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A Study on Syndesmotic Joint Restoration with Ankle Fracture Fixation

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Abstract: *The ankle joint in its entirety depends on bony as well as soft tissue structures restored to their normal anatomical alignment following trauma. The syndesmotic joint at the distal end of tibia and fibula is essential for regaining normal functional out comes especially so when the injury involves syndesmotic joint also. There are parameters to follow while assessing the syndesmotic injury as well as intra operatively when different ankle fractures are treated with internal fixation. Our study is to assess the syndesmotic injury pre and per operatively by following same parameters in both the situations. The variability of acceptable restorations is discussed while stressing on importance of the assessment of syndesmotic joint before a decision is taken whether to involve the syndesmotic joint in the internal fixation or not. We are presenting our study on 65 different type of ankle fractures before and during internal fixation with reference to syndesmotic joint.*
Keywords: *Syndesmotic joint, tibiofibular overlap, tibio fibular clear space, medial clear space*

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I. Introduction:

The functional outcome of ankle fractures involving disruption of syndesmotic joint essentially depend on restoration of bony architecture as well as soft tissues. Near normal or slight variation form anatomical reduction only is acceptable for achieving functional outcome at par with preinjury status.

Anatomical considerations: Inferior (distal) tibiofibular joint: The inferior (distal) tibiofibular joint is usually considered a syndesmosis. It consists of the anterior and posterior tibiofibular ligaments and the interosseous ligament. The distal tibiofibular joint is between the rough, medial convex surface on the distal end of the fibula and the rough concave surface of the fibular notch of the tibia. These surfaces are separated distally for approximately 4 mm by a synovial prolongation from the ankle joint, and may be covered by articular cartilage in their lowest parts.

The ligaments of the distal tibiofibular joint(fig 1) are the anterior, interosseous and posterior ligaments. The anterior tibiofibular ligament is a flat band which descends laterally between the adjacent margins of the tibia and fibula, anterior to the syndesmosis. The interosseous tibiofibular ligament is continuous with the interosseous membrane and contains many short bands between the rough adjacent tibial and fibular surfaces; it is the strongest bond between the bones. The posterior tibiofibular ligament is stronger than the anterior, and is disposed similarly on the posterior aspect of the syndesmosis

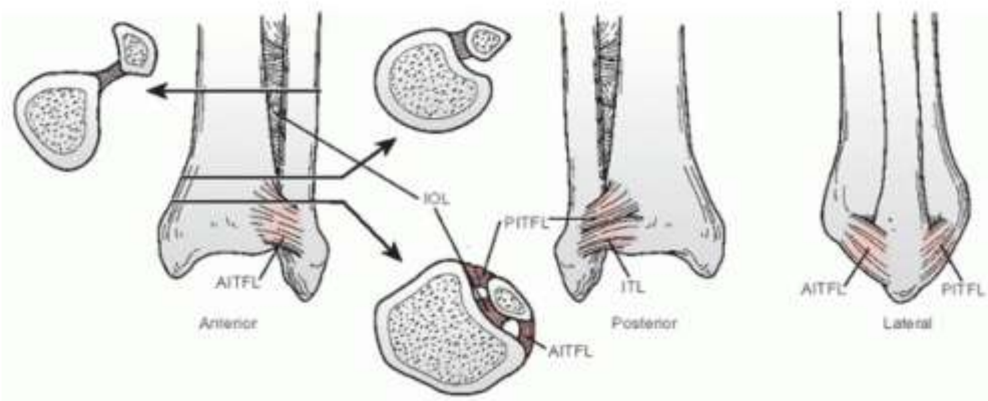

Fig. 1 shows three views of the tibiofibular syndesmotic ligaments. Anteriorly, the AITFL Posteriorly, the tibiofibular ligament has two components: the superficial PITFL and the thick,strong ITL. Between the anterior and PITFLs resides the stout interosseous ligament (IOL).

Ankle fractures can be classified purely along anatomic lines as monomalleolar, bimalleolar, or trimalleolar fractures.Lauge- Hansen classification (fig 2) describes associated mechanism of injury with fracture patterns with the mechanism of injury and proposed a detailed classification, with each broad classification subdivided into four groups. According to this classification, most fractures are supination-eversion, supination-adduction, pronation-abduction, and pronation-eversion injuries. In this classification system, the term eversion is a misnomer; it more correctly should be external or lateral rotation.

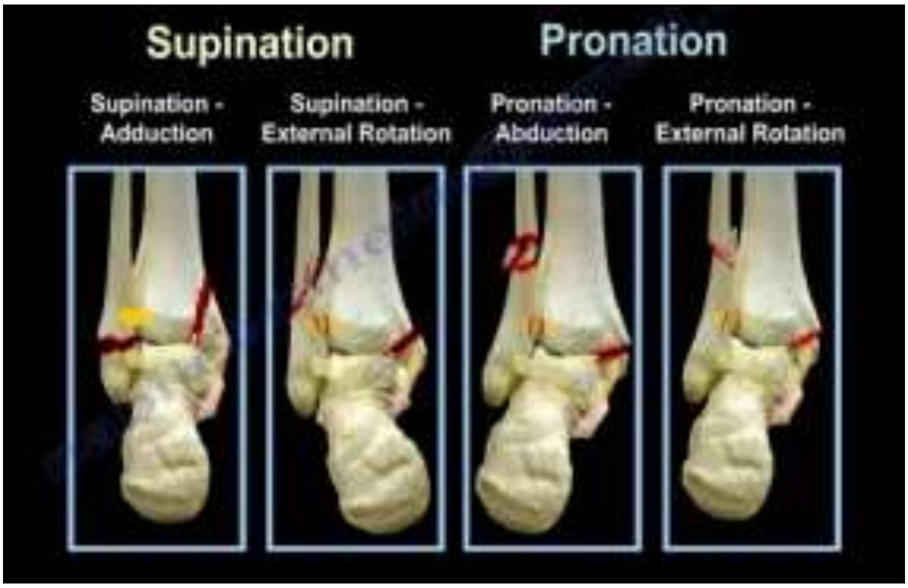

Fig. 2 shows Lauge- Hansen Classification of Ankle Fractures

The first word in the designation refers to the foot's position at the time of injury; the second word refers to the direction of the deforming force.

Danis - Weber classification(fig 3) is based on the location and appearance of the fibular fracture.

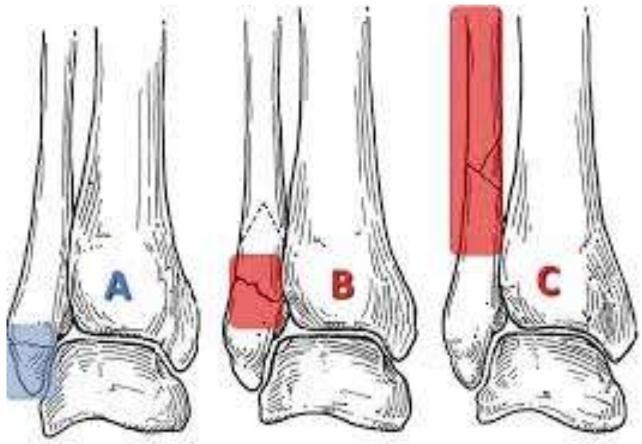

Fig.3 shows Danis - Weber classification of Ankle Fractures

Type A fractures are caused by internal rotation and adduction that produce a transverse fracture of the lateral malleolus at or below the plafond, with or without an oblique fracture of the medial malleolus. Type B fractures are caused by external rotation resulting in an oblique fracture of the lateral malleolus, beginning on the anteromedial surface and extending proximally to the posterolateral aspect. The injury may include rupture or avulsion of the anteroinferior tibiofibular ligament, fracture of the medial malleolus, or rupture of the deltoid ligament. Approximately 80% to 90% of lateral malleolar fractures fall into the Danis - Weber type B category. Type C fractures are divided into abduction injuries with oblique fracture of the fibula proximal to the disrupted

tibio-fibular ligaments (C-1) and abduction-external rotation injuries with a more proximal fracture of the fibula and more extensive disruption of the interosseous membrane (C-2).Type C injuries may involve a medial malleolar fracture or a deltoid ligament rupture. Fracture of the posterior malleolus may accompany any of the three types.
The AO classification (fig 4) divides the three Danis-Weber types further for associated medial injuries

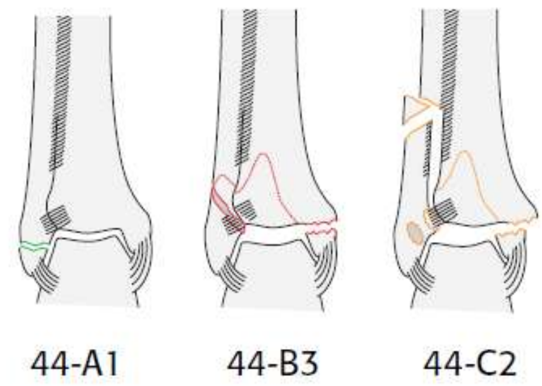

Fig.4 shows AO Muller Classification

SYNDESMOTIC INJURY

Syndesmotic injuries can create a diagnostic and therapeutic challenge for musculoskeletal physicians.Injury classification should facilitate prognosis, return to play and surgical decision making.[10]Syndesmotic injuries are most commonly caused by pronation-external rotation,pronation-abduction and, infrequently, supination-external rotation mechanisms (Danis-Weber type C and type B injuries).

These forces cause the talus to abduct or rotate externally in the mortise, leading to disruption of the syndesmotic ligaments. Syndesmotic injuries extending more than 4.5 cm proximal to the ankle joint altered joint mechanics but syndesmotic injuries extending less than 3 cm proximal to the ankle joint did not. Boden et al. opined that syndesmotic fixation may be unnecessary if the disruption extended less than 3 cm above the plafond or if the medial and the lateral injuries were stabilized by fixation of the medial malleolus or repair of the deltoid ligament.[9] The deep deltoid ligament is considered the primary stabilizer of the ankle.

In the setting of an isolated lateral malleolus fracture, identifying injury to the deltoid ligament and associated ankle instability influences management. The most effective methods for assessing tibiotalar instability include stress and weight-bearing radiographs which painful to the patient in an acute scenario. Clinical examination findings are important but less reliable. Advanced imaging may not be accurate for guiding management. If the ankle is stable, nonsurgical management produces excellent outcomes. In the case that clinical / radiographic findings are indicative of ankle instability, surgical fixation options include lateral or posterolateral plating or intramedullary fixation. Locking plates and small or mini fragment fixation are important adjuncts for the surgeon to consider based on individual patient needs.[1]

The syndesmosis stabilization can be planned if the extent of instability is ascertained. Ankle mortise can be restored to achieve anatomical parameters. Fixation of fibula shaft fractures and posterior malleolus fractures can restore sufficient stability of syndesmosis.[2]

Almost 10% of all ankle fractures lead to accessory syndesmotic injury. Syndesmotic instability is a very challenging injury to restore stability. Though the diagnostic techniques and the therapeutic options are extensive, it still is a controversial subject.[3]

The extent of instability is an important factor in decision making. Fracture fixation of fibula shaft and posterior malleolus can restore sufficient stability to render syndesmosis stabilization unnecessary.[4]

The mode of injury that can disrupt a syndesmotic joint involves external rotation of the foot, eversion of the talus within the ankle mortise, and excessive dorsiflexion. The ligament complex to support syndesmosis and Ankle mortise comprises of the anterior inferior tibiofibular ligament, posterior inferior tibiofibular ligament, and interosseous ligament.[5]

The pathomechanics and extent of syndesmotic injuries have been systematically described by Lauge-Hansen and Weber. The incidence of isolated distal tibiofibular syndesmotic ruptures in acute ankle sprains lies between 1% and 11%. These injuries are frequently overlooked or misdiagnosed and often become apparent through protracted courses. The external rotation and valgus position of Talus contributing to instability leads to a decrease in the contact area which results in posttraumatic arthritic changes.[6]

At the base of the syndesmosis, there is a small contact zone where the tibia and fibula directly articulate with a small band of hyaline cartilage about 0.5–1.0 mm thick that is contiguous with the articular surfaces of the respective bones. The convex fibular part of the syndesmosis is congruent with the concave incisura on the tibial side.The anterior tubercle of the tibial incisura is larger than the posterior tubercle, preventing forward slipping of the distal fibula. In syndesmotic injuries that result from external rotation, the posterior tubercle functions as a fulcrum about which the distal fibula spins around its longitudinal axis in a lateral direction.

The treatment options for Chronic injuries without instability are treated by arthroscopic or open debridement and arthrolysis. Chronic syndesmotic instability can be treated with a three-strand peroneus longus ligamentoplasty in the absence of symptomatic arthritis or bony defects.[7]

The normal radiographic tibiofibular clear space is approximately 5 mm. Increased widening of the ankle mortise in syndesmotic injury by as little as 1 mm decreases the contact area of the tibiotalar joint by 42 %, causing significant ankle instability. The abnormal ankle joint mechanics that can occur with even a mild syndesmotic injury will lead to both the prolonged recovery and long-term dysfunction associated with syndesmotic injuries [8]

Our study is designed as observational study to assess the disruption of the syndesmotic joint in ankle fractures and the restoration syndesmosis with fracture fixation.

II. Materials and methods:

Our study is done with 65 cases of different types of ankle fractures showing syndesmotic disruption treated at Govt. General Hospital, Vijayawada from September 2018 to December 2019. The inclusion criterion are (1) All adult ankle fractures involving malleoli on both tibia and fibula, (2) displaced fractures (3) intact skin, (4) intact blood supply. The Exclusion criterion are (1) Paediatric fractures (2) Open fractures (3) Vascular deficits (4) Neural deficits.

Initial evaluation is done for all the patients to rule out concomitant injuries threatening life. After the surgical profile of the patients is prepared, they are all subjected for Pre anaesthetic check up to establish their fitness to undergo surgical procedure.

The radiological evaluation is done with good quality AP, Mortise and Lateral view Radiographs.

The normal radiographic tibiofibular clear space (fig 5) is approximately 5 mm. Increased widening of the ankle mortise by as little as 1 mm decreases the contact area of the tibiotalar joint by 42 %.

Tibia/fibula x-rays should be obtained with mortise view, particularly high in the fibula. Radiographs can be useful in locating the fracture and demonstrating disruption of the normal relationship between the distal tibia and distal fibula, which may be indicative of syndesmotic injury. The possibilities of syndesmotic injuries are if radiographs show increased tibiofibular clear space, decreased tibiofibular overlap, and/or increased medial clear space.

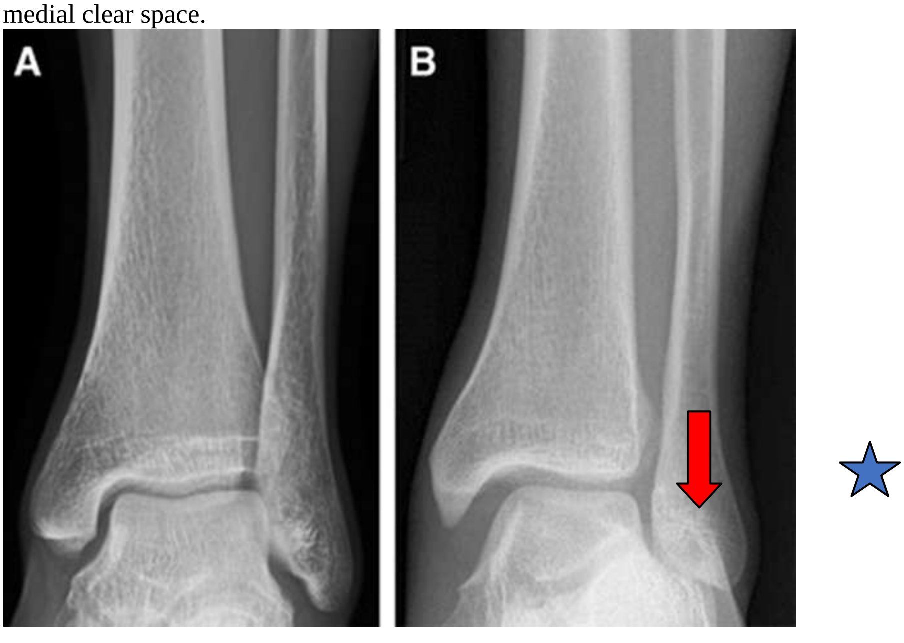

Fig 5 shows X Rays of normal ankle joint (A) and an ankle with syndesmotic injury (B). Note the widened medial clear space (arrow), loss of tibiofibular overlap (star), and widening of the distal tibiofibular syndesmosis

The following issues are considered during evaluation: (i)Tibiofibular clear space:(a) It is the distance between the medial border of the fibula and the lateral border of the posterior aspect of the tibial incisura. (b) Should be measured 1 cm proximal to the plafond (c) Should be less than 6 mm in both the AP and mortise views. (ii) Decreased tibiofibular overlap : (a) It is the overlap of the lateral malleolus and the anterior tibial tubercle (b) Measured 1 cm proximal to the plafond (c) In the AP view, the overlap should be greater than 6 mm or 42 % of the width of the fibula (c)In the mortise view, it should be at least 1 mm (d)Absence of tibiofibular overlap can be present as an anatomic variant.(iii) Increased medial clear space : (a) It is the distance between the lateral border of the medial malleolus and the medial border of the talus, measured at the level of the talar dome (b)In the mortise view, MCS should be equal to or less than the superior clear space between the talar dome and the tibial plafond .(c) An increase in MCS indicates a deltoid ligament injury. (d) Increased tibiofibular clear space is considered the most reliable indicator of syndesmotic injury.

The patients are evaluated and planned for internal fixation of ankle fractures primarily and to assess the syndesmosis whether disruption is treated along with the fracture fixation or not. The fracture fixation is planned as elective procedure as soon as possible, most of the times on the next day.

The limbs are thoroughly scrubbed and draped. Fractured limb is placed over a sand bag for easy manoeuvrability. If the fractured fibula is part of a bimalleolar fracture pattern, we usually reduce and internally fix the lateral malleolar or fibular fracture before fixing the medial malleolar component. The instability of the syndesmosis warranting focused attention results from rupture of two or more ligaments leading to a diastasis of more than 2 mm and requiring surgical fixation. Treatment consists of anatomic reduction of the fibula and fixation with one or two tibiofibular syndesmosis screws. Most Weber type B and type C lateral malleolar fractures are stabilized with plate and screw fixation. (fig 6) The comminuted fractures and doubtful soft tissue cover are fixed by passing a rush nail. The lateral malleolus and the distal fibular shaft are exposed through a lateral longitudinal incision. The superficial peroneal nerve is protected. The fibula is exposed in extra periosteal fashion. If the fracture is sufficiently oblique, if bone stock is good, and if there is no comminution, the fracture is fixed with one or two lag screws inserted from anterior to posterior to establish interfragmentary compression. The screws are spaced approximately 1 cm apart. The medial malleolus usually consists of two 4-mm cancellous lag screws oriented perpendicular to the fracture. The tip of the lateral malleolus is approached by splitting the fibers of the calcaneofibular ligament longitudinally for the entry point for Rush nail fixation.

The integrity of the syndesmosis is evaluated intraoperatively by performing an external rotation stress test and Cotton test. Distraction is applied to the fibula with a bone hook to try to separate it from the tibia to which an opposing force has been applied to prevent tibial motion. If no significant motion is noted between the distal tibia and fibula, the syndesmotic ligaments are intact. If more than 3 to 4 mm of lateral displacement occurs, syndesmotic fixation is necessary. Intraoperative radiographs should show a clear space of less than 5 mm between the medial wall of the fibula and the lateral wall of the posterior tibial malleolus. Persistent widening indicates an unreduced syndesmosis.

Fig 6 shows Post Operative X Rays of Ankle Fractures with LM: Rush nail, MM : TBW (A), LM: Rush nail, MM: MS (B) and LM : PS, MM : MS (C)

After performing the intra operative evaluation with AP view, Mortise view in respect to (i)Tibiofibular clear space (ii) Decreased tibiofibular overlap (iii) Increased medial clear space.
Out of 65 cases the following observations are made

Table 1

S.no.:	Fixation	n	TFCS		TFO		MCS	
			Observed	Normal	Observed	Normal	Observed	Normal
1	LM: Rush nail, MM : TBW	5	2 – 5	<6mm	5-7	>6mm	Equivocal	= / < SCS
2	LM: Rush nail, MM: MS	24	4-6 mm	<6mm	6-8 mm	>6mm	Equivocal	= / < SCS
3	LM : PS, MM : MS	36	3-6 mm	<6mm	5-8 mm	>6mm	Equivocal	= / < SCS
LM: Lateral Malleolus MM: Medial Malleolus TBW: Tension Band Wiring								
MS: Malleolar Screw TFCS : Tibio Fibular Clear Space TFO: Tibio Fibular Overlap								
MCS:Medial Clear Space SCS : Superior Clear Space PS: Plated Screw								

Table 1 showing TFCS, TFO & MCS of all cases operated by various internal fixation methods

III. Discussion:

Trimalleolar fractures carry a worse prognosis than bimalleolar fractures, i.e., the mere presence of a small posterior fragment has a negative effect on the clinical outcome.The indication for surgical treatment is made individually on the basis of comprehensive assessment of the three-dimensional outline of the Posterior Malleolus fracture and all associated injuries to the ankle including syndesmotic instability.Anatomic fixation of the avulsed posterior tibiofibular ligament will contribute to syndesmotic stability and restore the integrity of the incisura tibiae thus facilitating anatomic reduction of the distal fibula.[11] If the fibular fracture is above the level of the distal tibiofibular joint, this joint is assumed to be disrupted and must be anatomically reduced. Boden et al. showed in a cadaver study that disruption of the syndesmosis did not cause ankle instability if no medial injury was involved.[9] Kennedy et al., in a prospective study evaluating syndesmotic screw fixation of Weber type C ankle fractures in which the lateral malleolar fracture was located within 5 cm of the ankle joint, found that syndesmotic screw fixation was not necessary if the fracture was anatomically reduced and was immobilized for 6 weeks postoperatively. The ligaments stabilizing the syndesmosis prevent excess fibular motion in multiple directions: anterior–posterior translation, lateral translation, and internal and external rotation. In the presence of a fracture standing, stress views, squeeze test, passive external rotation are not possible. Beumer et al. showed that there is no optimal radiographic parameter to assess syndesmotic injury. The most useful parameters are the presence of both loss of tibiofibular overlap and widening of the medial clear space, since absence of tibiofibular overlap may indicate syndesmosis widening and a medial clear space larger than a superior clear space indicates deltoid disruption.

There is general agreement that syndesmotic fixation is indicated for (1) syndesmotic injuries associated with proximal fibular fractures for which fixation is not planned and that involve a medial injury that cannot be stabilized and (2) syndesmotic injuries extending more than 5 cm proximal to the plafond. Isolated disruption of the deltoid ligament can produce medial clear space widening even with a stable syndesmosis. Whether syndesmotic fixation should be used in lateral malleolar fractures located 3 to 5 cm from the ankle joint in which the medial injury (deltoid ligament) is not repaired remains controversial. If a high fibular fracture associated with a syndesmotic injury is not fixed, restoration of fibular length can be difficult to determine accurately.

This means that more severe injuries are fairly easily recognized, but moderate injuries with instability may be quite easily missed with stress radiography, even under anesthesia. Contralateral radiographs can also be useful. Standing x-rays can give an indication of anatomic normal for an individual patient, which can vary considerably , and intraoperative use of a true lateral x-ray can help confirm reduction in the coronal plane. In our study, we evaluated 65 cases, of which 5 (8%) were operated with Rush nail fixation to lateral malleolus and TBW to medial malleolus, 24 (37%) with Rush nail fixation to lateral malleolus and Malleolar screw to medial malleolus and remaining 36 (55%)with plating to lateral malleolus and Malleolar screw to medial malleolus. Results obtained in current study for TFCS, TFO & MCS were equivocal to normal acceptable parameters thereby implying acceptable reduction of syndesmosis. Overall this study shows that higher sensitivity is obtained for detecting syndesmotic injury pre and per operatively by measuring TFCS,TFO &MCS in both the situations . It also helps to make a decision regarding involvement of syndesmotic joint in the internal fixation in the OT itself thereby saving time and avoiding unacceptable clinical consequences.

IV. Conclusion

Hence we conclude that thorough knowledge of syndesmotic anatomy, adequate pre and intra op assessment of TBCS, TFO & MCS and adequate reduction confirmation after internal fixation help in achieving 100% ankle stability in fractures involving syndesmotic joint.

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