RECONSTRUCTION OF ANKLE FRACTURE MALUNION

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INTRODUCTION

Fractures of the ankle lead to chronic disability depending on the degree of displacement of the osseous fragments and the extent of ligamentous damage. In most instances, the degree of morbidity is directly proportional to the quality of fracture reduction and the overall repair process, whether treated by closed or open means. The purpose of this paper is to identify which fractures are associated with increased morbidity, and to impress upon the reader that early repair of these fractures can prevent long term disability.

HISTORICAL REVIEW

Until the mid 1930's most ankle fractures were treated via closed methods. It was not until 1936, when Speed and Boyd[1] reviewed their results that the operative means of treating ankle fractures was placed in its proper perspective. Since casting results were especially poor in bimalleolar and trimalleolar fractures, they identified that "some type of open operative reconstruction is required."

Ramsey and Hamilton[2] studied 23 amputated lower extremity specimens for tibio-talar contact after removal of all soft tissues and the lateral malleolus. They found a 42% mean decrease of tibio-talar contact with 1 millimeter of lateral talar displacement. An additional 14% loss of tibio-talar contact was noted with displacement between 1-2 millimeters, and a further 3% deficit of tibio-talar contact at 4-6 millimeters of lateral displacement. Therefore, a decrease in the tibio-talar surface contact results in increased stress per unit area, which may be a factor contributing to increased morbidity following ankle fractures or dislocations when anatomic reduction is not achieved.

A review of the Lauge-Hanson[3,4,5] classification of ankle fractures will indicate that the talus follows the plane of displacement of the fibula (Fig. 1A,B & 2A,B) due to the preservation of the lateral collateral ligament attachments between the fibula and the talus. Obviously, this lateral talar shift is predicated upon two factors: loss of the lateral buttress due to fracture or ligamentous destruction, and compromise of the deltoid ligament or medial malleolar fracture.

Joy, et.al.,[6] identified that Supination-external rotation IV; Pronation-external rotation IV; and Pronation-abduction III fractures (where fractures of the fibula and rupture of the syndesmotic ligaments occur), allow the greatest percentage of lateral shift of the talus on the tibia, and therefore, are associated with the highest degree of morbidity.

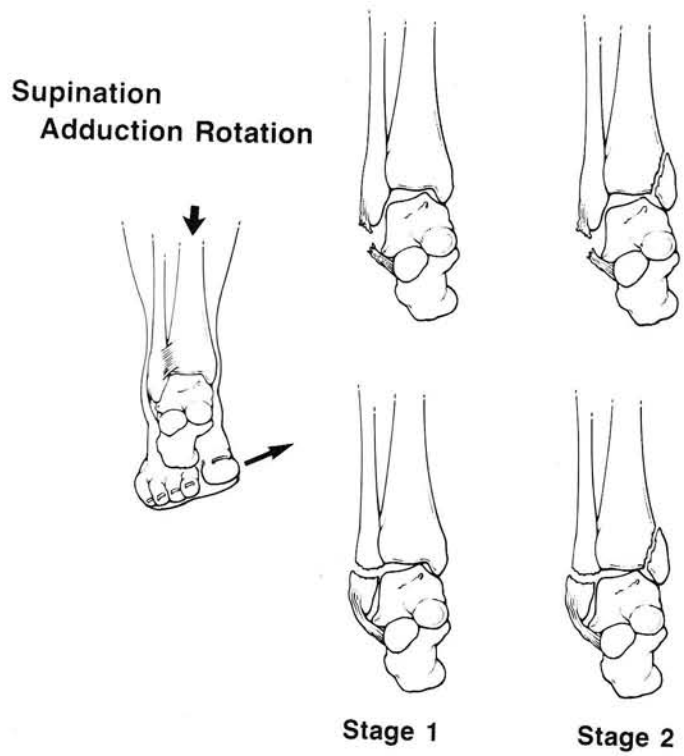

Fig. 1 A,B and 2 A,B show modified Lauge-Hansen ankle fracture classification. Thick arrow shows direction of injuring forces. Stages show progression of severity of injury. Each listed grade (I-IV) indicates structure(s) injured in addition to one or more previously listed lower grades. *Modified from artwork by S. Howard in Petrone et.al. J Bone Joint Surg 65A:668-669, 1983.*

Fig. 1A. Supination-Adduction fracture (SA).
Stage I - Tear of anterior talofibular and calcaneofibular ligaments or avulsion fracture of lateral malleolus at or below level of ankle joint.
Stage II - Near vertical fracture of medial malleolus.

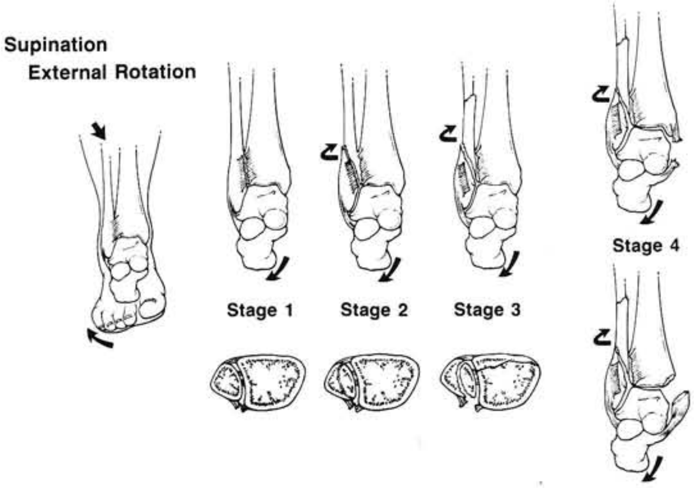

Fig. 1B. Supination-External Rotation fracture (SER).
Stage I - Rupture of anterior tibiofibular ligament.
Stage II - Spiral oblique fracture of lateral malleolus.
Stage III - Fracture of posterior tibial margin.
Stage IV - Rupture of deltoid ligament or fracture of medial malleolus.

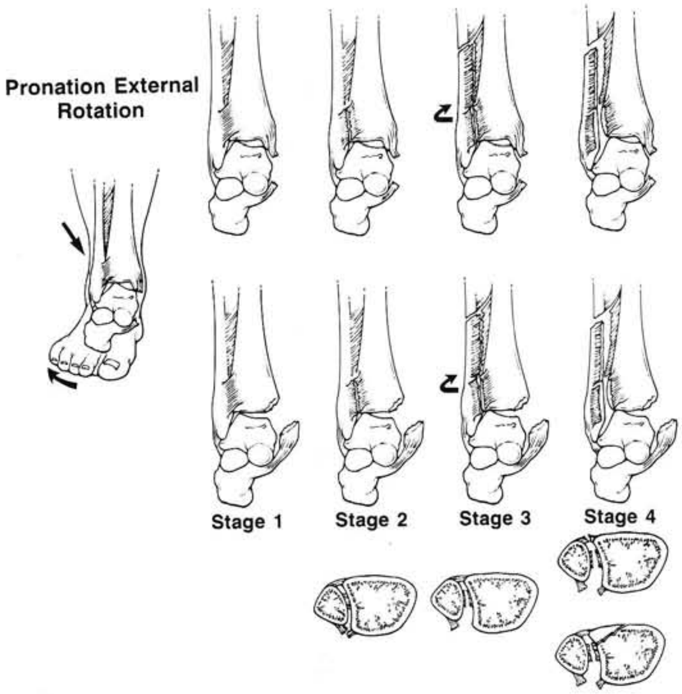

Fig. 2A. Pronation-External Rotation fracture (PER).
Stage I - Rupture deltoid ligament or fracture medial malleolus.
Stage II - Rupture anterior tibiofibular ligament and interosseous membrane.
Stage III - Short spiral oblique fracture of fibula, 6-8 cm. proximal to ankle joint, but can be higher.
Stage IV - Fracture of posterior tibial margin or rupture of posterior tibiofibular ligament.

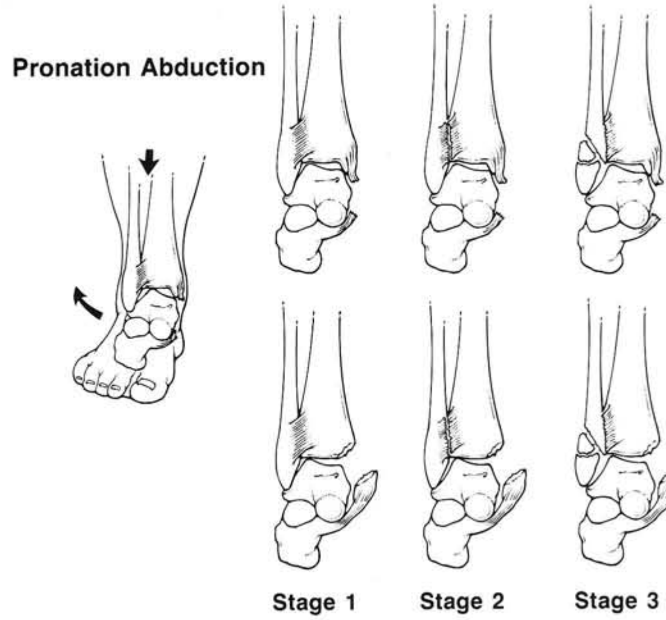

Fig. 2B. Pronation-Abduction fracture (PA).
Stage I - Fracture medial malleolus or rupture of deltoid ligament.
Stage II - Rupture of anterior and posterior tibiofibular ligaments.
Stage III - Bending fracture of fibula slightly proximal to ankle joint, often associated with displaced triangular fragment from lateral surface of the fibula.

ROENTGENOGRAPHIC EXAMINATION

X-ray evaluation of the normal ankle in the mortise view will demonstrate that the distance between the lateral aspect of the medial malleolus and the medial aspect of the talus (clear space) is normally 2 millimeters. This distance corresponds to the thickness of the contiguous articular surfaces at this level. In ankle fractures where the lateral malleolus has been fractured and/or tibio-fibular diastasis is present, lateral shift of the talus may occur with medial joint compromise. With severe injuries (Supination-external rotation IV; Pronation-external rotation IV; and Pronation-abduction III), obvious lateral displacement of the fibula may be evidenced as an increase in the radiographic clear space at the medial ankle. However, many times the talus may spontaneously reduce into an anatomic position despite this loss of integrity. In patients with supination-external rotation injuries, it is very important to rule out rupture of the deltoid ligament. Compromise of this structure results in total instability of the ankle mortise, regardless of the alignment demonstrated on radiographs.

Reduction of ankle fractures should attempt to recreate and maintain a clear space of less than 3 millimeters and can best be accomplished by exact realignment of the lateral malleolus and stabilization of the syndesmosis. This is very difficult to accomplish via closed reduction methods. Even with open reduction and internal fixation of these fractures, less than perfect technique can result in a clear space that has not been appropriately reduced. Therefore, it becomes incumbent upon the clinician to critically evaluate the reduction radiographically. Any residual lateral instability may cause incongruity of the tibio-talar joint with the potential for degenerative joint disease. Widening of the clear space can serve as a barometer to determine whether open or closed reduction is best, and as a predictor of potential complications.

Evaluation of the lateral malleolus for shortening should be performed for the same reasons (Fig. 3A,B). Soft tissue tension about the fracture site results in bayonetting of the distal fragment on the more stable proximal fibula. Bauer, et. al.,[7] in a 30-year follow-up study of 2,254 ankle injuries, 143 of which were followed for 29 years, found that a 2 millimeter posterior displacement of the distal fracture fragment was compatible with an acceptable result long term. Displacement of this degree could be easily treated via closed reduction methods and a below-knee weight bearing cast for 6 weeks. These findings are consistent with the studies of Vasli,[8] Burwell,[9] and Phillips, et. al.[10]

Posterior malleolar fragments which compose greater than 25% of the distal tibial articular surface may produce a "step defect" if not adequately reduced. Poor alignment in this area can similarly result in the potential for later degenerative joint disease.

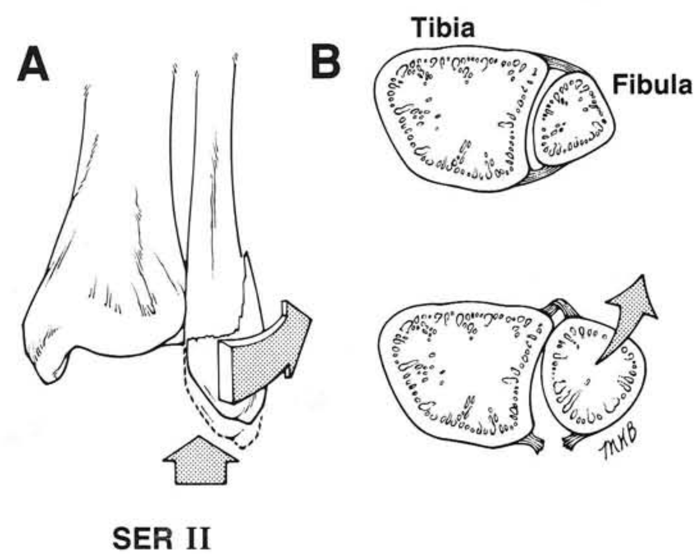

Fig. 3A. As distal fibular fragment displaces posteriorly, it also shortens. **Fig. 3B.** Wider distal portion of fibula has displaced superiorly. Note tear of anterior tibiofibular ligament.

Phillips, et. al, have devised an anatomical scoring system to assist in quantifying radiographic values for normal and abnormal ankles (Fig. 4). They found that the talo-crural angle was a reproducible indicator of fibular length (Fig. 5). Two values have been assigned by Pettrone, et. al.,[11] to determine integrity of the tibio-fibular syndesmosis: (a) the width between posterior-lateral tibia and the medial border of fibula should not be greater than 5 millimeters on the anterior-posterior ankle view, (b) tibio-fibular overlap between medial border of fibula and lateral most projection of posterior malleolus should not be greater than 10 millimeters (Fig. 4) on the anterior-posterior ankle view.

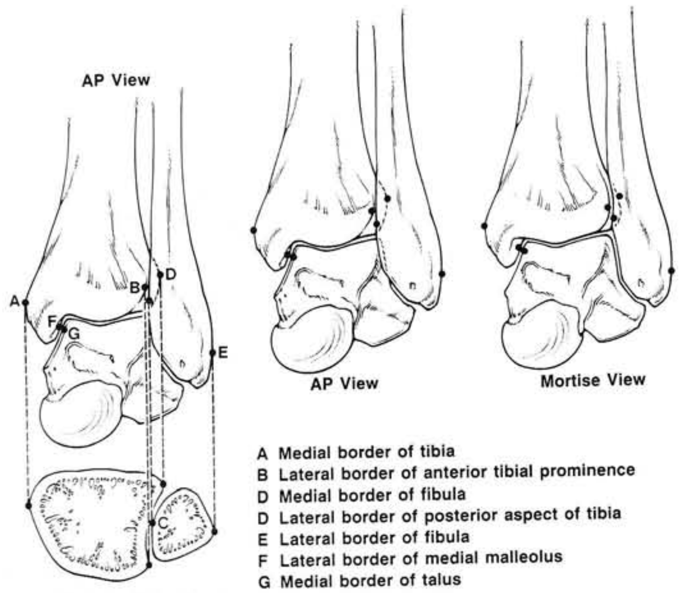

Fig. 4. Anatomical landmarks and values for evaluating integrity of the ankle.

A. Medial border of tibia.
B. Lateral border of anterior tibial prominence.
C. Medial border of fibula.
D. Lateral border of posterior aspect of tibia.
E. Lateral border of fibula.
F. Lateral border of medial malleolus.
G. Medial border of talus.

ACCEPTABLE VALUES FOR ANKLE INTEGRITY.

		X-RAY VIEW
1. Medial clear space(F-G)	4 mm.	Anterior-Posterior
2. Medial Malleolar displacement	2 mm.	Anterior-Posterior
3. Integrity of tibiofibular syndesmosis		
a. C-D	5 mm.	Anterior-Posterior
b. B-C (tibiofibular overlap)	10 mm.	Anterior-Posterior
c. B-C (tibiofibular overlap)	1 mm.	Mortise
4. Lateral malleolar displacement	2 mm.	Mortise
5. Lateral malleolar shortening	2 mm.	Lateral
6. Size of posterior malleolar fracture	25%	Lateral
7. Talar tilt	2 mm.	Mortise
8. Talar subluxation	Absent	
9. Anterior medial corner (continuity of articular surface)	Present	

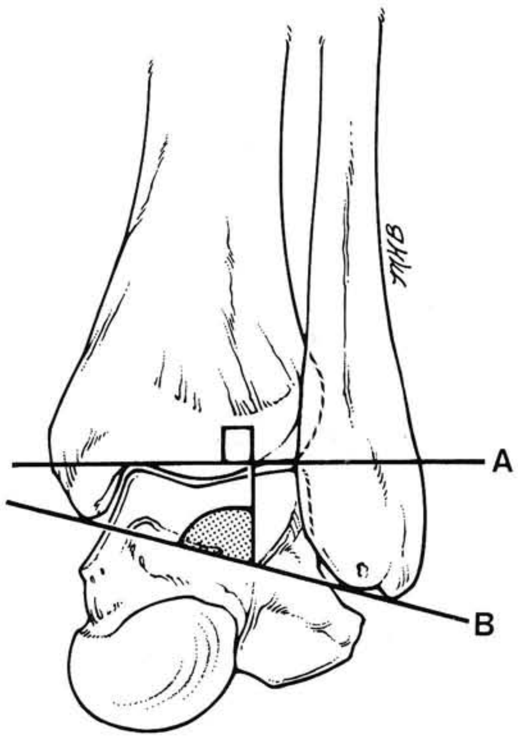

Fig. 5. Talo-crural angle

Used to determine amount of fibular shortening. Angle is found by drawing line parallel with distal tibial surface (A), and another line connecting the distal borders of the fibular and tibial malleoli(B). A line perpendicular to line "A" is extended to cross line "B". This latter intersection (shaded area) is the talo-crural angle.

As wear and tear continues in poorly reduced ankle fractures, radiographic evidence of osteophytic lipping and joint narrowing become obvious. The medial malleolus should be evaluated for fracture and shifts in any plane. Fractures of the medial malleolus below the ankle joint and tears of the anterior tibio-talar portion of the deltoid ligament alone do not cause significant changes in the tibio-talar articulation. When the medial clear space is greater than 4 millimeters, complete tear of the deep portion of the deltoid ligament should be suspected. Ten millimeters or greater, indicate deep deltoid tear along with tear of tibio-fibular ligaments and/or fracture of the fibula.

Transchondral fractures of the talar dome may not be obvious. Detection may be difficult without the assistance of CT scanning and tomography. If the fracture is in an area where tibio-talar articular degeneration can occur, the fracture should be addressed surgically.

Any evidence of the above early signs in radiographic evaluation of any ankle fracture should make the clinician suspicious of potential complications and appropriate reconstructive measures entertained.

SIGNS AND SYMPTOMS

Patients that have had closed reduction of Supination-external rotation IV, Pronation-external rotation IV, and Pronation-abduction III, or less than optimum open reduction where exact anatomic realignment has not been accomplished, may start to have symptoms related to the condition 3-12 months after the initial injury. Evening pain is found early in degenerative disease as a result of muscle splinting, ligamentous strain, and incongruous joint function. Edema is usually mild in early stages, yet becomes worse as the pathological state continues. Limitation of motion, guarded at first, can lead to a frank limp and hesitancy on the part of the patient to use the extremity. A grating sensation and audible snaps and clicks are heard as degenerative joint disease, osseous hypertrophy, and synovitis progress. Clinical examination in stance may reveal a valgus foot as a result of lateral shift of the talus, or from shortening and lateral rotation of the fibula.

Symptoms along the medial arch and midfoot similar to those of flatfoot conditions may be voiced by the patient. Tenosynovitis of the tibialis posterior is not uncommon. This "traumatic pronation" leads to development of forefoot pathologies (hallux abducto valgus, hammertoes, hyperkeratoses, etc.) from breakdown of the ankle, midtarsal and Lis Franc joints.

TREATMENT

Initial treatment is directed at diminishing "stiffness" and associated musculoskeletal discomfort. NSAIDS and other analgesics are helpful. An effort should also be made to protect the foot and extremity from deleterious effects of the "valgus" position. At times we have had good results with custom molded orthotics. Assisted walking with canes, crutches, etc., may be appropriate on occasion. However, when none of the above measures are helpful, ankle joint arthroplasty and arthrodesis have been standard forms of therapy. It is, therefore, imperative that the ankle pathology be evaluated and early treatment taken to avoid this long term disability.

Little attention has been focused on surgical reconstruction and salvage of malaligned malleolar fractures of the ankle. Usually, surgical intervention has been reserved for patients with frank arthrosis and pain. This may be due to a less than adequate understanding of functional anatomy of the ankle joint, or little experience and success with fixation methods and postoperative rehabilitation. However, current methods of osteosynthesis and a more advanced understanding of biomechanics and anatomy of the lower extremity are now available. Excellent success with "accelerated" postoperative fracture care can now be used to minimize some of the high failure rates reported in the literature. Speed and Boyd in 1936 identified the positive attributes of fibular osteotomy as an effective means of restoring length and derotation in ankle fracture malaligment. It was not until the mid-1970's,[12] and early 1980's[13, 14] that encouraging results were published regarding the later repair of poorly reduced ankle fractures. Further attention was directed towards this subject by later authors. In 1989, Yablon, et. al.,[15] reported in a seven-year follow up study that 20/26 patients resumed pre-injury levels of activity following repair of malunited ankle fractures. Yablon identified two types of ankle malunion by radiographic appearance. In "occult malunion" the talus remained in its normal position. The lateral malleolus was shortened and externally rotated. "Overt malunion" had lateral talar displacements with similar lateral malleolar changes.

This author believes that the podiatric physician need not wait for symptoms to appear before corrective reconstructive surgery for poorly reduced ankle fractures is attempted. If one can appreciate greater than 2 millimeters of displacement of the distal fibular fragment and/or lateral rotation of the fibula, then open reduction with internal fixation should be considered to regain enhanced reduction. In spite of the time which may have elapsed since the injury, if cartilage remains on the tibial, fibular, and talar articular surfaces, open reduction would seem to be an appropriate treatment plan so as to avoid future predictable sequelae.

SURGICAL RECONSTRUCTION

The aim of surgical reconstruction is to obtain a functional and pain-free range of motion of the affected ankle. Generally speaking, this necessitates restoring alignment and reducing displacement of the fibula. The degree and type of surgery will depend on the amount of talar displacement, the degree of lateral fibular shortening and external rotation, and whether or not the medial malleolar fragment or deltoid ligament has been realigned or repaired. Indications for surgery include the following: a. Malposition identified on x-ray, b. demonstrable increased joint space (medial clear space) visible on the anterior-posterior and mortise ankle views and c. presence of cartilage on the tibial plafond and talar articulation. Contraindications include: a. Severe degenerative joint disease, b. loss of bone stock and c. metabolic or severe vascular disease.

For the patient with minimal displacement of the talus, a transverse osteotomy may be performed in order to de-rotate and reposition the fibula in the tibial notch (Fig. 3). Once the fibular fragment has been relocated, a 5-6 hole plate is used to hold this new position. Gaping of the osteotomy will normally occur and may be filled with either autogenous or allogenic bone graft.

When long term lateral shift of the talus or malposition of the fibula and tibio-fibular diastasis are present, the quality of healing will need to be addressed. A Gatellier incision (posterior-lateral),[16] is utilized to more easily remove all scar tissue from the tibio-fibular and ankle joint. A medial approach gives good access for removal of scar tissue between the medial malleolus and talus. It is imperative that all scar tissue be removed medially to allow proper seating of the talus against the tibial malleolus. At times the deltoid ligament may have inverted into the joint proper and prevented full relocation of the talus. The leg is stabilized, the foot is distracted distally and internally rotated allowing the talus to rest against the tibial plafond and medial malleolus. A Steinman pin is directed from superior-medial to inferior-lateral entering the talus holding this position. X-rays are taken to ascertain proper alignment. The lateral malleolus is now fixated with a 5-6 hole plate to maintain lateral stability, length, and de-rotation. A 4.5 millimeter cortical transfixion syndesmotic screw prevents diastasis, allowing for healing of the syndesmotic ligaments and interosseous membrane. Closure is performed in a routine fashion. TLS drains are typically utilized. After a sterile dressing, a Jones Compression dressing is applied.

POSTOPERATIVE CARE

Elevation of the extremity is performed for 3 days. The Jones Compression dressing is removed in 10 days. A new cast is applied, bivalved, and structured so that a front half and back half exists. The patient is instructed and encouraged to partake in active-assisted range of motion exercises at home. If the deltoid ligament has been repaired, three weeks should be allowed before active range of motion is allowed. Bathing the extremity is permitted as long as the patient does not place weight on the extremity. After 4-6 weeks, semi-weight bearing is allowed in a lower leg orthotic brace allowing sagittal plane motion. Full weight bearing is allowed to tolerance. Hardware is removed in 10 to 16 weeks.

When a pin has been used to hold the medial talo-tibial position, adequate time must be allowed for new tissue healing to occur in this new position. After 3 to 6 weeks the pin is removed and postoperative care rendered as earlier identified.

SUMMARY

A strong recommendation for early evaluation and diagnosis of potentially disabling ankle malalignment is encouraged. Once malposition of previously treated fractures is noted, open reduction and internal fixation may be contemplated to avoid long term disability.

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