the fibula and diastasis has been performed for valgus arthritis after ankle fracture.

Valgus ankle arthritis in adult-acquired flatfoot has been the main treatment group because correction for valgus ankle arthritis with severe talar tilt is difficult. Several reconstruction methods for deltoid insufficiency have been suggested by various authors;<sup>38,39</sup> however, no-one has achieved predictable salvage of valgus arthritis with large talar tilt and joint space narrowing. Both superficial and deep deltoid ligament reconstruction have been successful in some cases. However, longer term results in a large number of patients should be demonstrated before this method is advocated as the best method for joint preservation in valgus ankle arthritis.

## Osteotomy at the distal tibia

### *Medial closing-wedge tibiofibular osteotomy: characteristics and indications*

Corrective osteotomy in the supramalleolar area aims to unload the lateral compartment in valgus deformity of the distal tibial plafond.<sup>6,7</sup> Unlike medial open-wedge osteotomy, the ankle mortise becomes wider after medial closing-wedge osteotomy. Therefore correction of the distal fibula might be needed to correct rotation or adjustment of fibula length (Fig. 6).<sup>13,36</sup>

### *Medial closing-wedge tibiofibular osteotomy: clinical outcomes*

Knupp et al<sup>7</sup> reported on 92 patients (94 ankles) with asymmetric ankle arthritis, 61 of whom had valgus deformity. At the mean follow-up of 43 months, a significant improvement in clinical scores was observed, with post-operative reduction of radiographic signs of arthritis in patients with mid-stage ankle arthritis. In ten patients, conversion to total ankle arthroplasty or arthrodesis was necessary owing to progression of ankle arthritis. Hintermann et al<sup>36</sup> performed a prospective study including 48 patients with malunited, pronation-external rotation fracture of the ankle. In all patients, valgus malalignment of the distal tibia and malunion of the fibula were corrected. At a mean follow-up of 7.1 years, good or excellent results were obtained in 42 patients. In one patient, total ankle arthroplasty was performed 26 months after corrective surgery.

Peritalar osteotomies have been used for successful joint preservation in both varus and valgus asymmetric ankle arthritis. Careful assessment of whole alignment, including foot deformity, can lead to good clinical outcomes. Restoration of talar position in the coronal and sagittal planes may be more effective for longevity of joint preservation surgery by restoration of parallel joint lines with minimal talar tilt.

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### **LICENCE**

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