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Total ankle replacement in moderate to severe varus deformity of the ankle

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Our study describes the clinical outcome of total ankle replacement (TAR) performed in patients with moderate to severe varus deformity. Between September 2004 and September 2007, 23 ankles with a varus deformity ≥ 10° and 22 with neutral alignment received a TAR. Following specific algorithms according to joint congruency, the varus ankles were managed by various additional procedures simultaneously with TAR.

After a mean follow-up of 27 months (12 to 47), the varus ankles improved significantly in all clinical measures (p < 0.0001 for visual analogue scale and American Orthopaedic Foot and Ankle Society score, p = 0.001 for range of movement). No significant differences were found between the varus and neutral groups regarding the clinical (p = 0.766 for visual analogue scale, p = 0.502 for American Orthopaedic Foot and Ankle Society score, p = 0.773 for range of movement) and radiological outcome (p = 0.339 for heterotopic ossification, p = 0.544 for medial cortical reaction, p = 0.128 for posterior focal osteolysis). Failure of the TAR with conversion to an arthrodesis occurred in one case in each group.

The clinical outcome of TAR performed in ankles with pre-operative varus alignment ≥ 10° is comparable with that of neutrally aligned ankles when appropriate additional procedures to correct the deformity are carried out simultaneously with TAR.

Deformity in the coronal plane must be considered in total ankle replacement (TAR) since residual angular deformity or malalignment after the operation can result in instability, progressive edge-loading or subluxation of the bearing, leading eventually to failure.[1,2] Relatively poor clinical results have been described in patients with severe pre-operative angular deformity,[1-5] and higher rates of complication occur in congruent varus ankles.[2]

Some authors have suggested that the indication for operation should be narrowed to those with < 10° to 15° of varus or valgus[1-5] and good results have been reported following arthrodesis of the ankle in patients with severe varus or valgus deformities of the ankle.[6] Between 33%[3] and 44%[2] of patients with end-stage osteoarthritis present with malalignment of > 10° in the coronal plane. Of 76 ankles receiving a TAR at our institution, 30 (39.5%) had pre-operative varus alignment ≥ 10°. Although lacking statistical evidence, there seem to be more patients with varus deformity of the ankle in Asian populations, presumably because of their varus aligned knees and a tendency to sit in a lotus position with their legs crossed, as well as kneeling with the ankle in plantar flexion and inversion.

Various additional procedures have been suggested to correct the accompanying deformities before or with TAR. However, there are few reports which describe the outcome of TAR carried out with additional procedures in patients with pre-operative deformity in the coronal plane. We have therefore set up algorithms which we have used to manage moderate to severe varus ankles, both congruent and incongruent, and to perform various corrective operations simultaneously with TAR. We have compared the clinical and radiological findings, complication rates and survival after TAR in ankles which were in moderate to severe varus before operation with those that were in neutral alignment.

Patients and Methods

Between September 2004 and September 2007, 23 ankles with varus deformity ≥ 10° and 22 with neutral alignment received a TAR. The pre-operative diagnoses did not differ significantly between the two groups, with post-traumatic osteoarthritis being the most common cause in both (Table I).

The radiological degree of alignment of the ankle in the coronal plane was defined as the angle between the anatomical axis of the tibia

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Table I. Clinical details of the varus and neutral groups

	Varus group (n = 23)	Neutral group (n = 22)
Mean (SD) pre-operative ankle alignment (°)	17.1 (5.6)	0.88 (5.1)
Mean (SD) talar tilt angle (°)	11.7 (7.3)	0.15 (4.6)
Mean (range) age in yrs	66.8 (50.0 to 76.0)	62.1 (34.0 to 76.0)
Male:female ratio*	16:7	7:15
Mean (range) weight (kg)	67.2 (55.0 to 85.0)	66.5 (52.0 to 84.0)
Mean (range) height (cm)	163.5 (150.0 to 184.0)	158.7 (145.0 to 174.0)
Mean (SD) body mass index (kg/m^2)	26.4 (3.2)	25.1 (2.5)
Pre-operative diagnosis (%)		
Degenerative OA†	7 (*30.5*)	9 (*40.9*)
Post-traumatic OA	15 (*65.2*)	10 (*45.5*)
Systemic arthritis	1 (*4.3*)	3 (*13.6*)
Takakura classification[12]* (%)		
Stage 3	16 (*69.6*)	4 (*18.2*)
Stage 4	7 (*30.4*)	18 (*81.8*)

* chi-squared test (Fisher's exact test), $p < 0.05$
† OA, osteoarthritis

Fig. 1a

Fig. 1b

Pre-operative standing anteroposterior radiographs showing a) ankle alignment which is defined as the angle between the anatomical axis of the tibia and a line drawn perpendicular to the talar dome and b) measurement of the talar tilt angle which is that between the tibial plafond and the talar dome.

and a line perpendicular to the articular surface of the dome of the talus on the standing anteroposterior (AP) radiograph of the ankle (Fig. 1a).[1,7] When the angle of alignment was < 10° of varus or valgus the ankle was thought to be in neutral, but was considered to be in varus when in > 10°.[1] Varus ankles were subdivided into congruent and incongruent according to the angle of talar tilt, which was measured as the angle between the tibial plafond and the dome of the talus on the pre-operative standing AP radiograph (Fig. 1b).[2] The joint was regarded as congruent if talar tilt was < 10° and incongruent if it was ≥ 10°.[2]

The Hintegra (Newdeal SA, Lyon, France) total ankle system was used in all cases. All the operations were performed by the senior author (JWL). Various adjuvant procedures were carried out at the time of TAR to restore neutral alignment and to correct accompanying deformities or instability. The clinical and radiological results were compared between the varus and neutral groups and between the congruent and incongruent varus groups after a mean follow-up of 27 months (12 to 47).

Operative technique. TAR was performed through a standard surgical approach.[8] When operating on a varus ankle, sufficient release of the medial soft tissue is mandatory since medial tightness or contracture is common. In an incongruent varus ankle, the mortise is usually in almost neutral alignment (Fig. 2) with the varus deformity due to talar tilt. Since this is caused by medial contracture and/or lateral laxity, optimal balancing of the ligaments can produce a neutral ankle. If this can be achieved by adequate medial release, no further additional procedure is necessary. If there is residual talar tilt with lateral opening even after sufficient medial release, lateral plication procedures such as transfer of peroneus longus to brevis and/or a modified Broström procedure[9] is needed (Fig. 3).

In a congruent varus ankle, the mortise is usually tilted along with the inclined talus (Fig. 4). Medial release must then be followed by a neutralising tibial cut. Maximal bony support with minimal resection of bone is an advantage of the implant[8] and resection of subchondral bone of a minimum of 2 mm to 3 mm from the tibial plafond is recommended.[8,10] However, in a congruent varus ankle, a higher tibial bone cut with insertion of a thicker polyethylene bearing may be needed in order to achieve a neutrally aligned articular surface (Fig. 5).

Any asymmetry or uneven stress distribution on the polyethylene liner in a non-weight-bearing supine position can result in subluxation or dislocation of the liner when weight is borne. Therefore, it is important to confirm symmetrical balancing of the ligaments with paralleling of the tibial and talar surfaces, grossly as well as under the image intensifier, before closing the wound.

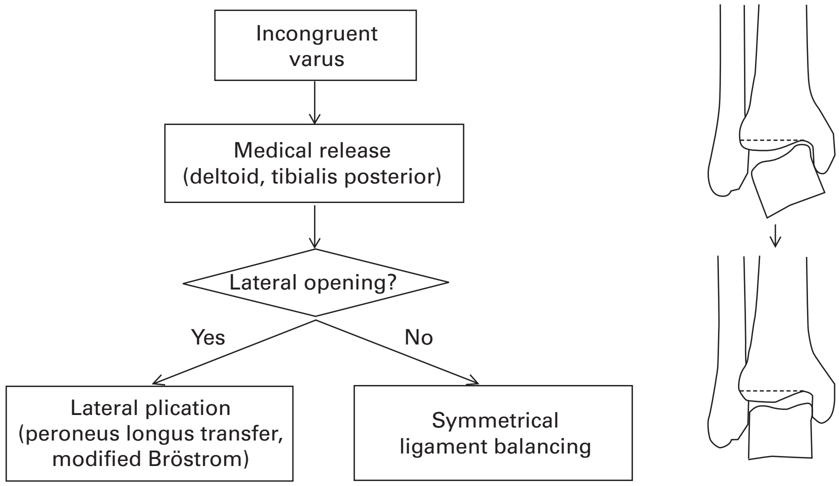

Fig. 2

Diagram and algorithm showing ligament balancing in the incongruent varus ankle.

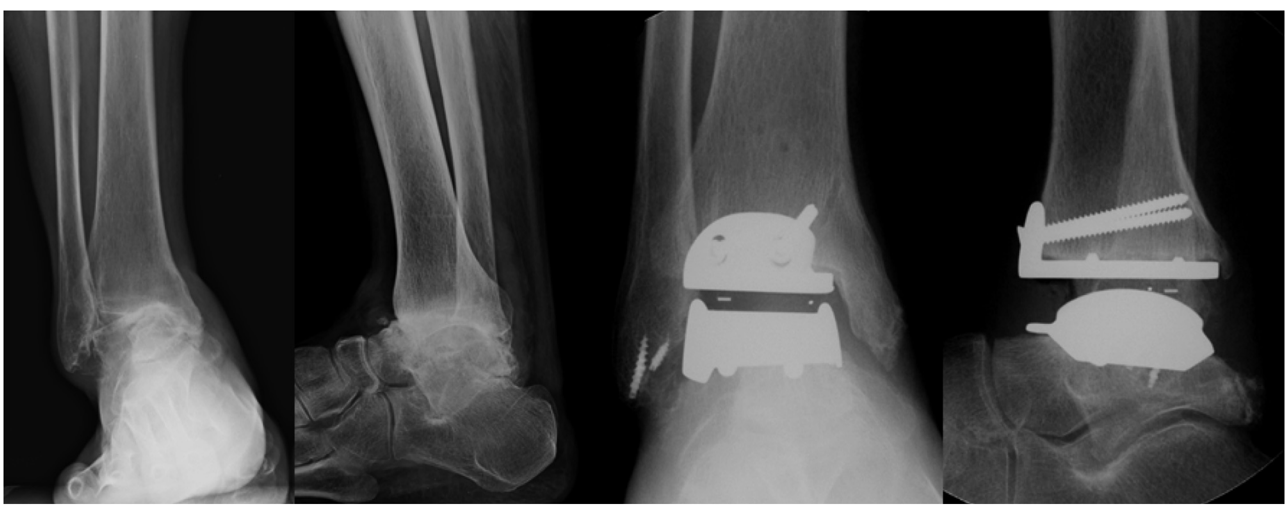

Fig. 3

Radiographs showing incongruent varus in a 77-year-old man with a history of recurrent ankle sprains and end-stage osteoarthritis. The pre-operative ankle varus was 27° with a talar tilt angle of 27°. Total ankle replacement was performed with release of the deltoid ligament and lateral ligament reconstruction using a modified Broström technique with lengthening of the tendo Achillis.

After insertion of the implant, the alignment of the heel was checked and corrected by a lateral closing-wedge calcaneal osteotomy if necessary. Prolonged ankle varus may be accompanied by forefoot pronation and plantar flexion of the first ray. In such cases a dorsiflexion osteotomy of the first metatarsal is required (Fig. 6). Tightness of the tendo Achillis restricting ankle dorsiflexion was managed by recession of gastrocnemius or percutaneous lengthening of the tendon.

Clinical evaluation. All the patients were evaluated before operation and reviewed after two and six weeks, three and six months, one year and yearly thereafter. Clinical evaluation included measurement on a visual analogue scale (VAS) for pain, assessment by the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score,[11] measurement of the range of movement (ROM) and patient satisfaction, including whether they would undergo the same operation if they were in a similar situation. The ROM of the ankle-hindfoot complex was measured manually by a goniometer for plantar flexion and dorsiflexion. Satisfaction was measured using a scale defining 'satisfied', 'somewhat satisfied' and 'not satisfied'.

Radiological evaluation. Standardised weight-bearing AP and lateral radiographs of the ankle were taken before operation and fluroscopy-assisted standing views obtained post-operatively to acquire true AP and lateral images. The serial radiographs were evaluated by two of the authors (JWL, BSK).

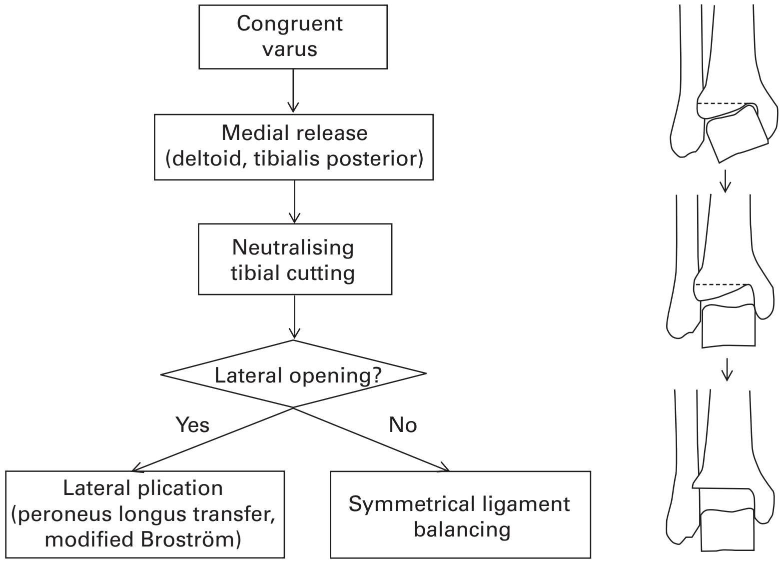

Fig. 4

Diagram and algorithm showing ligament balancing in the congruent varus ankle.

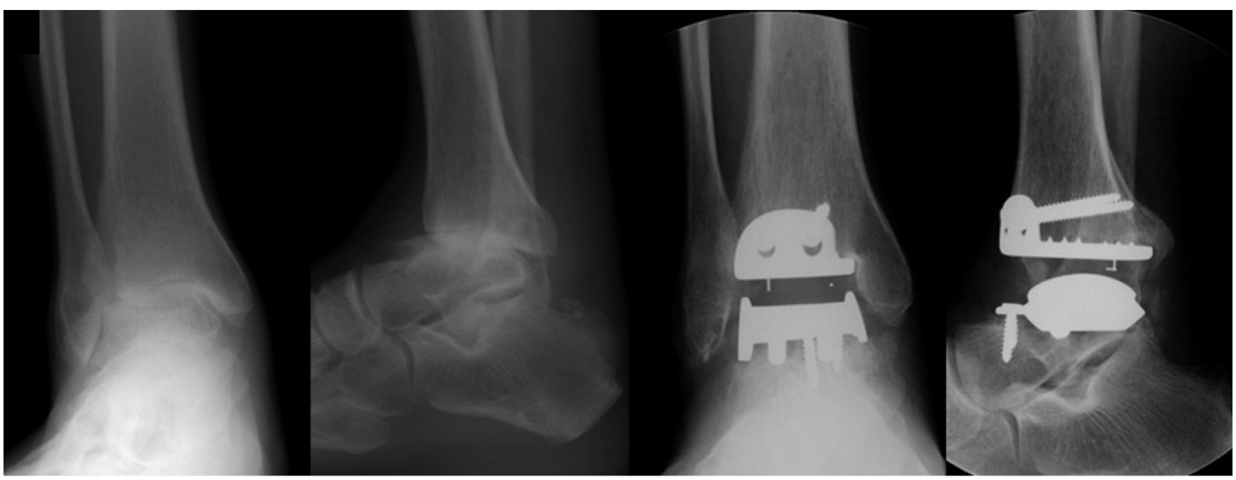

Fig. 5

Radiographs showing congruent varus in a 70-year-old man with degenerative osteoarthritis. The pre-operative ankle varus was 15° with a talar tilt angle of 1°. A higher tibial bone cut was required to achieve a neutral mortise and a 7 mm polyethylene liner was inserted with sufficient medial release. The patient was satisfied and had an American Orthopaedic Foot and Ankle Society score of 87 at four years after surgery.

The angular position of the tibial component was assessed by the α and β angles.[8]The angle between the longitudinal axis of the tibia and the articulating surface of the tibial component on the AP view was the α angle and on the lateral radiograph the β angle. Loosening of the tibial component was defined as a change in position > 2° and/or a progressive radiolucency of > 2 mm in either view. The position of the talar component was assessed by the γ angle,[8] measured as the angle between a line drawn through the anterior shield (anterior portion of the talar component) and the posterior edge of the talar component and a line drawn between the dorsal aspect of the talonavicular joint and the calcaneal tubercle on the standing lateral radiograph. Loosening of the talarcomponent was defined as a change in the γ angle of > 5°. Medial cortical reaction was defined as thickening of the cortex proximal to the medial malleolus and was checked on serial radiographs. The formation of heterotopic ossification and focal osteolysis were also monitored.

Statistical analysis. This was carried out using SPSS version 12.0 software (SPSS Inc., Chicago, Illinois). In order to evaluate the clinical changes before and after surgery a

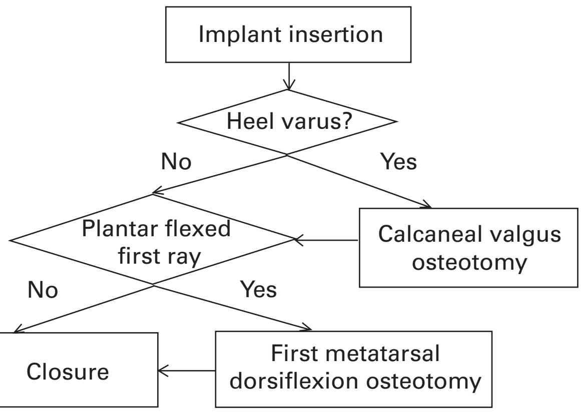

Fig. 6

Algorithm showing additional bony procedures.

paired *t*-test was used. For comparison of outcomes between the two groups, a two-sample *t*-test for continuous variables and a chi-squared (Fisher's exact) test for nominal data were used. In order to compare continuous variables between small groups according to various radiological findings the Mann-Whitney U test was used. A p-value ≤ 0.05 was considered to be significant.

Results

The age, height, weight, and body mass index were similar for the varus and neutral groups (Table I). There were more male patients in the varus group and more female patients in the neutral group ($p < 0.05$; Table I). According to the classification of Takakura et al,[12] most of the varus ankles were in stage 3 while the neutral ankles were mostly in stage 4 ($p < 0.05$; Table I). Within the varus group, there were 11 ankles (47.8%) in the congruent varus group and 12 (52.2%) in the incongruent varus group. No differences were found between the basic characteristics of these two groups.

Additional procedures. When required, additional procedures were carried out simultaneously with TAR in order to correct any accompanying malalignment, joint contracture or instability. Release of the deltoid ligament was required in all 23 patients and a further medial release with lengthening of tibialis posterior in one. On the lateral side transfer of the tendon of peroneus longus to peroneus brevis was required in two patients and lateral ligament reconstruction with a modified Broström procedure in a further two. Three patients had calcaneal valgus osteotomies and one a first metatarsal dorsiflexion osteotomy. Percutaneous lengthening of the tendo Achillis was required in eight patients and release of the gastrocnemius in one.

Clinical and radiological outcome. Varus ankles improved significantly in all clinical measures showing no significant differences between the varus and neutral groups (two-sample *t*-test $p > 0.05$, Table II). Regarding satisfaction, 20 (87.0%) patients were satisfied, two (cases 6 and 14) were somewhat satisfied and one (case 8) was not satisfied, complaining of pain around the lateral malleolus where transfer of the tendon of peroneus longus and a modified Broström procedure had been performed. When the congruent and incongruent varus groups were compared, the results were also similar. Both groups showed significant improvement in VAS and AOFAS scores ($p < 0.001$). ROM was enhanced in both congruent ($p = 0.025$) and incongruent ($p = 0.018$) groups (Table III).

The post-operative radiological evaluation showed a mean α angle of 92.3° (SD 1.6) and a mean β angle of 86.5° (SD 2.9) in the varus group, which was similar to that of the neutral group ($p = 0.355$ and $p = 0.622$, respectively). One ankle in the varus group, which was the sixth case in our series, had malposition of the tibial component with a β angle of 78°, but developed no associated complications. Heterotopic ossification was seen in seven (30.4%) ankles in the varus group, most commonly at the posterior aspect, but did not affect the VAS ($p = 0.6$), the AOFAS score ($p = 0.5$), nor the ROM ($p = 0.97$). Medial cortical reaction was found in two patients in the varus group who had pain on the medial side. In one the pain subsided as the cortical reaction stabilised after one year. In the other, a medial cortical reaction was followed by loosening of the tibial component, which was eventually revised. Focal osteolysis around the posterior tip of the tibial loading plate occurred in six (26.1%) of the varus ankles, but the p-value was > 0.05 (Table IV). The mean posterior slope of the tibial component was increased in ankles with posterior focal osteolysis (β angle = 83.7° (SD 4.6) *vs* 87.3° (SD 1.6)), but without statistical significance ($p = 0.28$). There were two patients with a small tibial component with an uncovered bony surface of less than 2 mm on the lateral radiograph. Posterior focal osteolysis developed in one. Although the sample sizes were not large enough for statistical analysis, no differences were found between the varus and neutral groups regarding the development of heterotopic ossification, a medial cortical reaction and focal osteolysis (Table IV).

Complications and revision operations. There were two patients with complications in the varus group and three in the neutral group. In the varus group, one had dislocation of the polyethylene liner and in the other the prosthesis became loose. In the first patient contracture on the medial side required further soft-tissue release and lengthening of the tendon of tibialis posterior with transfer of peroneus longus brevis. Symmetrical balancing of the ligaments was finally achieved, and the patient was fully satisfied, reporting excellent results and an AOFAS score of 84 at 29 months after the revision. The patient with loosening of the tibial component had a revision operation but eventually required an arthrodesis.

In the neutral group complications included dislocation of a liner, osteolysis and deep infection. One patient eventually required an arthrodesis.

With one case of failure in both the varus and neutral groups, at a mean follow-up of 27 months (12 to 47) the failure rates were 4.3% and 4.5%, respectively.

Table II. Clinical assessment (mean, SD) of the varus and neutral groups

	Varus group	Neutral group	p-value*
Visual analogue scale			
Pre-operative	6.7 (1.9)	7.1 (1.3)	0.315
Last follow-up	2.8 (1.1)	3.4 (1.8)	0.168
Improvement	3.9 (2.0)	3.7 (2.5)	0.766
p-value†	< 0.0001	< 0.0001	
AOFAS‡ score			
Pre-operative	54.4 (11.1)	53.3 (13.0)	0.767
Last follow-up	83.2 (7.7)	78.7 (13.2)	0.176
Improvement	28.8 (14.0)	25.5 (18.2)	0.502
p-value†	< 0.0001	< 0.0001	
Range of movement (°)			
Pre-operative	26.3 (14.6)	21.8 (12.6)	0.276
Last follow-up	41.6 (11.7)	35.7 (14.1)	0.131
Improvement	15.3 (18.9)	13.9 (13.8)	0.773
p-value†	0.001	< 0.0001	

* two-sample *t*-test
† paired *t*-test
‡ AOFAS, American Orthopaedic Foot and Ankle Society

Table III. Clinical assessment (mean, SD) of the congruent and incongruent varus group

	Varus group		
	Congruent	Incongruent	p-value*
Visual analogue scale			
Pre-operative	7.3 (1.5)	6.1 (2.0)	0.126
Last follow-up	2.8 (1.3)	2.8 (1.0)	0.889
Improvement	4.5 (1.5)	3.3 (2.3)	0.187
p value†	< 0.0001	< 0.0001	
AOFAS‡ score			
Pre-operative	55.4 (10.6)	53.5 (11.9)	0.697
Last follow-up	81.5 (9.0)	84.8 (6.3)	0.304
Improvement	26.1 (14.8)	31.3 (13.3)	0.381
p-value†	< 0.0001	< 0.0001	
Range of movement (°)			
Pre-operative	27.3 (11.7)	25.4 (17.3)	0.768
Last to follow-up	44.1 (14.8)	39.3 (8.0)	0.342
Improvement	16.8 (21.2)	13.9 (17.4)	0.722
p-value†	0.025	0.018	

* two-sample *t*-test
† paired *t*-test
‡ AOFAS, American Orthopaedic Foot and Ankle Society

Discussion

If the pre-operative varus or valgus deformity is not corrected, the residual deformity can seriously affect the clinical outcome of TAR, producing instability, recurrent tilting, subluxation or dislocation of the bearing.[1] Even if talar tilt does not occur, residual misalignment causes a concentration of forces in the interfaces between metal and bone and in the polyethylene liner,[13] producing acceleration of the rate of polyethylene wear with subsequent increased production of wear particles followed by osteolysis and an increased risk of revision surgery.[14] A high incidence of osteolysis has recently been reported with the use of the Ankle Evolution TAR.[15]

When failure occurred, additional procedures have usually been conducted as a secondary operation or a revision. Without correcting the accompanying deformity at the time of the TAR, the results in ankles with moderate or severe varus are generally unsatisfactory.[1,2,4] Wood and Deakin[4] described the development of edge-loading of the bearing in seven of 39 (18.0%) ankles with a pre-

Table IV. Details (mean, SD) of the radiological findings in the varus and neutral groups

	Varus group (n = 23)	Neutral group (n = 22)	p-value
α angle (°)	92.3 (1.6)	92.9 (2.4)	0.355*
β angle (°)	86.5 (2.9)	86.1 (3.2)	0.622*
Heterotopic ossification (%)	7 (*30.4*)	4 (*18.2*)	0.339†
Number with medial cortical reaction (%)	2 (*8.7*)	1 (*4.5*)	0.544†
Number with posterior focal osteolysis (%)	6 (*26.1*)	2 (*9.1*)	0.128†

* two-sample *t*-test

† chi-squared test (Fisher's exact test)

operative varus or valgus of more than 15°. They performed calcaneal osteotomy and/or lateral ligament reconstruction as a secondary procedure in three cases and fusion in another three. Wood et al[3] noted that the presence of varus or valgus deformity before operation had a significant effect on survivorship, with the likelihood of revision being directly proportional to the size of the angular deformity. Haskell and Mann[2] evaluated eight (22.9%) cases of progressive edge-loading in 35 ankles with pre-operative varus or valgus ≥ 10°. Seven did not have intra-operative balancing of the ligaments. Additional procedures, such as calcaneal osteotomy or tendon transfers, were performed as a secondary operation in failed cases. Doets et al[1] reviewed 17 ankles with pre-operative varus or valgus of > 10°. The survival rate of this group was 48% at eight years, which was significantly lower than that of the neutral group (90%).

As a result of poor clinical outcomes or higher revision rates, many authors have suggested excluding moderate to severe varus from the indications for TAR.[1,2,4] Wood and Deakin[4] considered that varus or valgus of > 15° was a relative contraindication for TAR. Doets et al,[1] reviewing their patients after eight years, concluded that a varus or valgus deformity of more than 10° should be considered as an absolute contraindication. Haskell and Mann[2] have analysed the effect of pre-operative joint incongruency on the clinical outcome. Defining an angle of talar tilt ≥ 10° as incongruent, four of their seven incongruent ankles developed progressive edge-loading. They suggested that talar tilt of > 10° should be a contraindication for TAR. Good results have, however, recently been reported following TAR in patients with a hindfoot deformity of up to 30°.[16]

Although many additional procedures are known, only a few series have included the results of TAR performed with additional operations[8,17,18] Hintermann et al[8] carried out 43 additional procedures simultaneously with 122 TARs using the Hintegra prosthesis, and had a good or excellent result in 82% and a revision rate of 6.6% after a mean of 18.9 months. In a follow-up study, including 271 cases with a mean follow-up of 36 months, the revision rate was 14.4%.[18] Doets et al[17] developed a lengthening osteotomy of the medial malleolus and reported 12 excellent or good results in 14 ankles followed for more than two years. However, if they failed to correct the hindfoot varus deformity at the time of TAR, a revision procedure was required.

We have followed our algorithms (Figs 2, 4 and 6) to perform additional procedures concurrently with the TAR to achieve good alignment and optimal soft-tissue balance in ankles with moderate to severe varus alignment. In an incongruent varus ankle, most of the mortise is kept in neutral alignment and it is the tilted talus which causes the ankle varus. Therefore, sufficient release of medial contracture or tightness can bring the tilted talus parallel to the neutral plafond, yielding a neutral ankle. In a congruent varus ankle, it is either the tilted mortise or malalignment in the supramalleolar region which causes the varus deformity. Malalignment of > 10° in any plane in the supramalleolar or distal tibial region requires corrective osteotomy at the level of the deformity before TAR.[10,19-21] A minor amount of deformity at the level of the ankle or mortise can be corrected with bone cuts during the operation.[9] The exact amount of deformity which can be corrected by tibial cuts in the mortise is not known, but our data included congruent varus of up to 16° which was successfully managed by correction in the mortise. In such cases, higher tibial cutting to achieve a neutrally-aligned articular surface is necessary, but caution must be taken to avoid removal of too much bone. We consider that congruent varus ≥ 20° should be managed by supramalleolar osteotomy before the TAR.

Our results indicate that the clinical outcome of TAR performed in ankles with pre-operative varus alignment ≥ 10° is comparable with that of neutrally aligned ankles as long as the appropriate additional procedures to correct the deformity are carried out simultaneously. There was no significant difference between the congruent and incongruent varus groups. A previous report by Haskell and Mann[2] suggested that incongruent varus ankles result in a poorer prognosis but our data suggest that additional procedures can also diminish the effect of pre-operative joint incongruency.

We had a preponderance of men in the varus group (Table I), which could have affected the results. There was a relatively higher percentage of post-traumatic osteoarthritis in men (14 of 23, 60.9%) compared with women (11 of 22, 50%), although the difference was not statistically significant (p = 0.500). Chronic lateral instability of the ankle or recurrent sprains occurred more often in men (11 of 14, 78.6%) than in women (6 of 11, 54.5%), but again this was not significant (p = 0.389). Ankle sprains and related post-traumatic osteoarthritis occur more often in men, probably because these injuries are sustained more frequently during sport.[22] Choi et al[23] found that in their series of 62 cases of chronic lateral ankle instability, 44 (71.0%) occurred in men. In a recent study by Valderrabano et al[24] on the aetiology of ankle osteoarthritis, of 65 patients with post-traumatic osteoarthritis due to ligament lesions, 44 (67.7%) were men. Such chronic lateral ankle instability can result in ankle osteoarthritis with varus malalignment.

The relatively short duration of follow-up is the most significant limitation of our study since problems with alignment may not manifest themselves immediately, but may occur in the mid or long term. Currently, there is a lack of long-term follow-up regarding TAR in moderate to severe varus ankles and caution should be exercised when applying our results. Longer follow-up is needed to evaluate the overall outcome. The relatively small sample size, especially in the congruent and incongruent subgroups, is another weakness of our study. Parametric as well as non-parametric analysis statistically validates the results, but further study with a larger series is required.

The most severe deformity in our series was incongruent varus of 28°. There were eight ankles in which the pre-operative varus deformity was ≥ 20°. This has been previously considered to be an absolute contraindication to TAR.[10,19] Although the number of cases is too small for statistical analysis, six of these eight ankles showed good or excellent results with no complications. Further study with larger samples including only severe varus cases is also required.

Instead of excluding moderate to severe varus deformity from the indications for TAR, we suggest that TAR should be performed with an effort to correct accompanying deformities. Satisfactory clinical outcomes can be achieved in varus-aligned ankles.

Supplementary material

A Table showing details of the 23 patients in the varus group is available with the electronic version of this article on our website at www.jbjs.org.uk

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No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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