

ANATOMICAL BASIS OF VARIABILITY IN INJURIES OF THE MEDIAL MALLEOLUS AND THE DELTOID LIGAMENT

II. Clinical Studies

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The anatomical concept of the deltoid ligament as being attached to the anterior colliculus of the medial malleolus by its superficial portion, and to the posterior colliculus by its deep portion has been applied to a clinical material. A number of singular and concurrent lesions of the medial malleolus and the deltoid ligament were recognized: fracture of the anterior colliculus, concurrent fracture of the anterior colliculus and rupture of the deep posterior talotibial ligament, fracture of the posterior colliculus, supracollicular fracture, rupture of the deltoid ligament, and chip fracture of the anterior colliculus. The clinical implications of these lesions are discussed.

Key words: ankle-anatomy, injuries, surgery, radiography; fracture of the ankle

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It is usually considered that in order for the talus to be displaced following an ankle injury, either the deltoid ligament must first rupture, or instead the medial malleolus must fracture. Yet, cases have been presented in the literature in which there existed significant widening of the medial mortise following anatomic reduction of the fractured medial malleolus indicating a concurrent rupture of the deltoid ligament (Close 1956, Burwell & Charney 1965, Mendelsohn 1965, Solonen & Luttamus 1965, Coonrad 1970). However, the underlying pathoanatomy and mechanism of injury in these cases were not provided.

Anatomic studies by Pankovich & Shivaram (1979) showed that the superficial portion of the deltoid ligament is primarily attached to the anterior colliculus of the medial malleolus and the deep portion is primarily attached to the posterior colliculus

and the intercollicular groove. When these findings were applied to clinical situations, it was possible to differentiate a number of separate lesions of the deltoid ligament and the medial malleolus and their combinations, some of which have not hitherto been described. The purpose of this paper is to describe these lesions.

PATIENTS AND METHODS

Records of 102 ankle fractures in patients treated at the Cook County Hospital, from September 1977 to May 1978, which had complete information with regard to physical examination and roentgenographic and operative findings, were available for the study. For the purposes of this study only the cases which had either fracture of the medial malleolus or rupture of the deltoid ligament were included. Certain patterns of injuries, evolved during the period of the study,

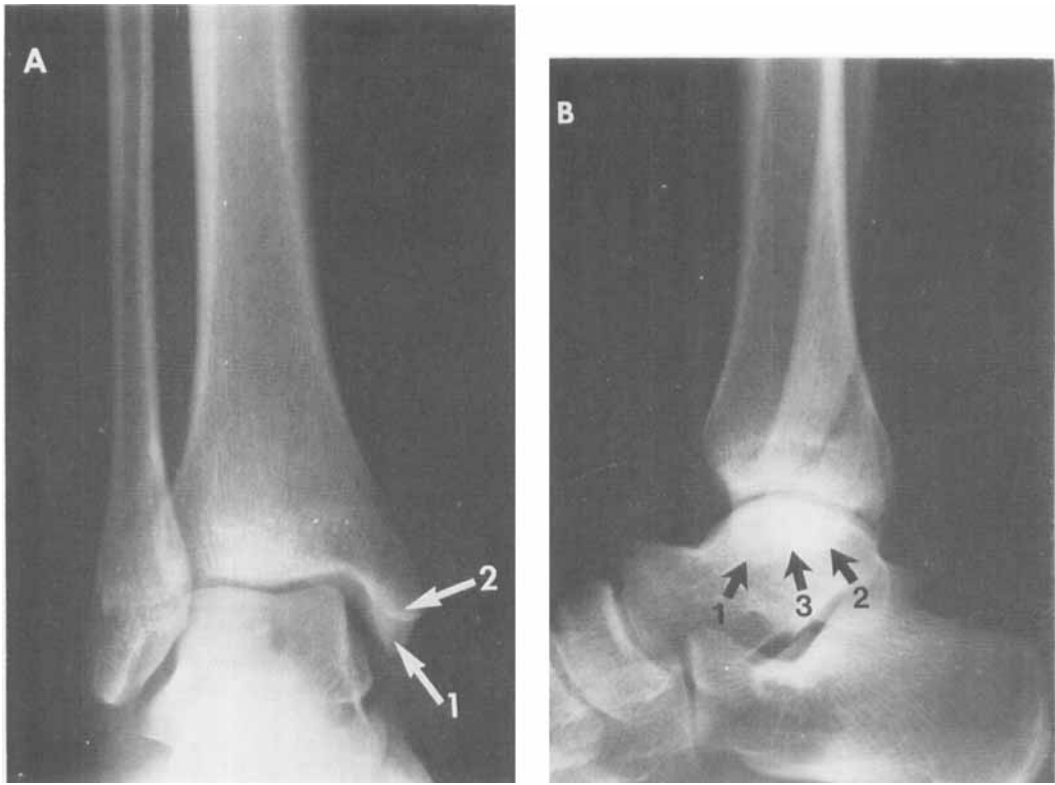


Figure 1. Correlation of the anatomy of the medial malleolus on the roentgenograms: A) anteroposterior view, and B) lateral view. Anterior colliculus (1), posterior colliculus (2), and intercollicular groove (3).

will be described on the basis of findings present in the cases in which the lesions were diagnosed preoperatively, and then confirmed at surgery. In some cases the diagnosis became evident only at surgery.

The following material was obtained in all cases: 1) data on the presence or absence of tenderness and swelling over the ligaments on the medial and lateral sides of the ankle and the anterior capsule of the ankle joint; 2) a roentgenographic examination which included three views of the ankle and when indicated anteroposterior and lateral views of the proximal parts of the fibula and tibia; 3) external rotation and valgus stress roentgenograms when indicated; and 4) the operative findings with special attention to lesions of the deltoid ligament and the medial malleolus. In a few cases where plain roentgenograms did not clearly demonstrate the fracture line of the medial malleolus and its relation to the colliculi, lateral tomograms of the medial malleolus were obtained.

In order to be able to recognize the anatomy of the medial malleolus on plain roentgenograms,

they were correlated with tomograms and findings at surgery whenever possible. The landmarks were recognized on the anteroposterior and lateral roentgenograms which represented the anterior and posterior colliculi and the intercollicular groove (Bonnin 1950) (Figure 1).

RESULTS

Six patterns of injuries of the deltoid ligament and the medial malleolus were observed:

1. *Rupture of the deep and superficial portions of the deltoid ligament.* The deep posterior talotibial ligament was considered to be ruptured only when widening of the medial mortise greater than 2 to 3 mm was present on the original roentgenograms or on subsequent valgus and external rotation stress roentgenograms (Figure 2). There were 15



Figure 2. Roentgenograms indicate rupture of the deep posterior talotibial ligament in a supination-external rotation injury. Widening of the medial mortise is greater than 3 mm.

such cases. At surgery in all of these cases there was rupture of the deep posterior talotibial ligament. The deep anterior talotibial ligament was also probably ruptured, although in the majority of cases it was not possible at surgery to identify this ligament due to hematoma and damage to the surrounding structures, and its small size. While it was easy to demonstrate at surgery rupture of the deep posterior talotibial ligament because of its intraarticular accessibility, this was not the case with the superficial deltoid ligaments which are covered with tendons of the tibialis posterior and flexor hallucis longus and their sheaths, and the crural fascia reinforced with the laciniated ligament. If these overlying structures are intact, as it is often the case, it is difficult and impractical to attempt to expose the superficial ligaments at surgery. In cases where there were ruptures of fascia and tendon sheaths, the presence of hematoma

indicated injury of the superficial ligaments. In some cases, clear rupture of the superficial ligaments, usually at their bony attachments, was demonstrated. Surgery was never performed if only rupture of the superficial portion of the deltoid ligament was suspected.

The site of rupture of the deep posterior talotibial ligament was found most often to be near its insertion into the medial surface of the talus, and only rarely from the posterior colliculus and the intercollicular groove.

The deltoid ligament was found to be ruptured in supination-external rotation, pronation-external rotation and pronation-abduction injuries, and in Maisonneuve lesions. Isolated ruptures were not observed. For obvious reasons, the ligament was never found to be ruptured in supination-adduction and various internal rotation lesions.

2. Fracture of the anterior colliculus. In these lesions, the fracture line extends obliquely (Figure 3A) or transversely between the anterior edge of the anterior colliculus and its posterior edge or the intercollicular groove. On the anteroposterior roentgenograms (Figure 3B) the fracture fragment is located just below the intact posterior colliculus and the medial mortise is not widened. The deep posterior talotibial ligament remains intact as demonstrated by valgus and external rotation stress roentgenograms (Figure 3C).

Fractures of the anterior colliculus were found in advanced stages of the supination-external rotation injuries, and sometimes as isolated fractures accompanied by tenderness of the distal tibiofibular syndesmosis, indicating that the mechanism of the injury was pronation-external rotation (Pankovich 1978) (Figure 4).

Nine fractures of the anterior colliculus were seen during the period of the study. In all cases, valgus and external stress roentgenograms were obtained and failed to demonstrate medial ankle instability. Seven of these cases were treated by immobilization in a short walking cast for 6 weeks and two underwent open reduction and internal fixation. Two patients treated by cast im-

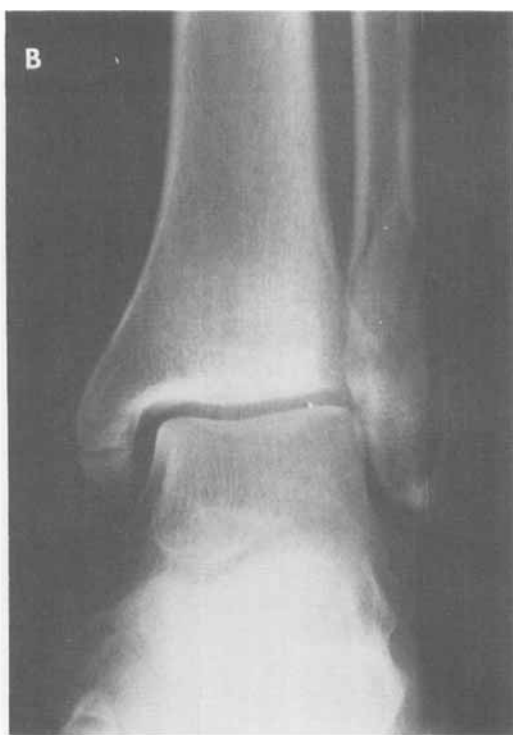


Figure 3. Roentgenograms of a displaced fracture of the anterior colliculus in a supination-external rotation lesion: A) lateral view; B) anteroposterior view; C) external rotation stress view revealed no widening of the medial mortise; and D) at 2 months, the fracture line is visible and the edges of the fragments are sclerotic.



Figure 4. A) Anteroposterior and B) lateral roentgenograms of a fracture of the anterior colliculus in a Stage 2, pronation-external rotation injury. The fracture line extends into the intercollicular groove leaving the posterior colliculus (arrow) intact. The ankle is stable.

mobilization developed fibrous union of fracture of the anterior colliculus, painful in one patient (Figure 3D). This latter patient could not undergo open reduction because he developed pulmonary embolism while under anticoagulation therapy, and continues to have ankle pain. In two patients who underwent open reduction, the deep posterior talotibial ligament was found to be intact. One patient treated conservatively removed the cast after 1 week and was bearing full weight when seen in the clinic 6 weeks later. Roentgenograms at that time revealed healed fractures of the anterior colliculus and the fibula in a good position (Figure 5).

3. *Concurrent fracture of the anterior colliculus and rupture of the deep posterior talotibial ligament.* There were six such cases. In the two initial cases, rupture of the

deep posterior talotibial ligament was recognized only at surgery, although the diagnosis was evident on preoperative roentgenograms (Figure 6).

At surgery in three cases, attachments of the deep posterior talotibial ligament were found to be separate from the fractured anterior colliculus, the ligament was ruptured in its middle in one case, and near talar insertion in two cases. The deep anterior talotibial ligament was not discernible in any of these cases because of local hematoma and tissue damage which prevented identification of the ligament. All three ankle injuries were an advanced supination-external rotation lesion with the fracture of the fibula at the level of the distal tibiofibular syndesmosis. Treatment consisted of approximation of the ends of the ligament with a chromic catgut suture and fixation of the anterior colliculus



Figure 5. A fracture of the anterior colliculus in a supination-external rotation injury. The patient removed her cast at 1 week post injury. At 6 weeks, fractures have healed in a good position.

with a navicular screw and usually a Kirschner wire. Stability of the medial side was further increased by internal fixation of the fracture of the fibula with a small fragment A0 plate.

In another three cases a segmental rupture of the deep posterior talotibial ligament was present. One patient was a 22-year-old male who twisted his left ankle in a fight on the day of admission. Roentgenograms revealed an advanced supination-external rotation lesion with a fracture of the fibula above the distal tibiofibular syndesmosis, widening of the medial mortise, and a fracture of the anterior colliculus which appeared to involve a small portion of the posterior colliculus (Figure 7A, B). At surgery, it was found that the fracture line did indeed involve a portion of the posterior colliculus which carried along approximately one half of the deep posterior

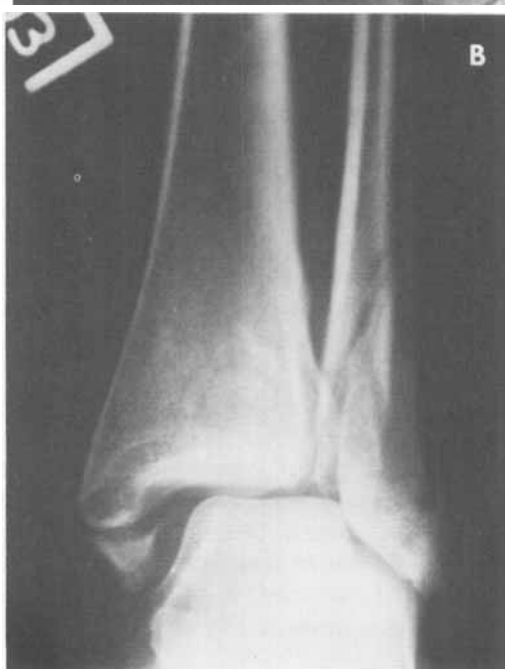


Figure 6. A concurrent fracture of the anterior colliculus and rupture of the deep posterior talotibial ligament, confirmed at surgery. A) Lateral and B) anteroposterior views.

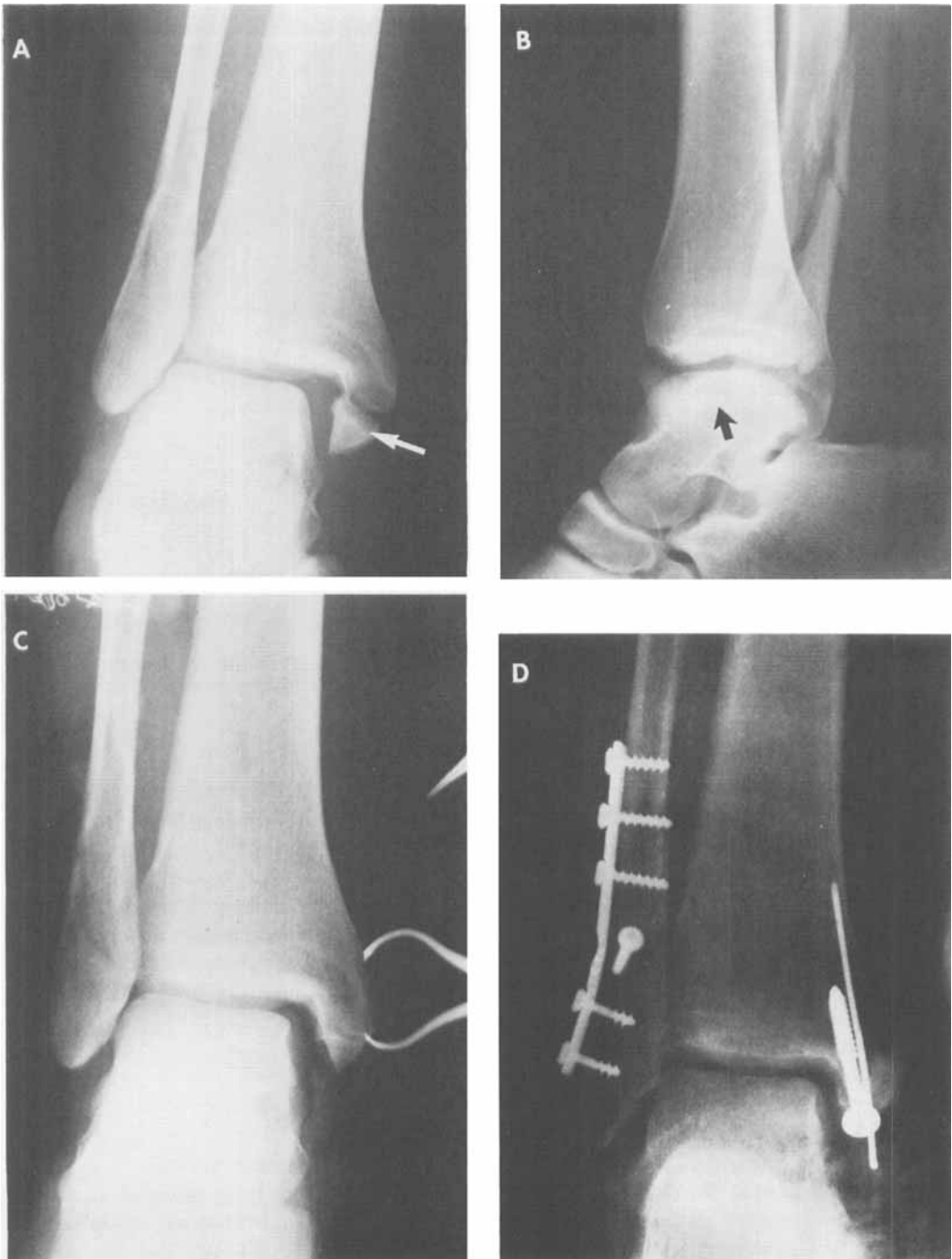


Figure 7. A, B) Concurrent segmental rupture of the deep posterior talotibial ligament and a fracture of the anterior colliculus involving a small portion of the posterior colliculus (arrow) confirmed at surgery. C). The collicular fracture was anatomically reduced and held in place with a clamp. Significant widening of the medial mortise is present when external rotation stress is applied. D) Following fixation of the medial and lateral fractures and repair of the deep posterior talotibial ligament, the anatomy and stability of the ankle are restored.

talotibial ligament; the other half, attached to the posterior colliculus, was ruptured in its middle. In order to test the stability of the talus after fixation of only the medial malleolar fragment and leaving the ruptured portion of the deep posterior talotibial ligament unrepaired, the fracture fragment was reduced and held in position with an A0 malleolar clamp. External rotation stress roentgenograms showed a 4 mm increase in width of the medial mortise (Figure 7C), which decreased to 2 mm following repair of the ligament. After fractures of the medial malleolus and the fibula were fixed, the medial mortise was only 1 mm wider (Figure 7D).

4. *Fracture of the posterior colliculus.* There were four such cases. In two of these cases the anterior colliculus was also fractured. In all cases, the posterior fracture fragment consisted of the posterior colliculus and a supracollicular spike of bone from the posteromedial part of the tibia which carried along the posterior tibial tendon (Figure 8). In two cases, there was an undisplaced, transverse fracture between the colliculus and the spike. Since the diagnosis of a fracture of the posterior colliculus by plain roentgenograms is often quite difficult, lateral tomograms of the medial malleolus were obtained preoperatively in the last two cases (Figure 9). Roentgenographic findings were confirmed at surgery.

5. *Supracollicular fractures.* Most of the fractures of the medial malleolus under study were shown by roentgenograms and at surgery to have the fracture line above the colliculi (Figure 10). Common to all these fractures was presence of the intact deltoid ligament attached to the fracture fragment. The three common types of fractures: vertical, oblique, and transverse were observed.

6. *Avulsion chip fractures.* Four such cases were available for study. These were isolated injuries of the ankle. In three cases, the chip



Figure 8. A fracture of the posterior colliculus has a supracollicular spike (arrow) which is typical of this lesion.

fracture was located in close proximity to the anterior colliculus and was best seen on the lateral roentgenograms (Figure 11). These lesions are considered to be a sprain fracture of the superficial deltoid ligament caused by forceful plantar flexion of the foot. A chip fracture of the posterior colliculus, as described by Bonnin (1950), was also seen in one case.

DISCUSSION

In order to recognize various singular and concurrent lesions, it is essential to understand the anatomical relations of the medial malleolus and its colliculi, and the various parts of the deltoid ligament (Pankovich & Shivaram 1979). It is also important to know which of these lesions are stable and which unstable. Thus a fracture of the anterior colliculus can be considered a singular, stable

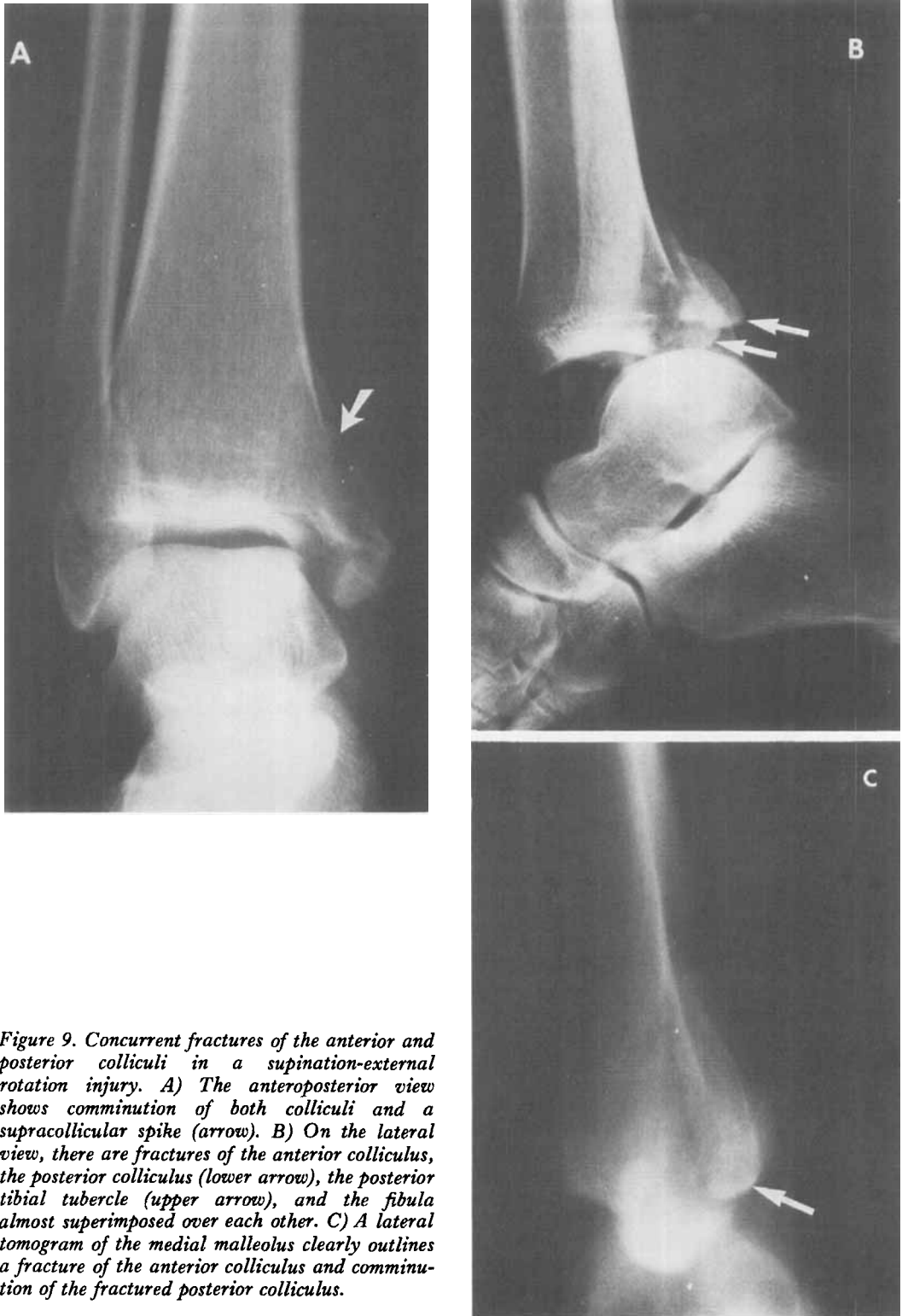


Figure 9. Concurrent fractures of the anterior and posterior colliculi in a supination-external rotation injury. A) The anteroposterior view shows comminution of both colliculi and a supracollicular spike (arrow). B) On the lateral view, there are fractures of the anterior colliculus, the posterior colliculus (lower arrow), the posterior tibial tubercle (upper arrow), and the fibula almost superimposed over each other. C) A lateral tomogram of the medial malleolus clearly outlines a fracture of the anterior colliculus and comminution of the fractured posterior colliculus.



Figure 10 A, B) The fracture line is supracollicular, indicating an intact deep posterior talotibial ligament.

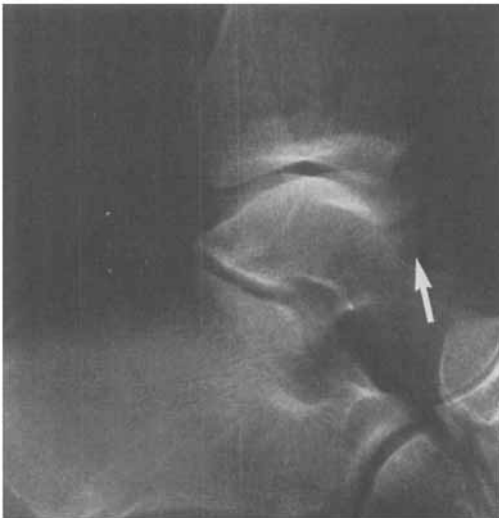


Figure 11. An avulsion chip fracture of the anterior colliculus is best seen on lateral views.

lesion if the deep posterior talotibial ligament is shown by external rotation and valgus stress roentgenograms to be intact. On the other hand, if the medial mortise widens under these stresses, the lesion is considered concurrent and unstable due to rupture of the deep posterior talotibial ligament. The variety of stable and unstable, singular and concurrent lesions are depicted schematically in Figure 12.

Recognition of the various singular and concurrent lesions of the medial malleolus and the deltoid ligament has a definite bearing on the choice of treatment. A singular, anterior collicular fracture, when undisplaced or slightly displaced, requires a short period of immobilization in a short cast because it is a stable lesion. Existence of this type of fracture, in which the deep posterior talotibial

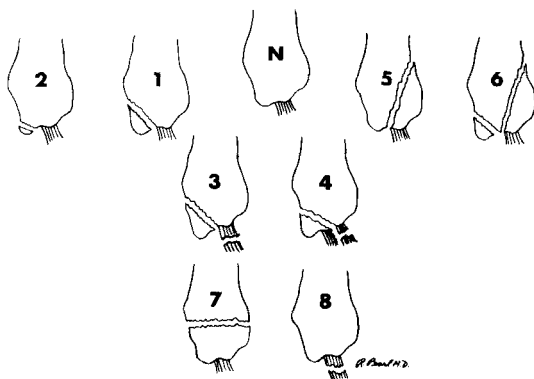


Figure 12. Types of lesions of the medial malleolus and the deep posterior talotibial (DPT) ligament: N-normal; 1-singular fracture of the anterior colliculus; 2-chip fracture of the anterior colliculus; 3-concurrent fracture of the anterior colliculus and rupture of the DPT ligament; 4-segmental rupture of the DPT ligament; 5-singular fracture of the posterior colliculus; 6-concurrent fractures of the anterior and posterior colliculi; 7-supracollicular fracture; and 8-singular rupture of the DPT ligament.

ligament is intact, explains absence of displacement of the talus in supination-external rotation injuries in patients who continued to bear weight on the injured ankle. However, if the fractured anterior colliculus is displaced, internal fixation may be preferable because conservative management in our two cases led to a fibrous union. Fixation of the lateral malleolus in such cases does not seem necessary because displacement of the fracture is only minimal and is not expected to increase since the deep posterior talotibial ligament is intact. On the other hand, a concurrent fracture of the anterior colliculus and rupture of the deep posterior talotibial ligament, an unstable lesion, requires repair of both structures, and usually additional stabilization of the talus by fixation of the fracture of the fibula, and sometimes fibulotibial transfixion. It is quite obvious that fixation of only the anterior colliculus would not prevent talar displacement and consequent widening of the medial mortise. The existence of this type of concurrent lesion provides an explanation for the cases

found in the literature in which widening of the medial mortise remained after anatomical reduction and fixation of the fracture of the medial malleolus.

Variability of the direction of the fracture line is responsible for different lesions of the medial malleolus and the deep posterior talotibial ligament. The fracture line usually starts at the anteromedial corner of the ankle mortise. Horizontal and only slightly downward oblique fracture lines in the anteroposterior direction are representative of supracollicular fractures. In singular fracture of the anterior colliculus, the fracture line is more oblique, and if the injuring force is strong enough it will rupture the deep posterior talotibial ligament as well. Although all these lesions are usually easily recognized on the plain and stress roentgenograms, in some cases the fracture line may appear to be supracollicular while in fact it passes above the intercollicular groove, and involves a portion of the posterior colliculus. In such cases, a considerable portion of the deep posterior talotibial ligament may be ruptured from the posterior part of the posterior colliculus, and fixation of the fracture fragment alone would still leave medial instability, as seen in three of our cases. This points to the importance of the more abundant posterior portion of the deep posterior talotibial ligament to ankle stability and to the need for repair of all injured structures.

Methods of treatment of these lesions were discussed primarily to emphasize the anatomical findings. A long-term follow-up study of a greater number of cases is needed in order to determine the best method of treatment, particularly of singular and concurrent collicular fractures. Results of such a study will be reported at a later date.

Credit for the first description of the collicular injuries goes to Bonnin (1950) who mentioned them in his monograph on injuries to the ankle. To the best of our knowledge there are no other descriptions of these lesions in the English medical literature.

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