DIFFERENTIAL DIAGNOSIS OF ACUTE ANKLE INJURY

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INTRODUCTION

Inversion injuries to the ankle and foot are a highly common presentation in both the emergency room and the practitioner's office. Because of its frequency the condition has been historically under diagnosed and under treated. Most often, the patient presents with a swollen, tender, and occasionally ecchymotic area after having twisted the ankle in an inversion direction. The most common injury that occurs because of the inversion mechanism is damage to the lateral ankle ligaments. However, there are a variety of other injuries that can occur with this mechanism. Unless one carefully examines for other types of injuries, the proper diagnosis may be missed.

All too often these injuries are given a cursory evaluation and treated symptomatically. Frequently, we will see the patient two to three months later at which time they are still experiencing significant pain and disability in the area of the ankle joint. The purpose of this paper is to identify the types of injuries that can be sustained other than lateral ligamentous injuries, as a result of the inversion mechanism.

Table 1

Differential Diagnosis of Inversion Injuries

Ankle fractures
Anterior calcaneal beak fractures
Ligamentous disruptions of the ankle
Extensor digitorum brevis avulsion
Cuboid fractures (traction and crush)
Fifth metatarsal fractures (tuberosity and base)
Osteochondral fractures of the ankle
Peroneal subluxation
Lateral talar process fractures
Sinus tarsi syndrome
Entrapment neuropathies

Table 2

Approach to the Acute Ankle

1. History
2. Inspection
3. Palpation
4. Ankle radiographs
5. Foot radiographs
6. Stress views, arthrography
7. Other imaging techniques

In evaluating patients with inversion injuries, the presenting history may give vital clues as to the type of injury. First of all, it is important to take into account the elapsed time between the injury and the time of presentation. An ankle may not appear grossly swollen and may, therefore, look like an insignificant injury. However, if the elapsed time between injury and presentation has been small, and if the patient has already treated the ankle with ice, the visible edema and ecchymosis may be minimal. On the other hand, a grossly swollen and ecchymotic ankle may appear far worse than the true extent of damage especially if the patient has treated the ankle with heat or if there has been a significant time delay between injury and presentation.

When eliciting the history, the patient may recall the exact type of mechanism which resulted in the injury. Information such as whether or not the foot was fixed with the ankle then turning over, or whether the patient experienced an audible snapping sensation may help determine areas of injury. The amount of pain that the patient experiences at the time of injury is variable and may not necessarily correlate with the extent of injury. An initial neuropraxia may cause the area to be temporarily anesthetic.

The most important technique for evaluating other areas of the ankle foot complex is the inspection and palpation technique. This should be done in a systematic and clockwise fashion, beginning with the anterior inferior tibiofibular ligament. Next the anterior talofibular ligament is inspected and palpated. In sequence, the dorsal calcaneocuboid area, fifth metatarsal base and tuberosity, and inferior calcaneocuboid area are palpated. Next the inferior fibular area is palpated including the fibula itself as well as the insertion of the calcaneofibular ligament on the calcaneous. Lastly, the entire fibula is palpated including the course of the peroneal tendons.

With a history of an inversion injury, initial ankle views are performed with additional foot radiographs as needed, based upon the initial inspection and palpation. A variety of additional techniques can be used. These are most commonly used in the patient who presents with a chronically painful foot and ankle some months following an ankle injury. These techniques may include arthroscopy, technetium scans, tomograms, CAT scans, and various arthrographic techniques.

Just as important as the initial diagnosis is followup examination of patients with inversion ankle injuries. It is possible to miss one type of injury, particularly when it may be overshadowed by a larger initial injury. Periodic followup of these patients is critical in order to insure a return to full function.

The inversion injury of the foot and ankle is most commonly labeled ankle sprain. It our purpose to identify and discuss three specific conditions which can occur under the same presentation. Competent evaluation of the foot and ankle inversion injury requires a thorough knowledge of foot and ankle anatomy and mechanics, as well as experience in treating traumatic conditions of the foot and ankle. Success in the management of these conditions requires a thorough initial evaluation as well as consistent followup examinations and treatment.

A discussion of more common injuries such as avulsion fractures of the fifth metatarsal base, ligamentous ankle disruption and fractures, osteochondral fractures of the talus, and entrapment neuropathies are not in the scope of this paper.

ANTERIOR PROCESS FRACTURES OF THE CALCANEUS

The orthopedic literature dealing with the subject of fractures of the calcaneus is quite extensive, and the mere suggestion of the words calcaneal fracture immediately impart images of severe and extensive disruption of the architectural configuration, alterations of the articular relationships, and gross disturbance or loss of normal function. The largest of the bones in the foot, it is fractured more often than any other tarsal bone and, thus, has received widespread recognition and study. The results have been an impressively detailed orderliness to several classifications for calcaneal fractures; however, most have placed little emphasis on the potential disability of fractures to the superior distal portion of the calcaneus (1-5).

Textbooks of anatomy have failed to give a specific name to this anatomic portion of the calcaneus (6-8). This dorsal or superior distal protuberance has been referred to as the anterior process or superior beak most commonly (9-17) and the calcaneal promontory (18) or anterior lip (19) less often.

The true incidence of fractures of this portion of the calcaneus has been difficult to determine, although some reports indicate that it may be one of the most common types but is so frequently overlooked (12,15,20). Several reports have indicated that the injury represents from 3 to 23 percent of all calcaneal fractures (3,13,21). Although Dachtler is credited with the first major article drawing attention to this fracture in 1920 with a review of 20 cases (9), the fracture was briefly described in the Scandinavian literature prior to that (22). During the 1950's several authors provided additional detailed descriptions of the fracture and their experience with various treatment modalities (11,14-16,18, 19).

Rowe et al. classified the fracture as Type IC, along with fractures of the tuberosity (Type IA) and fractures of the sustentaculum tali (Type IV) (13). Based on a review of 154 fractures, the overall incidence was determined to be 21 percent. Only central depression fractures with varying degrees of comminution and other fractures involving the subtalar joint accounted for a higher incidence (13). The Watson-Jones classification designates this fracture as a Type 4 injury (1,2,5). Essex-LoPresti referred to it as "parrot nose" type fracture with an overall incidence of about 5 percent and identified the failure of Bohler to include this injury in his original classification of calcaneal fractures (4). We believe, as do other authors, that fractures of the anterior process of the calcaneus are the most common extra-articular fractures of the calcaneus, extra articular being defined as fractures not involving the subtalar joint proper (Fig. 1) (12,20).

In 1982, Degan et al. reported a classification of this particular fracture based upon the size and location of the fracture line (12). Type I is an undisplaced fracture involving only the tip of the process itself. Type II is a displaced fracture that does not involve the articular surface, and Type III is a large displaced fragment involving the calcaneocuboid joint itself.

Anatomically, the dorsal distal portion of the calcaneus is continuous with the distal articular saddle-shaped surface which articulates with the cuboid. A portion of it may also articulate with the navicular. The architectural configuration of this structure varies considerably in its development; it may be broad and blunt or beak-shaped and prolonged (15,17). It is well developed between the ages of 7 and 10 years.

A detailed anatomic description of the process was recently published by Jahss and Kay (17), and the reader is referred to that reference for greater detail. When well developed, it may possess a medial cartilaginous articular surface which articulates with a corresponding portion of the talus. The authors suggest that perhaps an enlarged anterior process of the calcaneus is related to the formation of calcaneonavicular coalitions, although this has not been previously reported.

The bifurcate ligament is a strong ligament with a narrow origin from the lateral aspect of the anterior calcaneal process. It goes forth to attach medially to the navicular as the calcaneonavicular ligament and laterally to the cuboid as the calcaneocuboid ligament. The calcaneocuboid portion of the bifurcate ligament is wider; it appears weaker and tears more readily than the calcaneonavicular portion, based on anatomic studies (Fig. 2)(17).

Fractures of the anterior process of the calcaneus have been associated with industrial accidents (9), motor vehicle injuries (19,12), and misadventures while climbing or descending stairs (15,17). Although they may occur in any age group, there appears to be greater frequency of injury in individuals between the ages of 30 and 60 years (11,14,20). The fracture not infrequently occurs in sedentary individuals, especially housewives and wearers of high-heeled shoes where there is believed to be a predisposition to twisting injuries (11,18). The fracture may occur as a result of a direct or indirect blow to the area (9, 15). In other cases, twisting is reported by patients, although they are usually uncertain of the precise direction (11).

Authors generally agree that fractures of the anterior process of the calcaneus occur by one of two different mechanisms. Most fractures are believed to represent an avulsion fracture and occur as a result of a severe twisting or sprain injury in which the foot is suddenly placed in a position of plantarflexion and inversion. This results in a sudden increase in tension on the bifurcate ligament with an avulsion fracture of the calcaneus (3,10,12,14,15,17-20). Rarely does this fracture fragment originate from the navicular bone. Because the mechanism of injury so closely resembles the mechanism responsible for rupture of the anterior talofibular ligament of the ankle joint, it is often referred to as a sprain fracture (Fig. 3).

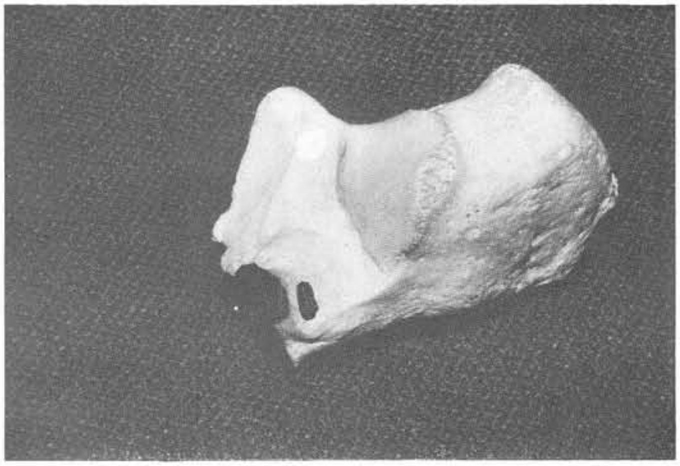

Fig. 1. Bone model demonstrating area of anterior process of calcaneus involved in fracture.

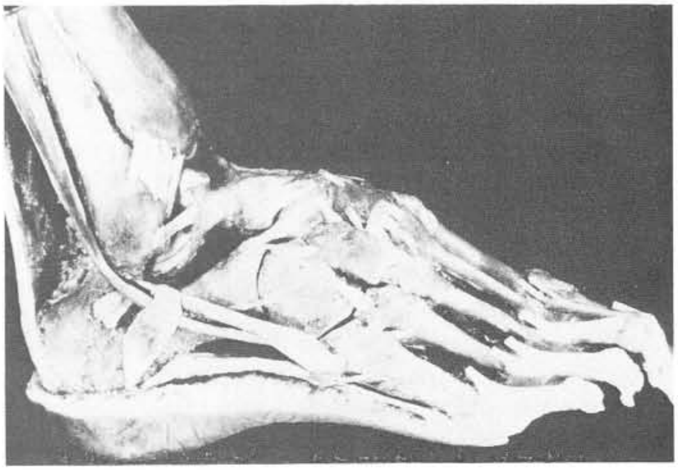

Fig. 2. Cadaveric prosection demonstrating ligamentous attachments and articular relationship between calcaneus, talus, cuboid, and navicular.

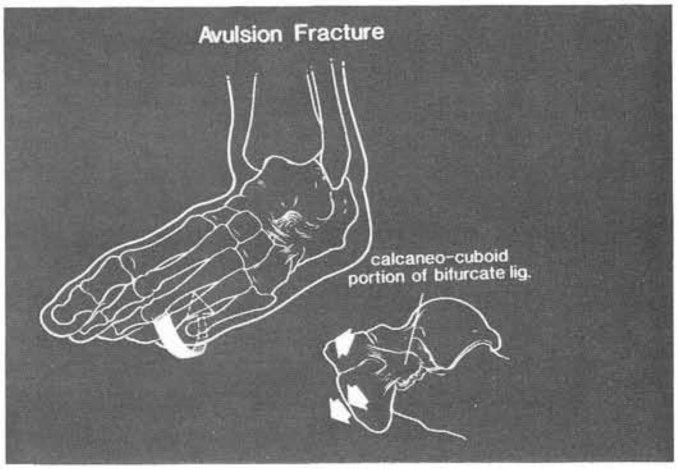

Fig. 3. Diagrammatic representation of avulsion-fracture mechanism of injury resulting from sudden plantarflexion and inversion of foot.

A second, less common mechanism is a shearing or impaction fracture that occurs as a result of a sudden dorsiflexion and eversion force against the forefoot, resulting in a compression fracture of the anterior process of the calcaneus by the cuboid bone (12,14,18,19). Misadventures while climbing stairs, falls from a height, and stepping into unsuspected holes may result in this type of fracture (Fig. 4).

As one might suspect, fractures of the remaining bones of the foot and ankle could also occur as a result of the same mechanisms of injury described above. Associated soft tissue structures might also be injured.

The clinical characteristics of the injury closely mimic those of the typical ankle sprain; however, there are several specific findings which readily distinguish it from an injury to the lateral collateral ligaments of the ankle joint. Like ankle fractures, a cracking sensation may be reported by the patient, and the patient may be seen to have a severe limp or hop. Immediate pain develops and persists for several days. The focal point of maximum tenderness is identified 2 to 3 cm anterior and 1 to 2 cm distal to the lateral malleolus.

This is a striking feature, both visually and upon digital palpation of both areas. A hematoma formation may occur. Ecchymosis is usually present in the area, both on the dorsum and, less often, on the plantar aspect of the foot (Fig. 5). Pain is significantly increased by simultaneous plantarflexion and adduction/inversion of the forefoot or simultaneous dorsiflexion and abduction/eversion of the forefoot when the subtalar joint and ankle joint are immobilized. Pronatory and supinatory movements of the subtalar joint and active dorsiflexion or plantarflexion of the ankle joint are comparably much less uncomfortable. This is another striking feature which differentiates the injury from the typical ankle sprain. Manipulation of the midtarsal joint and forefoot may also result in muscle spasm. The development of a peroneal spastic flatfoot has been reported as a result of this injury (11,12). Because of pain, walking or weightbearing are often virtually impossible. Inability to stand on the affected limb without contralateral limb support is usually reported.

Associated injuries of the same extremity include fractures of the remaining tarsal bones or of the ankle itself (12,15,23). Fractures of the calcaneus and ankle may occur if sufficient supinatory or rotary forces are present (15). Fractures of the navicular, cuboid and fifth metatarsal, as well as dislocations of the talonavicular joint and talocalcaneal joint, have also been reported (3,20,23). Because of the potential for simultaneous injury, clinical examination must include a comprehensive and detailed scrutiny of both the osseous and soft tissue structures of the ankle joint and rearfoot complex.

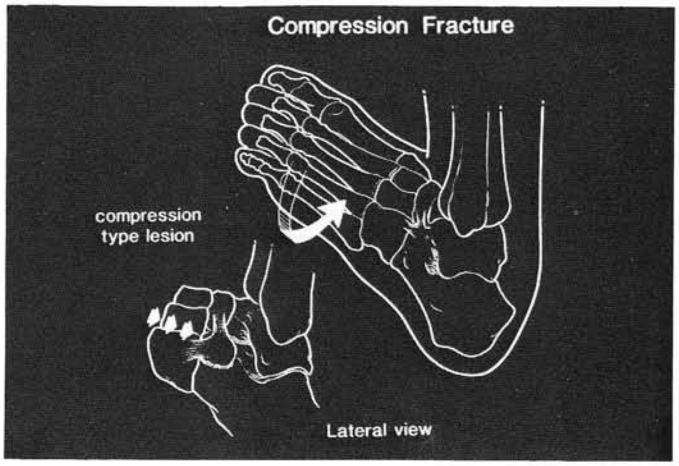

Fig. 4. Diagrammatic representation of shearing or impaction fracture mechanism of injury resulting from sudden dorsiflexion and eversion force.

Fig. 5. Typical clinical appearance of foot five days post injury with fracture of anterior process of calcaneus.

The diagnosis of fracture of the anterior process of the calcaneus requires multiple foot radiographs. Because of the possibility of other fractures, a series of ankle radiographs should be obtained. The medial oblique radiograph (standard oblique) is most useful for visualization of this fracture. We are in agreement with several authors who suggest obtaining the medial oblique radiograph at several different angles of projection to allow for variation in the size and shape of the anterior process of the calcaneus (11,15). The fracture line runs obliquely across a variable portion of the distal superior portion of the calcaneus at its articulation with the cuboid. At times, the fracture may present as only a faint linear shadow or lucency. The fragment may be displaced or nondisplaced (Fig. 6-9) (7-9).

Lateral radiographic views may also be helpful, but overlap of the talus with the anterior process of the calcaneus frequently obscures clear visualization of the fracture line, especially if no significant displacement is present. A non weight-bearing lateral x-ray or an oblique

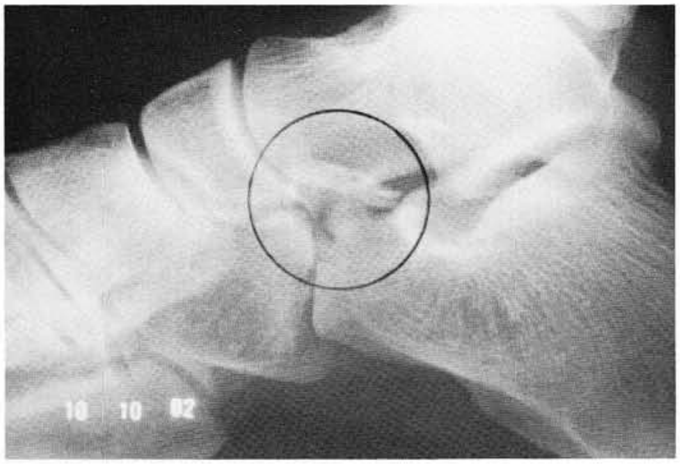

Fig. 6. Lateral view demonstrating comminuted anterior process fracture of calcaneus.

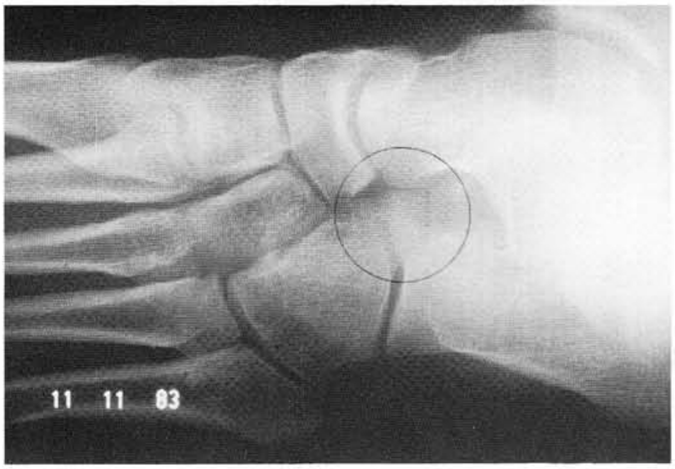

Fig. 7. Medial oblique view demonstrating anterior process fracture of calcaneus.

Fig. 8. Medial oblique view (modified mortice view) demonstrating fracture of both anterior process of calcaneus and spiral oblique fracture of fibula.

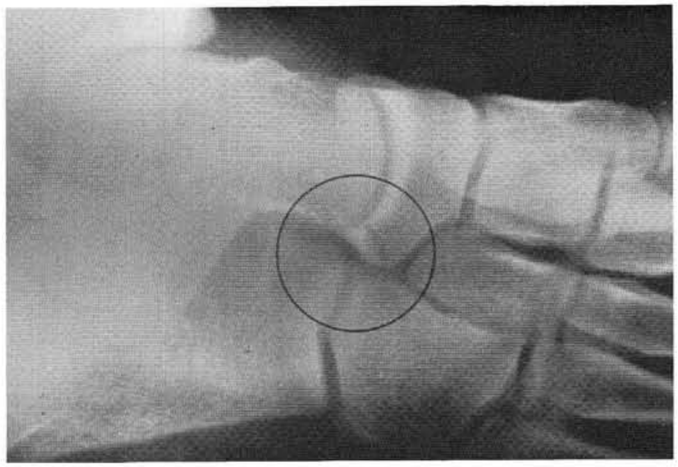

Fig. 9. Medial oblique view demonstrating an unusual fracture of lateral aspect of navicular at site of insertion of bifurcate ligament.

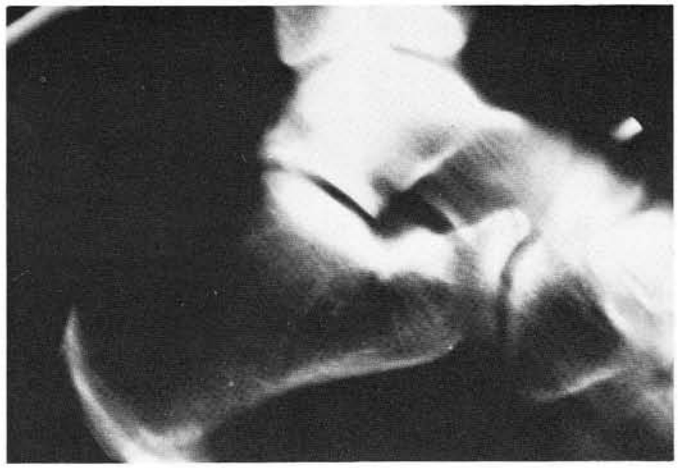

Fig. 10. Lateral tomogram demonstrating small non displaced anterior process fracture of calcaneus not initially identified on plane film.

lateral may be helpful in visualizing the full extent of the fracture line (19). The use of a magnifying glass has been reported as helpful in evaluating radiographs of this fracture (11). Post traumatic amorphous calcifications may also occur.

On rare occasions, the authors have found it helpful to employ specialized radiographic techniques to identify and confirm this fracture. These may include lateral tomography, computerized axial tomography, or magnetic resonance imaging. When prolonged disability is present and strong suspicion of osseous pathology cannot be confirmed on standard radiographs, a conventional bone scan may prove helpful in confirming or excluding such a diagnosis. Because of their prohibitive cost, such studies should not be ordered indiscriminately or injudiciously (Fig. 10).

It is important to distinguish this fracture from the supernumerary bone, os calcaneus secundarius, which generally has smooth edges, a rounded appearance, and a thin cortical sheath (12,18,19,23,24). The configuration of the os calcaneus secundarius, however, may be variable (7,25). The suggestion of an ununited epiphysis has also been reported (18).

Appropriate treatment will vary depending on the size and degree of comminution of the fracture fragment, as well as the amount of displacement. Recommended treatments have ranged from adhesive strappings and elastic bandages (15) to short leg casting (11-13,18-20) to surgical intervention (12,13,16,19,25). If a fracture is incomplete, a compression bandage for a period of four to six weeks may be adequate with partial weightbearing as tolerated. The initial treatment consists of rest, ice, compression, and elevation. We routinely employ a Jones compression bandage as the initial treatment to minimize and resolve edema (Fig. 11). This may be followed by a course of aggressive physical therapy for range of motion, ultrasound or phonophoresis and cross-fiber massage to decrease fibrosis and improve mobility.

Complete undisplaced fractures should be casted for a period of five to eight weeks until radiographic consolidation is seen. The authors recommend an initial non weight-bearing period of four weeks, followed by weightbearing for the balance of the time of cast immobilization. Simple displaced fractures deserve an attempted manipulation and closed reduction under fluoroscopic control.

When the fracture fragments fail to unite and prolonged disability occurs, surgical excision is highly recommended. If a displaced fracture fragment cannot be close-reduced anatomically, open reduction with internal fixation employing compression screws is indicated (26). If anatomic reduction with appropriate internal fixation cannot be attained, consideration should be given to primary excision. Delayed surgical excision is more likely to result in a poor clinical result and prolonged disability (12).

In cases where severe degenerative changes develop, isolated arthrodesis of the calcaneocuboid joint, or more commonly triple arthrodesis, will be necessary. In our experience, triple arthrodesis has proven more successful than isolated midtarsal joint fusions.

Unless the correct diagnosis is established and early, appropriate treatment rendered, prolonged disability is likely. Disability periods ranging from three weeks to 60 months have been reported (9,11,12,15,18,19) and it is not uncommon for total disability to persist for periods of six months or greater with residual discomfort and swelling present to varying degrees (9,12,15,18). It is the authors' belief that this injury, although now recognized and diagnosed more commonly than in the past, continues to be misdiagnosed or even undiagnosed in a great number of cases. It is a definite clinical entity deserving of recognition and close scrutiny whenever a significant traumatic injury of the foot or ankle is sustained. A high index of suspicion is paramount for successful diagnosis and treatment.

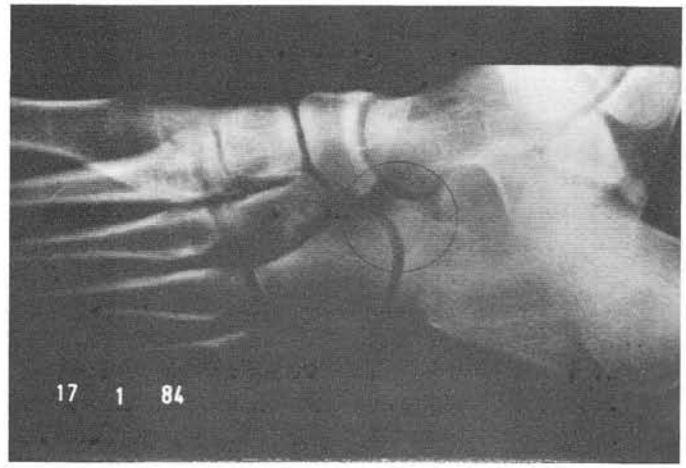

Fig. 11. Followup medial oblique view seven weeks post casting for anterior process fracture of calcaneus. Clinical symptoms are absent. Full range of motion of calcaneocuboid joint is present.

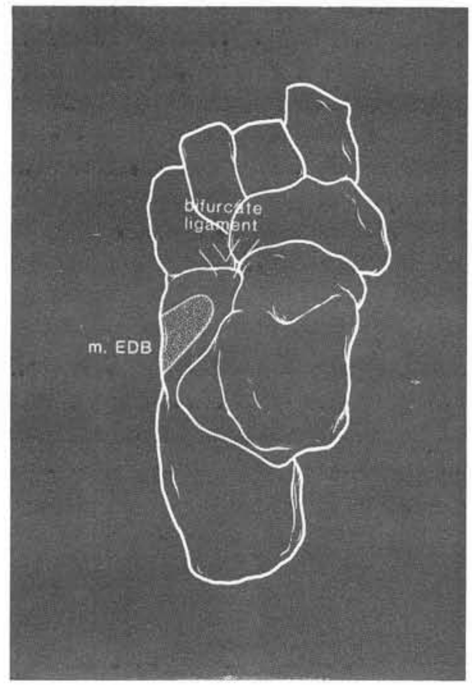

Fig. 12. Diagram showing origin of extensor digitorum brevis muscle. Note relationship to bifurcate ligament.

EXTENSOR DIGITORUM BREVIS AVULSION FRACTURES

An avulsion fracture of the superior lateral aspect of the calcaneus at the site of origin of the muscle extensor digitorum brevis has been seen by the authors in the emergency room setting on several occasions following what is described as a typical ankle sprain injury. An exhaustive review of the medical literature, however, reveals only two articles to date dealing with this specific entity (27,28). Kohler made reference to this injury and demonstrated such a fracture (28). Norfray and associates discussed the details of the injury in a publication in 1980 and estimated the frequency of the injury following ankle sprains to be 10 percent, based upon a review of 100 con-

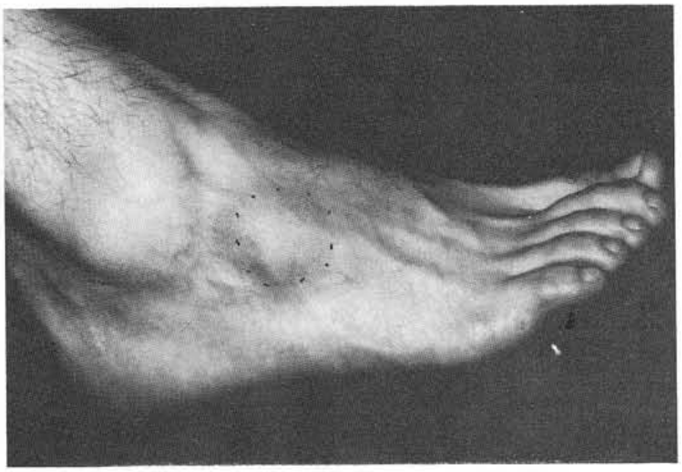

Fig. 13. Clinical picture demonstrating well demarcated hematoma over origin of extensor digitorum brevis muscle belly.

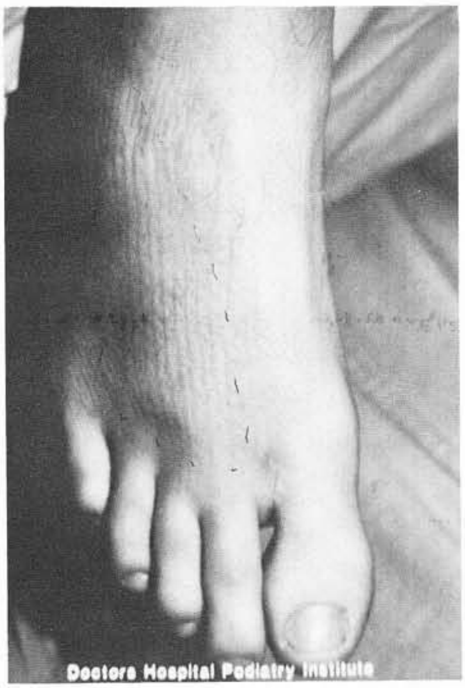

Fig. 14. Clinical appearance of foot seven days following extensor digitorum brevis avulsion fracture. Note hematoma and ecchymosis along course of extensor tendons.

secutive ankle injuries seen during one winter period in a hospital emergency room.

The extensor digitorum brevis muscle is a thin muscle originating on the dorsum of the foot, from the dorsal or superior aspect of the calcaneus, the interosseous talocalcaneal ligament and a portion of the stem of the inferior extensor retinaculum. The origin of the muscle is just proximal and slightly lateral to one of the attachments of the bifurcate ligament. It attaches to the calcaneus at the lateral expanded edge of the tarsal canal. Thus, the origin of this muscle lies in close proximity to a number of soft tissue structures which support the intertarsal joints of the rearfoot and major extrinsic tendons to the foot. The muscle divides distally into four distinct bellies which insert into the hallux and second, third, and fourth toes. There is no attachment to the fifth toe. The muscle serves as an extensor during foot function (Fig. 12).

Norfray and associates have suggested that during forced inversion of the foot as can occur during the common ankle sprain, the extensor digitorum brevis is rapidly stretched beyond its physiologic limits, resulting in a tear of the muscle at its origin, along with an avulsion fracture of the calcaneus. We also suggest that this may occur with sudden reflex contracture of the muscle, along with other extrinsic musculature, in an attempt to halt aggressive inversion or supination movement of the foot and ankle in an acute ankle sprain injury. This injury most probably involves significant strain across the midfoot region, and in particular, the midtarsal and subtalar joints in the direction of the supination. This would be consistent with the injuries reported by Norfray and associates which involved slipping on ice, falling over snow-covered obstacles, falling off a porch, or twisting the foot and ankle on stairs.

Physical examination reveals an acutely swollen foot and ankle at the lateral aspect just anterior and inferior to the lateral malleolus and adjacent to the sinus tarsi. A usual finding is that of a well demarcated hematoma directly over the substance of the muscle itself. This can be easily confirmed by direct observation and comparison to the contralateral extremity. The area of hematoma is the site of both maximum tenderness and swelling which is not infrequently well demarcated from the surrounding tissues.

The lateral collateral ligaments of the ankle and the fibula itself are usually much less tender to direct palpation. Active contraction of the muscle even to mild or moderate resistance is extremely painful. In some cases, we have found the patient unable to voluntarily contract the muscle due to severe pain. Surprisingly, passive inversion of the subtalar joint and dorsiflexion or plantarflexion of the ankle joint produces less pain than anticipated. Clinical differentiation of this injury from fractures of the anterior beak or promontory of the calcaneus may be difficult. Midtarsal joint motion and motion of the joint on weightbearing cause increased pain in the latter injury.

With the passing of several days, one may observe the appearance of ecchymosis extending distally into the hallux and lesser toes along the course of the individual muscle bellies, making the diagnosis easier (Fig. 13, 14). Multiple radiographic views are usually necessary to confirm the clinical suspicion of an avulsion fracture of this muscle.

An avulsion fracture caused by the extensor digitorum brevis muscle can usually be readily identified on a series of foot and ankle radiographs. The fracture has a characteristic location on the dorsoplantar radiograph of the foot and anteroposterior radiograph of the ankle. Additional coned-down views may better delineate the small cortical fragments. Norfray and associates demonstrated the precise anatomic location of the extensor digitorum brevis muscle on a nonpreserved lower extremity amputation specimen by isolating its origin, covering it with a radiopaque substance, and visualizing the substance on a dorsoplantar view of the foot and anteroposterior view of the ankle.

The anteroposterior view of the ankle usually demonstrates the fracture as a small cortical, somewhat linear, fragment well inferior to both the fibular malleolus and the lateral process of the talus. Its distance from the tip of the fibular malleolus and presentation of a normal architecture of the fibula discourages the diagnosis of an avulsion fracture of the lateral collateral ligaments (Fig. 15). The standard dorsoplantar view of the foot also demonstates the fracture fragment along the lateral margins of the calcaneocuboid joint (Fig. 16). The larger the hematoma, the more easily visualized the fracture fragment due to displacement of the avulsed cortical bone laterally away from the calcaneus. The hematoma will manifest as a well demarcated increase in soft tissue volume and density inferior to and distal to the fibular malleolus. The authors have found that a lateral oblique view of the foot (reverse oblique) may, on occasion, prove helpful in visualizing the avulsed piece of bone displaced into the soft tissue structures.

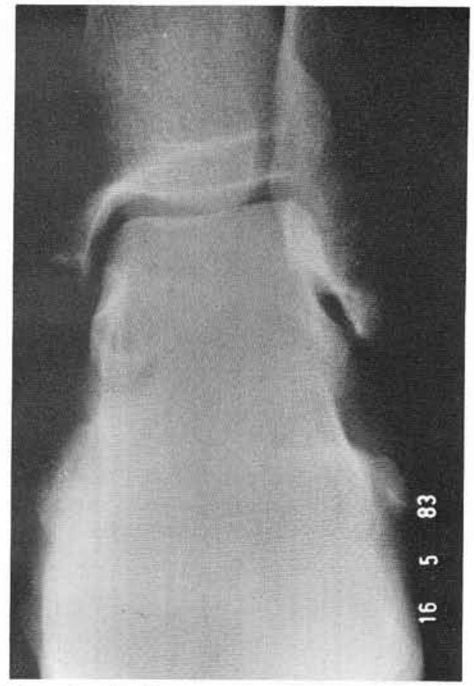

Fig. 15. AP view of ankle demonstrating extensor digitorum brevis avulsion fracture.

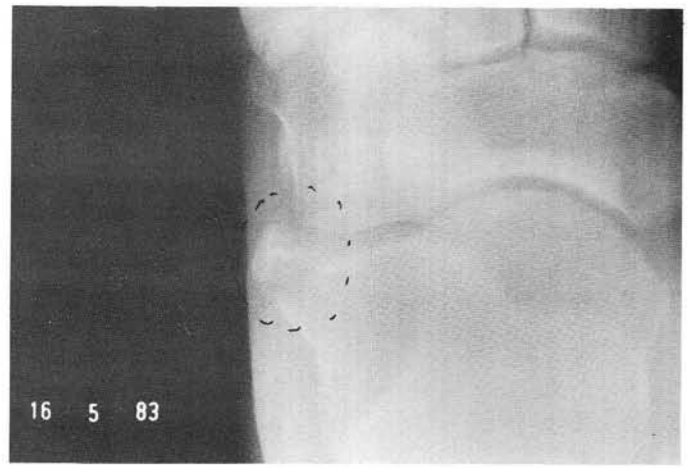

Fig. 16. Dorsoplantar view of foot shown in Fig. 15 demonstrating extensor digitorum brevis avulsion fracture. Note close proximity to calcaneocuboid joint.

Other views of the ankle or foot are generally not beneficial in the diagnosis. Stress films and in-ankle arthrography, although useful in the diagnosis of ligamentous injuries of the ankle, are of no help in this injury, as the muscle is not related in an anatomic sense to the ankle joint proper. While specialized radiographic techniques such as computerized axial tomography, nuclear magnetic resonance imaging, and conventional bone scans may be helpful, their prohibitive costs preclude recommending their use on a routine basis.

The avulsion fracture may be confused with the accessory bones, secondary cuboid, secondary os calcis, and os peroneum, however, their contour and shape and ready visualization on multiple radiographic views helps distinguish these entities. An avulsion fracture involving the calcaneofibular ligament, although presenting similarly on the anteroposterior view of the ankle, is not seen on the dorsoplantar view of the foot. The nutcracker fracture of the cuboid identified by the lateral, dorsoplantar, and medial oblique views of the foot has been well reported and will not be discussed here (29).

Treatment of the acute injury is generally conservative in nature and consists of rest, ice, compression bandaging, and elevation. We frequently employ a modified Jones compression type of dressing to control edema and simultaneously immobilize the extremity for 24 to 72 hours. Evacuation of the hematoma to relieve pressure and local infiltration of a steroid, enzyme, and local anesthetic may prove helpful in controlling symptoms and disseminating the hematoma.

Primary surgical repair of the torn origin with excision of the fracture fragment or fragments is rarely necessary. Limitation of weightbearing will be determined by the severity of the injury, the degree of symptomatology, and other concomitant injuries to the foot or ankle. In select cases, a short leg weight-bearing or non weight-bearing cast may be required for three to four weeks. Within five weeks, most patients are able to return to near full activity with conventional shoe gear. Follow-up radiographs not infrequently demonstrate resorption of the thin fracture fragments.

Fig. 17. A. Clinical photograph demonstrating bony prominence of healed extensor digitorum brevis avulsion fracture.

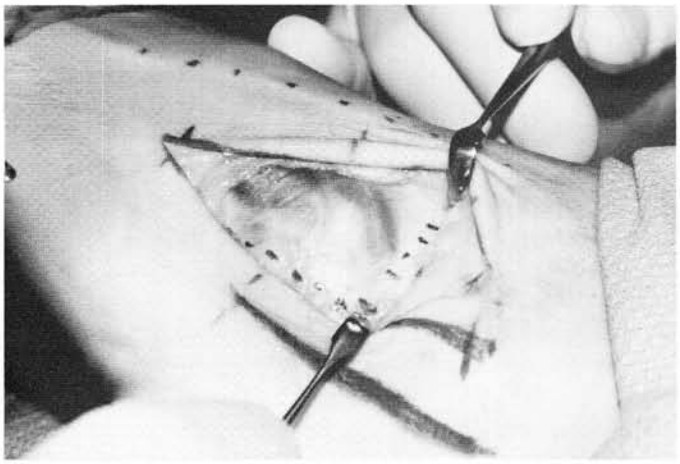

Fig. 17. B. Incisional approach showing retraction of subcutaneous tissue and intermediate dorsal cutaneous nerve with exposure of deep fascia over extensor digitorum brevis muscle belly.

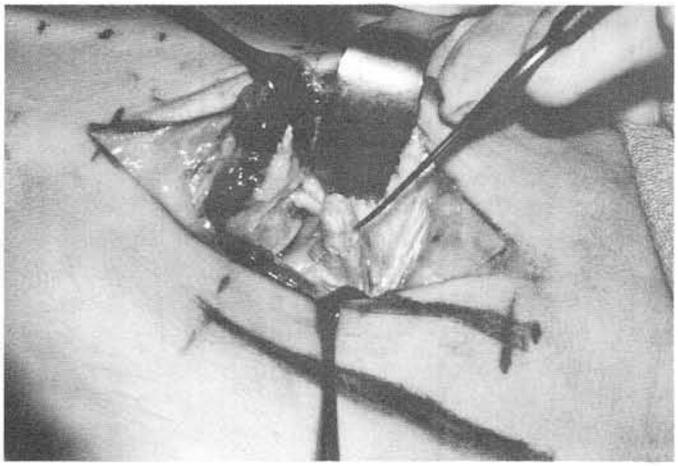

Fig. 17. C. Intraoperative appearance of old avulsion fracture which healed to dorsal surface of calcaneus. Osseous protuberance caused paresthesia and dysesthesia because of compression of overlying intermediate dorsal cutaneous nerve.

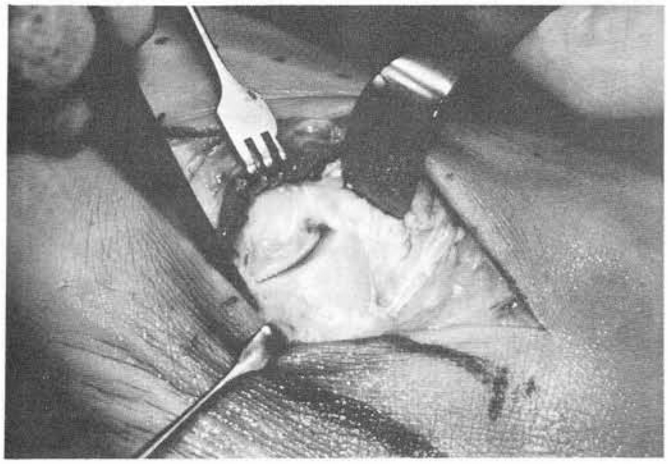

Fig. 17. D. Intraoperative appearance following resection of bony prominence.

Various physical therapy modalities, especially ultrasound, may prove helpful in the later stages to resolve symptoms. If pain persists, simple excision of the fracture fragments may be required (Figs. 17 A-D). In such cases, one can expect to find significant atrophy and degenerative changes of the muscle itself during surgical exploration. If left for a long period of time, the displaced fracture fragments may interfere with the movement of the tarsal joints and contribute to the formation of degenerative arthritis. In such cases, single or multiple joint arthrodesis may be required.

FRACTURES OF THE LATERAL PROCESS OF THE TALUS

Acute or persistent pain about the lateral aspect of the ankle and foot may be due to a fracture of the lateral process of the talus. The fracture, which may occur as an isolated entity or in combination with other soft tissue or osseous injury of the foot or ankle is more common than previously thought. It has received increased attention in more recent years (30-33). Most of the English literature emphasizes the need for greater recognition of this fracture as a potentially disabling entity if undiagnosed, ignored, or mistreated.

Fractures of the talus themselves are rare and estimated to comprise only about one percent of all fractures (34). Fractures of the lateral process have been estimated to represent 24 percent of all fractures of the body of the talus.

In 1965, Hawkins reported on 50 consecutive fractures of the talus and indicated that 13 of these were lateral process fractures. This fracture was the second most common fracture seen in the talus. In the same year, Mukherjee and associates independently reported on 13 cases over a period of 13 months from approximately 1,500 cases of ankle sprains and fractures, an incidence of 0.86 percent. Prior to these two major publications, the authors are able to document only 24 other cases of this injury based upon an extensive review of the literature (30, 34, 35-40). Marottoli is credited with the first reported cases (ten total) in 1942 (35).

Anatomically, the lateral surface of the talus is triangular in outline and forms an apex on its inferior aspect referred to as the lateral process of the talus. It extends from the lower margin of the articular surface of the talar dome to the posterior inferior surface of the talus. It has both articular and non-articular surfaces. Both the lateral and inferior surface of this portion of the talus are coated with hyaline cartilage, and these form components of both the ankle joint and of the subtalar joint. Specifically, the lateral surface articulates with the medial or inner surface of the fibula, while the inferior surface articulates with the superior surface of the posterior calcaneal facet, the major component of the subtalar joint complex (Fig. 18).

Fractures of the lateral process of the talus are thus intra-articular fractures and subject to the disabling afflictions of such fractures. Although no ligamentous structure is attached directly to the apex of the process, a number of ligaments surround this process, including the lateral collateral ligaments of the ankle (anterior talofibular ligament, posterior talofibular ligament, and calcaneofibular ligament), and the lateral ligaments of the subtalar joint.

In anatomic studies performed to define the lateral process of the talus, Hawkins found that the lateral talocalcaneal ligament lies deep to, parallel with, and slightly anterior to the calcaneofibular ligament (32). This is a fairly small band of tissue whose action is to restrict separation of the adjacent surfaces of the talocalcaneal joint. The calcaneofibular ligament, by its anatomic position and orientation to the subtalar joint, also assists in this restraining action.

Hawkins also studied the trabeculation pattern of the lateral process of the talus. While there is little trabeculation seen at the apex of the process itself, it is clear that there is adequate provision made for the transmission of forces between the superolateral and inferolateral surface near the root of the process. The opposing surfaces of the posterior subtalar joint are normally in close apposition to each other. In inversion, the lateral part of

Fig. 18. Cadaveric specimen showing lateral process and dome of talus following disarticulation of ankle joint.

the posterior talar facet migrates superiorly on the posterior calcaneal facet, causing separation as well as an increase in compression force transmission on the lateral process itself.

Several mechanisms of injury have been postulated. The most popular theory is based on anatomic cadaveric research that suggests that the fracture occurs with a fall from a height with the ankle in a dorsiflexed position and the foot supinated or inverted in the rearfoot complex (30). Fjeldborg referred to this as a supination-dorsal flexion fracture, in which the incongruence of the talocalcaneal joint resulted in fracture of the lateral process because of its weakness. The incongruity results in compression or shearing of the lateral process by the underlying calcaneus. The lateral portion of the talus is thus wedged between the calcaneus and tibia primarily, with the fibula playing a secondary or passive role.

Hawkins and Mukherjee, in attempting to correlate their 13 cases each, agreed with the theory proposed by Fjeldborg (31,32). They were able to establish that their patients suffered an inversion injury and in many instances had dorsiflexion of the foot at the time of injury. A fall from a height or unexpectedly stepping into a hole, frequently reported by patients, are consistent with the proposed mechanism.

Fjeldborg describes the three stages to this injury: fissure (state I), fracture with displacement of the lateral process of the talus (stage II), and finally, fracture with displacement of the fragment and subtalar joint dislocation (state III). He presented three cases as clinical evidence to support his staging and proposed mechanism of supination-dorsal flexion fracture.

Cummino has suggested that such fractures represent an avulsion fracture of the tip of the lateral process produced by pull of the lateral talocalcaneal ligament or a direct compression or direct blow to the process itself. This has not been confirmed clinically to any significant

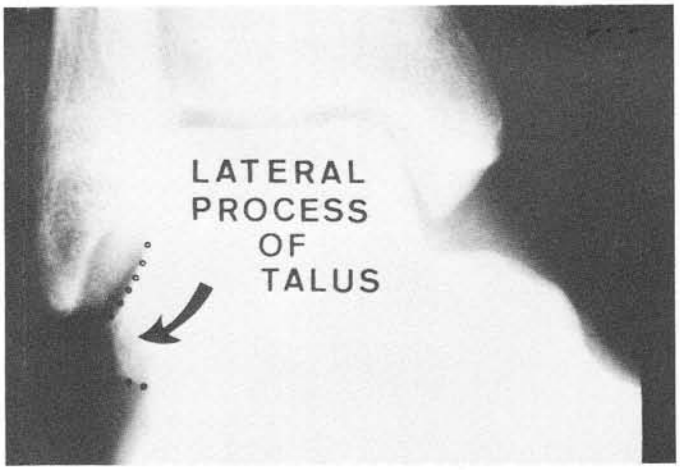

Fig. 19. Normal anteroposterior (AP) view of ankle demonstrating normal appearance of lateral process of talus.

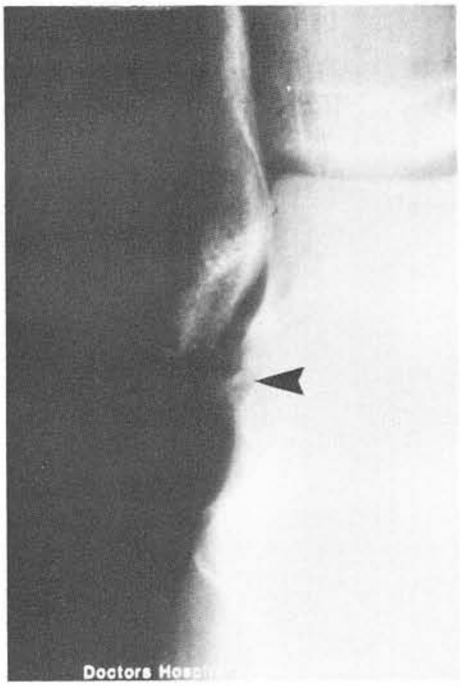

Fig. 20. AP of ankle demonstrating comminuted fracture of lateral process of talus.

degree and, although possible, these are not commonly accepted mechanisms.

Physical Findings

The physical findings are frequently unremarkable and often indistinguishable from those of a severe ankle sprain. The immediate disability, pain and swelling just anterior and distal to the lateral malleolus, are typical. Pain on direct palpation of the fibular malleolus itself is not remarkable, while direct palpation just inferior and anterior to the malleolus may be excruciatingly painful, especially in the acute injury period.

Ecchymosis and edema may be seen and will generally develop sometime later if not within the first few hours. Pain upon active or passive range of motion of both the ankle and subtalar joint may be severe and help to distinguish this injury from others described in this chapter. Crepitus of one or both joints is not infrequently present, especially if the injury is undiagnosed or mistreated. Chronic, unexplained, and persistent pain on motion are clues to the diagnosis of this fracture. Post traumatic arthritis results when the condition persists for years without appropriate treatment.

An accurate diagnosis requires radiographic evaluation and should include anteroposterior, lateral, and mortise views of the ankle (Figs. 19, 20). Placement of the foot in slight plantarflexion may prove helpful in improving visualization of the fracture. Three types of distinct fracture patterns have been described (32). The first is a simple fracture of the lateral process of the talus that extends from the talofibular articular surfaces inferiorly to the posterior talocalcaneal articular surfaces of the subtalar joint. This type is easily recognized on the previously mentioned radiographs.

The second type is the comminuted fracture that involves both the fibula and the posterior calcaneal articular surface with that of the talus and the entire lateral process.

The third type is a chip fracture of the anterior and inferior portion of the posterior articular process of the talus. This fracture is best seen on the lateral radiograph in close proximity to the sinus tarsi and does not involve the talofibular articulation itself, as do types I and II.

Adequate visualization of this anatomic area is usually accomplished with the standard radiographic views discussed above. In a limited number of cases, tomograms, or preferably computerized axial tomograms or MRI, will be helpful in further delineating the extent of injury and status of the ankle joint and/or subtalar joint complex.

Treatment

There is general agreement that early treatment is likely to produce the best results and may be either conservative or surgical, depending on the nature and type of fracture. Displaced fractures must be reduced by either closed or open reduction techniques. Closed reduction should be confirmed radiographically. If successful, the extremity is immobilized in a non weight-bearing cast for four to six weeks, followed by a weight-bearing cast for an additional two to three weeks. The foot should be placed in a neutral position in the sagittal plane with slight eversion of the subtalar joint.

Fractures which remain displaced should be considered for open reduction and internal fixation (30-32). The use of two small Kirschner wires (K-wires) have been shown to be effective in maintaining alignment and position of the fracture fragments (31). Whenever possible, however, small compression screws are preferred over K-wires and have been shown to be extremely effective (33, 41). The commonly employed screws are the 2.0 or 2.7 mm cortical screws; small fractures may be fixated with a 1.5 mm cortical screw, and larger fractures involving a substantial portion of the lateral process of the talus fixated with one or more cortical or one or more 4.0 mm cancellous screws. A small metallic washer is occasionally employed.

Primary surgical excision should be a strong consideration whenever comminuted fractures are present. The results of early excision have been far superior to nonoperative treatment and treatment by later excision for these fractures (31,32,39,41).

Persistent disability and chronic pain are frequently seen due to malunion, nonunion, or post traumatic degenerative changes involving the talofibular component of the ankle joint and/or posterior facet of the talocalcaneal joint. These will usually require surgical intervention which may consist of excision of loose fragments or cheilectomy or arthroplasty type procedures. The surgical approach consists of a lateral incision inferior to the tip of the lateral malleolus and lying within the natural skin lines (Figs. 21, 22). Not only does this approach provide excellent exposure to the lateral aspect of the ankle joint and posterior facet of the subtalar joint, but also results in a very cosmetically acceptable and barely perceptible scar.

The surgical technique requires meticulous dissection and preservation of the ligamentous structures and joint capsule. Failure to preserve these structures may result in chronic ankle instability. Detailed attention to identification of the sural nerve posteriorly and the intermediate dorsal cutaneous nerve anteriorly is important to avoiding post surgical entrapment neuropathies. A small surgical drain should be employed whenever less than ideal hemostasis has been achieved. The extremity is placed in a Jones compression type dressing for three to five days, the surgical site redressed and examined, and then immobilized for four to six weeks in a short leg non weight-bearing cast.

In a small percentage of cases, severe degenerative arthritis of the subtalar joint, and to a lesser degree the ankle joint, may develop. These may not be amenable to the surgical approaches outlined above. Not infrequently, a subtalar joint arthrodesis is necessary to resolve the patient's complaints of pain and loss of normal function. When fusion is necessary, subtalar joint arthrodesis is accomplished with a single 6.5 mm cancellous bone screw. Resection of the articular surface

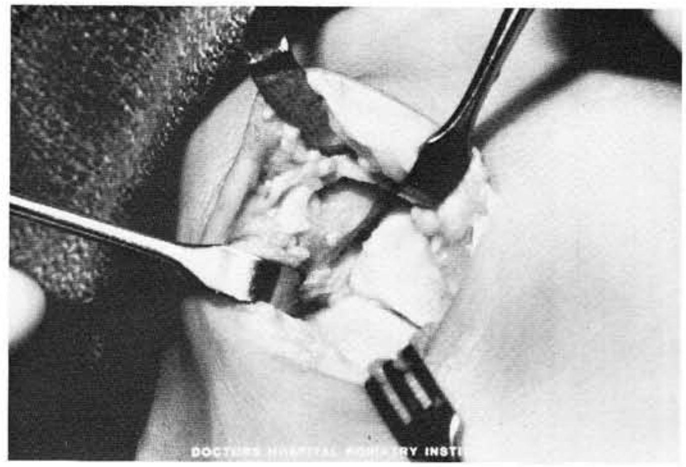

Fig. 21. Intraoperative appearance following cheilectomy and arthroplasty of ankle and subtalar joint to relieve chronic pain resulting from fracture of lateral process of talus (same patient as in figure 20).

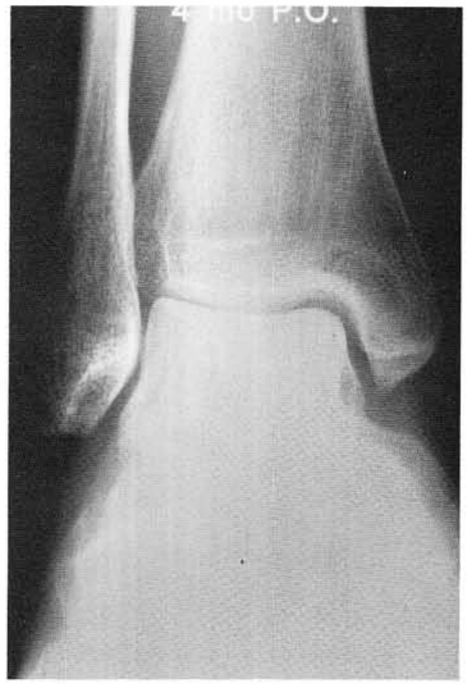

Fig. 22. Radiographic appearance four months postoperative.

of the posterior facet is performed through a lateral incisional approach and a compression screw inserted through a medial incisional approach just anterior to the medial malleolus. It is not necessary to resect the middle and anterior facets of the subtalar joint in such cases.

If severe valgus of the subtalar joint is present, an appropriately fashioned allogeneic cortical cancellous bone graft is inserted within the posterior facet prior to insertion and tightening of the cancellous screw. Rigid internal compression fixation is readily achieved and permits an accelerated postoperative care program, precluding the necessity of cast immobilization. The patient is still maintained in a non weight-bearing status for 8 to 12 weeks. If severe degenerative arthritis involving the ankle joint or the midtarsal joints of the foot develops, an ankle, triple, or pantalar arthrodesis may be necessary. In severe cases requiring major arthrodesis of one or more tarsal joints, the clinical and radiographic results have been extremely gratifying.

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