CHAPTER **32**

REARFOOT AND ANKLE DEGENERATION FOLLOWING MALPOSITIONED ARTHRODESIS

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Malalignment of a major rearfoot joint or joints following injury or arthrodesis requires compensation for motion at adjacent joints. Often, the next proximal or distal joint is required to function at or near its end range of motion. If the amount of motion necessary to compensate for the malalignment exceeds the available range of motion in the next adjacent joint, then additional compensation will occur at each joint that is in line with the direction of the deformity. This cascade of compensation will continue until one of two events occurs: complete compensation will be afforded to the deformity, or there will be a degree of residual deformity that is unable to be compensated for and the joint will forcefully and repetitively jam at its end range of motion.

Increased motion in the direction of the deformity occurs at adjacent joints until the available motion is fully utilized. When there is not enough reserve motion, the joint will function at its end range of motion. Repetitive function of a joint at its end range of motion will produce degenerative changes (arthritis), usually over a relatively short period of time.

The acceptable amount of residual deformity depends on the amount of motion that is available in the direction of the acquired deformity. This varies greatly depending on which joint(s) was fixed, and to what degree its motion was contributing to functional gait. Restricting motion in a joint with a relatively large range of motion (such as the ankle joint) will require more compensation from adjacent joints than will a joint with relatively little motion (such as the 2nd metatarsocuneiform joint). Likewise, a malpositioned joint with a large range of motion will have a more significant effect on adjacent joints if they are unable to compensate for the lost or altered motion.

ANKLE JOINT COMPENSATION

The ankle joint has a relatively large range of motion, nearly all of which occurs in the sagittal plane. With a large range of available sagittal plane motion, the ankle joint has a generous capacity to compensate for sagittal plane malalignments in proximal and distal joints or segments. For example, a pes cavus foot with purely sagittal plane contracture relies upon the ankle joint for compensation. In most instances, the ankle has more motion available than is required by the foot contracture. Thus, most pes cavus deformities are well-compensated for at the level of the ankle joint, with infrequent degeneration of the ankle joint. Similarly, a malunited tibia fracture, with a residual sagittal plane deformity (procurvatum or recurvatum), will be well-compensated for in the ankle joint, often to the magnitude of 30 degrees of deformity. At the level of the knee, sagittal plane contractures, such as occur in spastic cerebral palsy, often compensate well at the level of the ankle joint.

ANKLE ARTHRODESIS MALALIGNMENT AND EFFECT ON REARFOOT

The ankle joint is responsible for the majority of sagittal plane motion below the knee. Therefore, restriction of ankle joint motion through arthrodesis will have a significant effect on sagittal plane compensation. The position of fusion then becomes critically important with regard to function in gait, and the ability of adjacent joints to compensate for even a slight malposition in the sagittal plane. The subtalar and midtarsal joints have little available sagittal plane motion, and thereby little ability to compensate for a plantarflexed or dorsiflexed position of fusion. Degenerative arthritis of the rearfoot (subtalar and midtarsal joints) is a frequent sequela of sagittal plane malposition of an ankle fusion. Regardless of patient activity level or footwear choice, the correct sagittal position for an ankle arthrodesis is with the foot 90 degrees to the leg. Deviation from this position, even to a slight degree, will require compensation beyond that which is available within the foot.

FRONTAL PLANE COMPENSATION

In contrast to sagittal plane motion, the ankle joint has relatively little frontal plane motion, and will not tolerate a great degree of frontal plane deformity which is imposed upon it. Frontal plane foot deformities, such as forefoot varus, which are uncompensated for within the foot can impart frontal plane torque on the ankle joint. With little available frontal plane motion, there is also limited ability within the ankle to compensate for external frontal plane deformities. An example of a frontal plane structural foot deformity leading to ankle degeneration is that seen in residual clubfoot. Incompletely-reduced or non-reduced varus from within the foot will attempt compensation in the ankle joint, leading to accelerated degenerative arthritis. Likewise, uncompensated valgus foot deformities, such as that encountered with Charcot-Marie-Tooth disease, lead to lateral ankle instability and eventual degenerative arthritis

Varus or valgus malposition of an ankle arthrodesis will also transmit forces into the foot, which can tolerate a mild degree of deformity. Mild ankle valgus will lead to supination of the rearfoot and medial column, and is generally well-tolerated. Ankle varus is less tolerated, since the rearfoot and lateral column have less inherent motion in the direction of pronation, and one less joint than the medial column of the foot.

ANKLE EQUINUS

The most frequently encountered sagittal plane malalignment following an ankle arthrodesis is residual equinus. This complication occurs either intra-operatively, with poor positioning at the time of surgery, or postoperatively, with the foot drifting into equinus prior to complete osseous consolidation. Intra-operative malposition may occur due to inaccurate visualization of the desired position.

A contracted Achilles tendon may also contribute to residual equinus. Soft tissue equinus which is encountered during surgery will add resistance to positioning the foot at a right angle to the leg. Thus, the intended position of the ankle fusion may never be achieved at the time of surgery. Following surgery, static (and often dynamic) resistance from the Achilles tendon will promote equinus drift at the arthrodesis site. When internal fixation hardware is poorly positioned across the ankle joint, there is little resistance to the Achilles tendon, which acts like an additional point of fixation. Since the Achilles tendon passes external to the joint, its force upon the joint is often greater than the resistance being afforded through the fixation hardware. Thus, centrally- or posteriorly-positioned hardware, in combination with a tight heel cord, can lead to equinus drift of the arthrodesis site, and possible malunion or non-union of the ankle joint.

Rearfoot pronation occurs through the subtalar and midtarsal joints when the ankle is dorsiflexed in an attempt to gain position during the arthrodesis procedure. Although the ankle may visually appear to be at a right angle to the leg, some of the position is attributed to pronation within the foot. When the range of motion of the rearfoot is utilized to gain dorsiflexion, there is little reserve motion for compensation. Following arthrodesis of the ankle in these patients, the rear-foot must maximally pronate with each step to gain a plantigrade foot position. Thus, there is little reserve motion within the subtalar and midtarsal joints to compensate for uneven terrain, since the joint is constantly functioning at its end range of motion. Davis and Millis reported a 56% incidence of subtalar joint limitation following ankle arthrodesis,[1] while Ahlberg and Henricson noted long-term pain in the subtalar joint in two-thirds of their patients.[2] Because there is a narrow degree of available sagittal plane motion from the subtalar-midtarsal complex, it is critical to position the ankle independent of, and without compromising, the rearfoot complex.

A well-positioned ankle fusion has reserve motion for both dorsiflexion and plantarflexion within the foot.[3] This primarily occurs at the subtalar and midtarsal joints (Figs. 1A-1D).

Residual equinus following ankle arthrodesis will lead to pronation of the rearfoot and early degenerative arthritis. Early repair of such a complication through revision arthrodesis of the ankle joint can be attempted to prevent degenerative arthritis of the rearfoot, and obviate the need for additional surgery. A triple arthrodesis is often required to gain a plantigrade foot once degenerative changes have occurred in the rearfoot following ankle arthrodesis (Figs. 2A-2E).

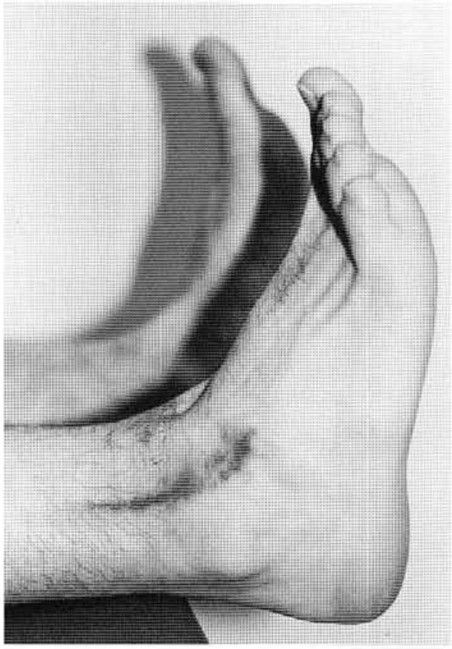

Figure 1A. Well-positioned ankle fusion, demonstrating active dorsiflexion.

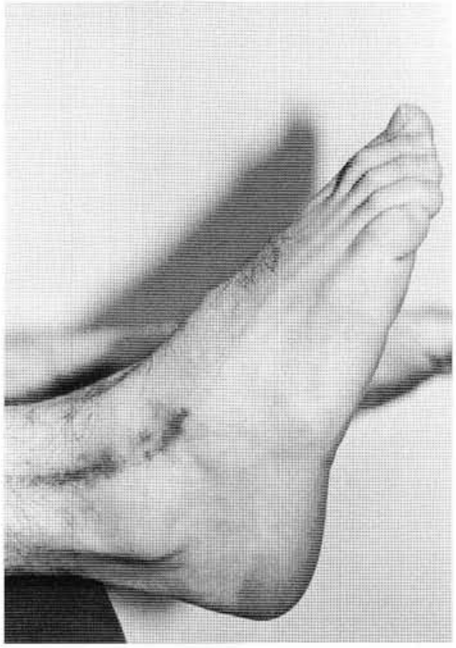

Figure 1B. Active plantarflexion following ankle arthrodesis.

Figure 1C. Lateral projection radiograph demonstrating neutral position arthrodesis in the sagittal plane.

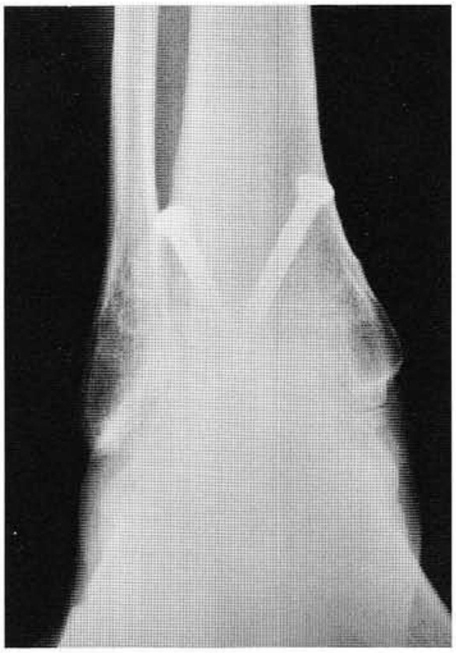

Figure 1D. Anterior-posterior projection radiograph demonstrating neutral position arthrodesis in the frontal plane.

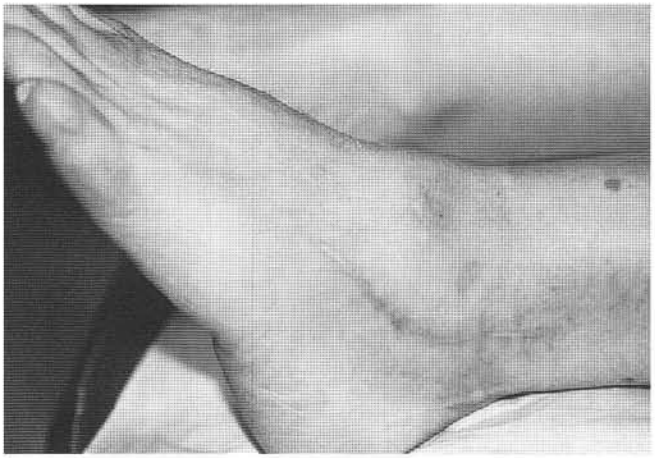

Figure 2A. Lateral view of ankle arthrodesis with severe residual equinus.

Figure 2B. Compensation for ankle equinus through rearfoot pronation and forefoot abduction.

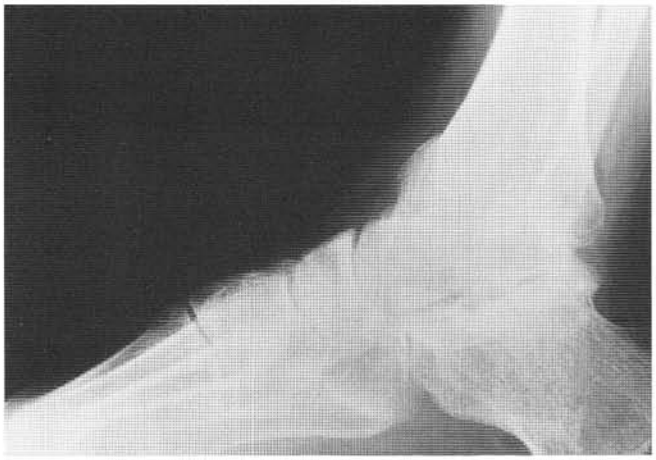

Figure 2C. Lateral projection radiograph with the foot in a position of comfort. Note the position of the leg in relation to the foot, and a visibly open subtalar joint.

Figure 2D. Lateral projection radiograph with the leg vertical, and the weight equally distributed on each foot. Note the change in position of the leg to the foot, and occlusion of the subtalar joint secondary to compensatory pronation.

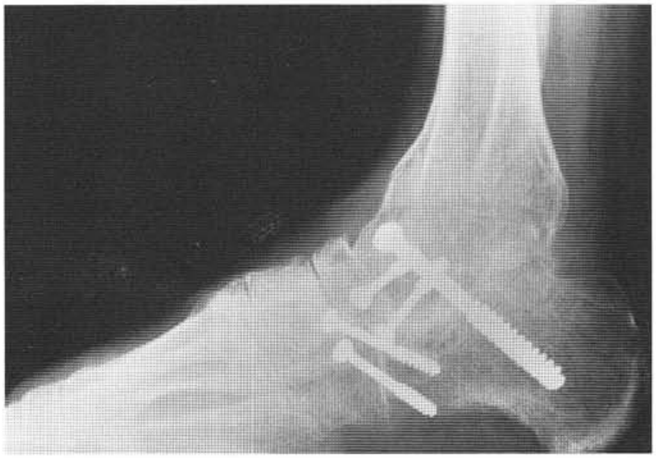

Figure 2E. View following triple arthrodesis with dorsal wedging of the midtarsal joint to compensate for residual ankle equinus.

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1. Davis R, Mills M: Ankle arthrodesis in the management of traumatic ankle arthrosis: a long-term retrospective study. *J Trauma* 20:674-678, 1980.
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3. Mahan KT: Ankle and Pantalar Fusion. In McGlamry Ed, Banks AS, downey MS, eds. *Comprehensive Textbook of Foot Surgery*, 2nd ed. Baltimore, Md: Williams & Wilkins; 1992: 1076-1091.