Varus Malalignment of the Talar Neck. Its Effect on the Position of the Foot and on Subtalar Motion*{{dagger}}

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Article

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ABSTRACT: **We performed an *in vitro* study on twelve specimens of the foot and ankle from cadavera to determine whether varus malalignment of the talar neck alters the position of the foot and subtalar motion. An osteotomy of the talar neck was performed, and the specimens were studied with and without removal of a medially based wedge of bone. Removal of the wedge produced an average varus malalignment of the talar neck of 17.1 ± 2.4 degrees (range, 12.5 to 21.0 degrees). In the coronal plane, the average arc of motion of the subtalar joint decreased from 17.2 ± 3.3 degrees before the osteotomy to 11.7 ± 2.9 degrees after the osteotomy and removal of the wedge. In the transverse plane, it decreased from 17.5 ± 2.9 degrees to 11.9 ± 2.4 degrees. In the sagittal plane, it decreased from 8.9 ± 2.4 degrees to 6.8 ± 2.3 degrees. The decrease in subtalar motion was characterized by an inability to evert the foot; inversion was not limited, however.**

The malalignment produced an average of 4.8 ± 1.2 degrees of varus deformity and 8.7 ± 2.3 degrees of internal rotation of the hindfoot and an average of 5.5 ± 2.0 degrees of varus deformity and 11.5 ± 2.4 degrees of adduction of the forefoot. A linear correlation analysis was used to compare the change in subtalar motion and the position of the foot with the degree of varus malalignment at the talar neck. The correlation coefficient was 0.90 ($p < 0.01$) for subtalar motion, 0.76 ($p < 0.01$) for internal rotation of the calcaneus, and 0.81 ($p < 0.01$) for adduction of the forefoot. This indicated a direct correlation between the degree of varus malalignment at the talar neck and the change in the position of the foot and in subtalar motion.

Fractures of the talus are high-energy injuries that commonly involve the talar neck[6,10,15]. Malunited fractures of the talar neck have been associated with a poor clinical outcome[3,4,19,28]. A fair or poor result was reported after a fracture of the talar neck in ninety-seven (51 per cent) of 189 patients[4-6,10,19,27]. Malunion has been noted as a frequent cause of an unsatisfactory result, and it was associated with forty-five (28 per cent) of 163 displaced fractures from several series[3,5,19,28]. Canale and Kelly[4] reported malunion with a varus deformity of the talar neck after fourteen of fifty-six displaced fractures; subtalar osteoarthrosis developed in five of the fourteen feet.

In the present study, we used specimens from cadavera to evaluate the effect of varus malalignment of the talar neck on the position of the foot and on subtalar motion and to identify the pathomechanics of the deformity that could be used to establish guidelines for the treatment of talar fractures.

Materials and Methods

Twelve specimens of the foot and ankle (including the distal eight inches [twenty centimeters] of the fibula) were obtained from cadavera of individuals who had been seventeen to seventy-seven years old at the time of death. There was no known history of trauma, osteoarthrosis, or visible abnormality of the hindfoot. The specimens were stored at -20 degrees Celsius for no longer than eight months. Each was thawed at room temperature before use, and none was refrozen for later use. Each specimen was dissected free of overlying skin, muscles, and tendons, and the ligaments and joint capsules were left intact. The toes were disarticulated through the metatarsophalangeal joints.

Two smooth 0.11-inch (0.28-centimeter) Steinmann pins were passed from the tibia into the body of the talus to stabilize the tibiotalar joint in the neutral position. Another Steinmann pin was passed through the distal aspects of the shafts of the metatarsals, at 90 degrees to the shaft of the second metatarsal, to stabilize the tarsometatarsal joints by preventing any motion of the metatarsals. Two Steinmann pins were used to attach an aluminum block to the posterior aspect of the calcaneus and served as reference points with which to measure the position and motion of the calcaneus (Fig. 1).

Two 0.054-inch (0.14-centimeter) Kirschner wires were placed parallel to each other into the lateral aspect of the talus. One was placed through the fibula into the body of the talus and served as a constant reference point to ensure that the varus deformity created at the talar neck was isolated to the transverse plane. The other was placed anteriorly at the dorsolateral aspect of the junction of the talar neck and head so that it did not interfere with eversion of the foot. A weight was attached to the lateral aspect of the transmetatarsal pin to maintain the foot in the neutral position parallel to the table in the transverse plane with the calcaneus aligned with the midline of the tibia in the coronal plane. Two Steinmann pins, placed at right angles in the tibial diaphysis, were used as constant reference points to define any changes in the position of the foot (Fig. 1).

The osteotomy was performed on the dorsal surface of the talar neck, just distal to the articular surface of the talar dome, and directed toward the tarsal canal. In six specimens, the talar neck and head were secured to the talar body without the creation of a varus deformity and the subtalar motion was measured. Subsequently, a wedge measuring five millimeters at its base was removed from the medial side of the talar neck of all twelve specimens. The wedge tapered toward the lateral side so that when the osteotomy was closed it would not pivot at the center. This prevented true lengthening of the lateral side of the talus. The talar neck was secured to the body with one 0.054-inch (0.14-centimeter) Kirschner wire anteriorly (from the talar neck into the body) and two 0.08-inch (2.0-millimeter) Schantz screws directed from posterior to anterior. Loss of bone from the medial side shortened the medial column of the foot and simulated the clinical situation frequently seen with comminution and impaction of the medial side of the talus[5,34].

The change in the position of the foot was measured by recording the corresponding changes that occurred in its shadow, cast on two sheets of artist paper (Fig. 2-A). One constant light source was placed above the specimen to create a shadow in the transverse plane (Fig. 2-B) and another was placed in front of it to create a shadow in the coronal plane (Fig. 2-C). The light sources and the recording paper were placed perpendicular to the foot in both planes. The light sources were 150 centimeters from the specimen. The artist paper was seven centimeters below the specimen in the transverse plane and twenty-five centimeters behind the specimen in the coronal plane. The large ratio between the source and the recording distances decreased any distortion of parallelism that can occur when angular changes in the position of objects are measured with use of a light source or x-ray beam[14]. Rotation of the hindfoot and varus and valgus shift of the forefoot were documented before and after the osteotomy.

The degree of varus malalignment created at the talar neck was measured with use of the position of the Kirschner wire as a reference point before and after the osteotomy. Care was taken not to change the orientation of the wire in the talar neck in the coronal or sagittal plane to ensure that no rotation, flexion, or extension was incorporated into the varus osteotomy. There is no standard terminology to describe the motion and position of the foot; we used adduction to describe the position of the forefoot in the transverse plane and varus to describe its position in the coronal plane (Figs. 2-B and 2-C).

Subtalar motion was estimated by measurement of the position of the calcaneus in the coronal, sagittal, and transverse planes at the points of maximum inversion and eversion of the foot. A protractor, calibrated in 1-degree increments, was placed on the transverse and coronal surfaces of the posterior block while the foot was maximally inverted and everted. Varus-valgus alignment of the calcaneus was measured in the coronal plane (Fig. 3-A), and flexion-extension was measured in the sagittal plane (Fig. 3-B). The superiorly placed pin was used to measure motion of the calcaneus in the transverse plane. The forefoot was put through the range of maximum inversion and eversion, and the angle subtended between the described positions was expressed as internal-external rotation of the calcaneus (Fig. 3-C). Positional changes of the aluminum block were used to record the resting position of the calcaneus in the coronal and sagittal planes. Changes in the angle of declination of the first metatarsal were used to measure flexion and extension of the forefoot in the sagittal plane.

The measurements of subtalar motion obtained with the gravity-dependent protractor were evaluated for interobserver reliability with a paired t test. A Bonferroni adjustment was used to ensure a rate of type-I error of 0.05. None of the measurements were significantly different between the two observers ($p < 0.05$).

Results

The average arc (and standard error) of subtalar motion before the osteotomy was 17.2 ± 3.3 degrees (range, 11.5 to 24.0 degrees) of varus-valgus angulation in the coronal plane, 8.9 ± 2.4 degrees (range, 3.5 to 16.5 degrees) of flexion-extension in the sagittal plane, and 17.5 ± 2.9 degrees (range, 12.0 to 29.0 degrees) of internal-external rotation in the transverse plane (Table I). The arc of subtalar motion after the osteotomy without creation of a varus deformity in the six specimens was 14.8 ± 2.5 degrees (range, 11.5 to 21.0 degrees) in the coronal plane, 8.6 ± 2.0 degrees (range, 5.0 to 12.5 degrees) in the sagittal plane, and 15.3 ± 1.7 degrees (range, 12.0 to 19.0 degrees) in the transverse plane (Table I). A non-parametric test (the signed-rank test) was used to compare the values for these six specimens before the osteotomy with those after the osteotomy without creation of a deformity. The sample size of six subjects was not large enough to test for differences with use of the paired t test. There was no significant difference ($p = 0.6$ in the sagittal and transverse planes and $p = 1.0$ in the coronal plane) between the values for the six specimens before the osteotomy and those for the specimens after the osteotomy in the absence of a deformity of the talar neck (Fig. 4).

Removal of the medial wedge produced an average varus deformity of the talar neck of 17.1 ± 2.4 degrees (range, 12.5 to 21.0 degrees) (Table I). The average arc of subtalar motion decreased in all planes: to 11.7 ± 2.9 degrees (range, 7.5 to 18.5 degrees) in the coronal plane, to 6.8 ± 2.3 degrees (range, 3.5 to 12.0 degrees) in the sagittal plane, and to 11.9 ± 2.4 degrees (range, 7.0 to 20.0 degrees) in the transverse plane (Fig. 5). The decrease in motion was 32, 24, and 32 per cent, respectively. The average decrease in the subtalar arc was 30 per cent. The analysis of variance and a Tukey test for pairwise comparisons showed significant differences between the values for the specimens before the osteotomy and those for the specimens after the osteotomy with creation of a varus malalignment ($p \leq 0.001$).

There was no change in the maximum degree of varus angulation of the calcaneus in the coronal plane at the point of maximum inversion; however, at the point of maximum eversion, the calcaneus could not regain its neutral position (Fig. 6). A similar change was seen in the transverse plane: after the osteotomy, the maximum point of internal rotation increased by 4 degrees. In contrast, the point of maximum external rotation decreased by 10 degrees (Fig. 7). The varus malalignment of the talar neck placed the hindfoot in a position of varus and internal rotation at the point of maximum eversion (Fig. 8). The position of the calcaneus in the sagittal plane was not altered.

There was a strong positive linear correlation ($r = 0.90$), which was significant ($p < 0.01$), between the decrease in subtalar motion and the degree of varus deformity created at the talar neck. The varus malalignment of the talar neck was designated as the independent variable and the change in the subtalar arc, as the dependent variable. The ratios suggest that for every 3 degrees of varus produced at the talar neck there was a 1-degree loss of motion in the coronal and transverse planes. In the sagittal plane, a varus deformity of 7 degrees was needed to produce a loss of motion of 1 degree.

In the coronal plane, the calcaneus was tilted into an average of 4.8 ± 1.2 degrees (range, 2.0 to 7.0 degrees) of varus (Table I). In the transverse plane, the varus malalignment at the talar neck produced an average of 8.7 ± 2.3 degrees (range, 4.0 to 13.0 degrees) of internal rotation of the calcaneus (Fig. 2-B). In all of the specimens, the changes in the position of the forefoot followed those of the hindfoot. In the coronal plane, the forefoot tilted into an average of 5.5 ± 2.0 degrees (range, 2.0 to 9.0 degrees) of varus (Fig. 2-C). In the transverse plane, the forefoot was adducted an average of 11.5 ± 2.4 degrees (range, 6.5 to 18.0 degrees) (Fig. 2-B). The dorsomedial border of the foot, as represented by the angle of declination of the first metatarsal, was in an average of 34.3 ± 4.1 degrees of dorsiflexion before the osteotomy and 28.3 ± 5.8 degrees after the osteotomy with varus malalignment, indicating dorsal displacement in the sagittal plane (Table I).

A linear correlation analysis was performed with use of the varus deformity of the talar neck as the independent variable and the change in the position of the foot as the dependent variable, to determine the effect of the degree of varus deformity of the talar neck on the changes in the position of both the hindfoot and the forefoot. A positive linear correlation was found for all of the changes in the position of the foot. However, the correlation was only significant ($p < 0.01$) for the positional changes in the transverse plane (internal rotation of the hindfoot [$r = 0.76$] and adduction of the forefoot [$r = 0.81$]). The ratios suggest that for every 2 degrees of varus deformity of the talar neck there was 1 degree of internal rotation of the hindfoot and that for every 3 degrees of varus deformity of the talar neck there was 2 degrees of adduction of the forefoot. Adduction of the forefoot paralleled the varus malalignment of the talar neck.

At the end of each experiment, the talar body was dissected out of the ankle mortise and was examined carefully. The inferior aspect of the osteotomy site was found to extend into the tarsal canal or the middle facet but not into the posterior facet of the subtalar joint.

Discussion

Complications associated with displaced fractures of the talar neck include osteoarthrosis, avascular necrosis, arthrofibrosis, and malunion(3-7,10,15,16,18,19,24,27,28,30,32,33). There appears to be a higher prevalence of poor results associated with malunion. Canale and Kelly(4) noted malunion of eighteen of seventy-one fractures of the talar neck; fourteen of the eighteen had a varus deformity. Their patients walked with the foot in internal rotation, bearing most of the weight on the lateral border of the foot(4). A triple arthrodesis was performed in five of twelve patients who had evidence of severe degenerative osteoarthrosis of the subtalar joint, and two of these five had a poor result that was due to persistent pain in the ankle joint(4). In a series of twenty-eight fractures, Peterson et al.(28) reported a poor result for eight of nine fractures that had been inadequately reduced. Of the remaining nineteen fractures, which had been adequately reduced, eight had a poor result. Lorentzen et al.(19) identified inadequate reduction of eighteen of sixty-four displaced fractures of the talar neck; seventeen of the eighteen had a poor result. In comparison, eighteen (39 per cent) of the forty-six fractures that were adequately reduced had a poor result.

There is little additional information regarding the prevalence of varus malunion and its effect on clinical outcome. This may be due to the difficulty in recognizing varus deformity of the talar neck on standard roentgenograms(4) and to a lack of understanding of how the malalignment alters the mechanics of the foot. In the present study, removal of the wedge of bone shortened the medial column and tilted the hindfoot into varus angulation in the coronal plane and into internal rotation in the transverse plane. The unconstrained forefoot followed the positional change of the hindfoot and acquired a varus and adducted (internally rotated) position (Figs. 2-B and 2-C). The combined deformities gave the foot a c shape in the anteroposterior plane (Fig. 8). The arc of subtalar motion was decreased because the foot was locked in an inverted position. This was reflected by the fact that the arc of eversion was restricted; however, the arc of inversion was unchanged.

A varus position of the hindfoot can decrease the mobility of the forefoot and compromise the normal reciprocal relationship between the hindfoot and the forefoot(12,22). At heel-strike, when the hindfoot is in valgus, the forefoot is supple because the axes of the talonavicular and calcaneocuboid joints are parallel (11-13,16,21,22,26,31). This increases the mobility of these joints and allows the forefoot to adapt to undulating terrain. As the weight of the body shifts forward and the heel rises, the hindfoot inverts and the mid-tarsal axes lose their parallel relationship, resulting in a decrease in the mobility of the mid-tarsal joints. The midfoot becomes a rigid lever arm in preparation for toe-off. It is possible that the varus and internally rotated position attained by the hindfoot following varus malalignment of the talar neck decreases the mobility of the mid-tarsal joints and interferes with the normal reciprocal relationship between the hindfoot and the forefoot. This could explain the formation of a painful callus on the lateral border of the foot(3,4). The inability to evert the hindfoot maximally placed the foot in this inverted position and could have been a result of the navicular following the medial deviation of the talar head. The rotational capacity of the talonavicular joint is greater than that of any other tarsal articulation(20,26), and any restriction in the arc of motion of this joint influences the entire tarsal mechanism. Other factors that could account for the decreased subtalar motion are an alteration in the direction of the fibers of the interosseous talocalaneal ligament or a change in the orientation of the subtalar articular facets as a result of the varus deformity.

The degree of displacement at the talar neck that can result in increased morbidity and the guidelines to define an acceptable reduction have been areas of controversy[29]. Some studies have suggested two millimeters as the maximum acceptable malalignment[2,36]. In the past, an acceptable reduction of the talar neck was considered to be less than five millimeters of displacement and 5 degrees of varus[4]. King and Powell[16] suggested that anything less than an anatomical reduction is an indication for operative intervention. In the present study, the width of the medial wedge that was removed from the talar neck was approximately five millimeters and this produced an average varus deformity of 17.1 degrees (range, 12.5 to 21.0 degrees). The linear correlation analysis indicated a direct correlation between the degree of varus malalignment of the talar neck and the change in the subtalar motion and position of the foot. With the malalignment of the talar neck created in the transverse plane, the motion that was maximally affected was subtalar rotation and the maximally affected positions were internal rotation of the hindfoot and adduction of the forefoot. This suggests that the more anatomical the reduction of the talar neck the less the subtalar motion and position of the foot are adversely affected.

We did not measure subtalar motion with stereophotogrammetric roentgenographic analysis[35]; however, our values are similar to those reported in other studies. Gellman et al.[8] reported an average varus-valgus arc of 19 degrees in the coronal plane, with the ankle joint immobilized in the neutral position. Lundberg et al.[20] noted that the calcaneus flexed approximately 10 degrees on the talus in the sagittal plane, and Van Langelaan[35] reported that the average rotation in the transverse plane was 23.6 degrees. Although the latter figure is greater than that found in the present study (11.7 degrees), the ranges of values in the two reports are similar (15.8 to 30.0 degrees and 12.0 to 29.0 degrees).

Since the mid-1970's, there has been an increased tendency to treat displaced fractures of the talar neck with open reduction and internal fixation[5]. The placement of fixation has varied, and medial, lateral, and posterolateral approaches have been advocated[1,9,22,34]. We suggest caution when compressive fixation is used in the medial column of the talus, especially in the presence of medial comminution, as excessive compression could itself create a varus deformity. The personal experience of the senior one of us (J. W. S.) has been that the varus deformity of the forefoot is hard to correct even with a triple arthrodesis, as coaptation of the talar head and the navicular necessitates medial translation and rotation of the forefoot, thereby maintaining the forefoot in a varus position. This problem could be circumvented by shortening of the lateral column or lengthening of the medial column with an opening-wedge osteotomy of the talar neck. Although this results in correction at the site of maximum deformity, caution is advised because the blood supply to the talar body could be jeopardized.

Our study shows that varus malalignment of the talar neck shortens the medial column and locks the hindfoot in varus and internal rotation. We found a direct linear correlation between the degree of varus malalignment of the talar neck and the change in the position of the foot and in subtalar motion; thus, we emphasize the importance of an anatomical reduction of fractures of the talar neck.

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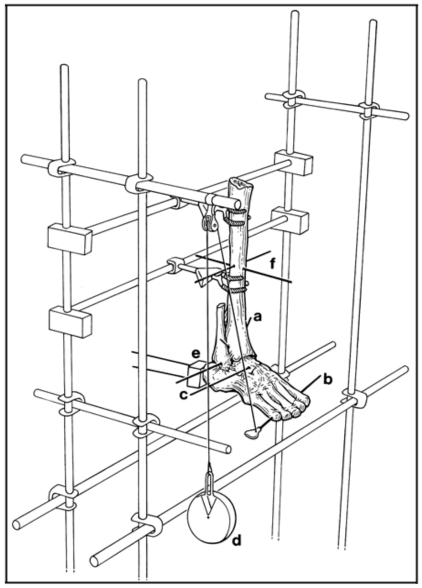
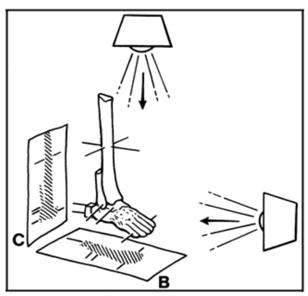
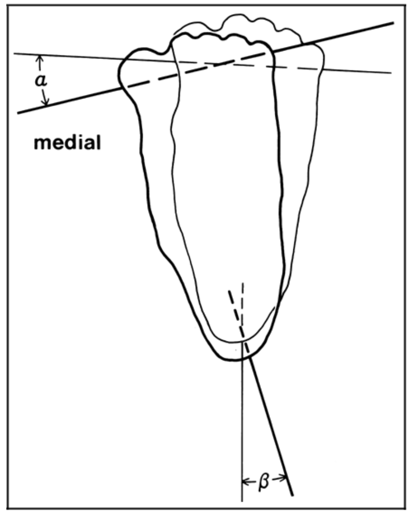


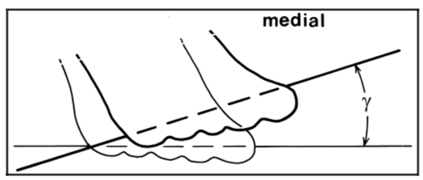
Illustration of the specimen in the frame. a = the Steinmann pins immobilizing the ankle joint, b = the Steinmann pin in the metatarsals, c = the Kirschner wires in the talar body and neck, d = the weight attached to the transmetatarsal pin, e = the aluminum block secured to the posterior aspect of the calcaneus, and f = the Steinmann pins in the tibial diaphysis that were used as reference points.



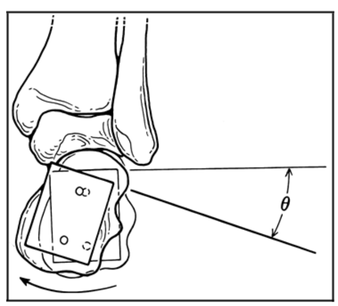
Figs. 2-A, 2-B, and 2-C: Illustrations showing how changes in the position of the foot were measured. Fig. 2-A: Light sources were placed above and in front of the specimen.



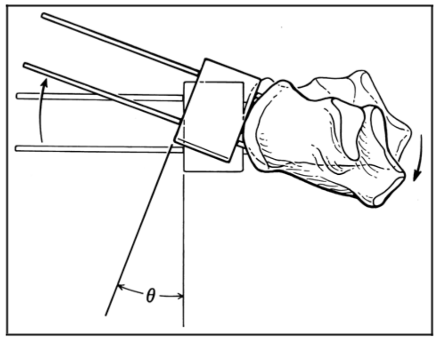
The shadows in the transverse plane before and after the osteotomy. α = the angle of adduction of the forefoot and β = the angle of internal rotation of the calcaneus after the osteotomy.



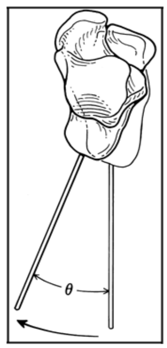
The shadows in the coronal plane before and after the osteotomy. γ = the varus deformity of the forefoot after the osteotomy.



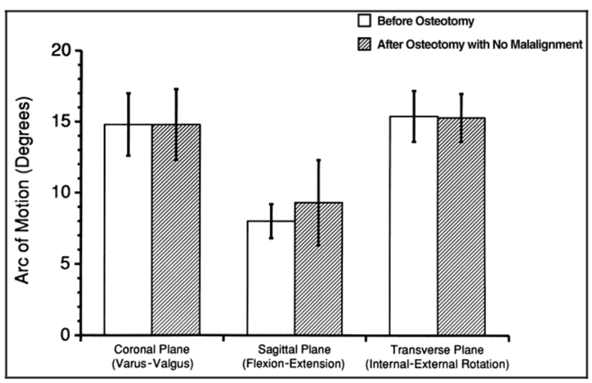
Figs. 3-A, 3-B, and 3-C: Illustrations showing how the gravity-dependent protractor was used to measure movement of the calcaneus at the subtalar joint. Fig. 3-A: To measure varus-valgus motion in the coronal plane, the protractor was placed on the superior surface of the aluminum block while the subtalar joint was maximally inverted and everted. θ = varus-valgus arc of subtalar motion in the coronal plane.



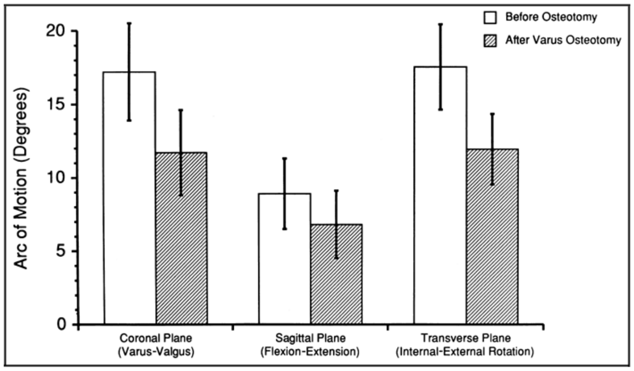
To measure internal-external rotation in the transverse plane, the change in the position of the superiorly placed pin from maximum inversion to maximum eversion of the subtalar joint was noted. θ = internal-external rotation arc of subtalar motion in the transverse plane.



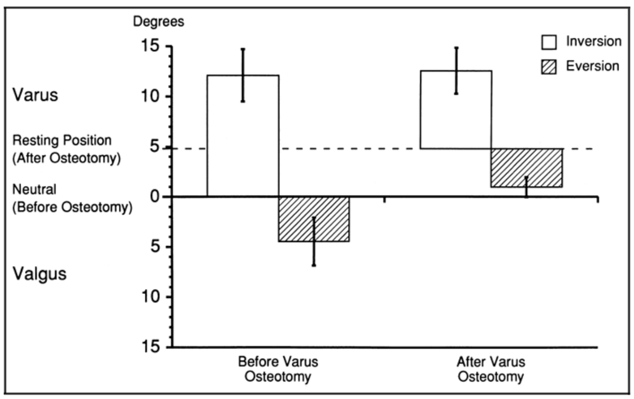
To measure flexion-extension in the sagittal plane, the protractor was placed on the frontal surface of the block while the subtalar joint was maximally inverted and everted. θ = flexion-extension arc of subtalar motion in the sagittal plane.



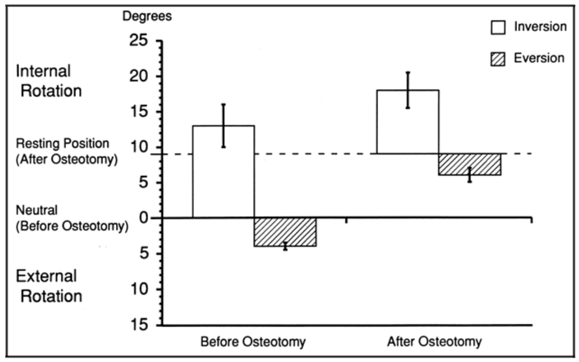
Graph demonstrating no significant difference between the average arcs of subtalar motion before and after the osteotomy without varus deformity. The I-bars indicate the standard error.



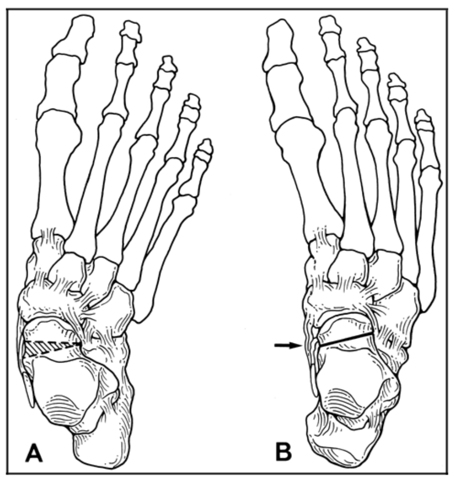
Graph demonstrating significant ($p \leq 0.01$) differences between the average arcs of subtalar motion in all planes before and after the osteotomy with varus deformity. The I-bars indicate the standard error.



Graph of the maximum degree of varus and valgus angulation of the calcaneus before and after the osteotomy with varus deformity. The resting position indicates the varus shift of the calcaneus after the osteotomy. The maximum varus deformity during inversion did not change. During eversion, the calcaneus could not return to the neutral position in all specimens. The I-bars indicate the standard error.



Graph of the maximum internal and external rotation of the calcaneus before and after the osteotomy. The resting position indicates internal rotation of the calcaneus produced by the varus malalignment of the talar neck. The maximum internal rotation during inversion increased after the osteotomy; however, the calcaneus could not be rotated externally to its neutral position at the point of maximum eversion. The I-bars indicate the standard error.



Illustrations of the normal position of the foot before the osteotomy (*A*) and the position after the osteotomy (*B*). After the osteotomy, the hindfoot and forefoot are inverted and shortening of the medial column has brought the calcaneus beneath the talus. The forefoot is adducted and tilted into varus malalignment, and the foot is c-shaped. The tibionavicular and tibiotalar portions of the deltoid ligament are lax (arrow).

TABLE I
DATA ON THE SPECIMENS*

	Before Osteotomy				
	Arc of Subtalar Motion				
Specimen	Varus-Valgus	Flex.-Exten.	Int.-Ext. Rotation	Angle of Declination of 1st Metatarsal‡	Varus-Valgus
1	19.5	10.5	18.5	NA	
2	14.5	10.5	15.5	43.0	14.0
3	21.5	16.5	29.0	35.0	
4	19.5	10.5	20.0	25.0	
5	24.0	7.5	19.0	NA	
6	18.0	10.5	14.5	28.5	
7	14.5	3.5	16.0	30.5	
8	20.5	9.0	18.0	36.5	21.0
9	15.0	6.5	18.0	37.5	15.5
10	15.5	8.0	14.0	40.0	15.5
11	12.0	6.0	15.0	34.0	11.5
12	11.5	8.0	12.0	33.5	11.5
Average (and standard error)	17.2 ± 3.3	8.9 ± 2.4	17.5 ± 2.9	34.3 ± 4.1	14.8 ± 2.5

*All values are given in degrees.
†A blank space indicates a specimen for which only an osteotomy with varus deformity was performed.
‡NA = data were not obtained from the specimen.

Flex.-Exten.	Int.-Ext. Rotation	Angle of Declination of 1st Metatarsal‡	Varus-Valgus
			9.5
10.5	15.0	NA	11.0
			18.5
			12.0
			15.5
			12.0
			9.5
12.5	16.0	34.5	18.0
7.0	19.0	36.0	9.5
8.0	14.0	40.0	9.0
5.0	16.0	32.5	7.5
8.5	12.0	32.5	8.0
8.6 ± 2.0	15.3 ± 1.7	35.1 ± 2.3	11.7 ± 2.9

Int.-Ext. Rotation	Angle of Declination of 1st Metatarsal‡	Varus Deform. of Talar Neck	Change in Varus of Hindfoot
10.5	NA	18.0	7.0
15.0	43.5	14.0	3.0
20.0	27.0	20.0	5.5
15.0	18.5	18.5	4.0
14.0	NA	12.5	5.5
10.0	23.5	18.5	5.0
8.0	23.5	21.0	6.5
12.0	31.0	18.0	3.5
9.5	32.5	20.0	6.5
11.5	35.0	16.0	4.5
10.0	26.0	14.0	4.5
7.0	22.5	15.0	2.0
11.9 ± 2.4	28.3 ± 5.8	17.1 ± 2.4	4.8 ± 1.2

Adduct. of Forefoot‡	Int. Rotation of Calcaneus‡
NA	NA
6.5	4.0
12.0	10.0
11.0	10.0
7.5	5.5
14.0	10.0
18.0	13.0
13.5	10.0
13.0	10.0
11.5	9.0
10.0	9.5
9.0	4.5
11.5 ± 2.4	8.7 ± 2.3