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Radiographic parameters with intraoperative stress tests to detect syndesmotic instability in ankle fractures

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ABSTRACT

Introduction: Syndesmotic injuries of the ankle most frequently occur due to external rotation injury or forceful abduction injury at the ankle. Frequently they are associated with Pronation-External rotation and pronation-abduction injuries, and infrequently with Supination-External rotation injuries (SER) and Supination-Adduction injuries. Although the incidence of syndesmotic injury is less in SER injuries as compared to Pronation external rotation injuries, when missed, it will lead to a chronically unstable ankle joint with chronic persistent pain and early osteoarthritis. Thus, the detection of syndesmotic injuries in SER type of ankle fractures is of paramount clinical importance to prevent morbidity to the patient.

Aim: To assess the role of fracture height, fracture length, medial joint space, fracture geometry of the medial malleolus, and tibiofibular overlap as radiological parameters in the prediction of syndesmotic injuries.

To find out the frequency of missed syndesmotic injuries in Supination-External Rotation Lauge-Hansen II and IV and Weber Type B ankle fractures.

Materials & Methods: A total of 39 patients with SER injuries were included. Fracture height, fracture length, medial clear space, tibiofibular overlap, and medial malleolus fracture geometry were measured preopera-

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tively on a plain radiograph. Intraoperative stress tests were performed and correlated with the measurements to detect syndesmotic injuries.

Results: In our study 12/39 (30.7%) of patients had a syndesmotic injury. In our study, we found that the Mean± SD of fracture height and the medial clear space in the group with syndesmotic injury was 6.43±1.61 and 6.8±0.79 respectively and Mean± SD in the group without syndesmotic injury was 5.28±1.23 and 5.03**±0.68** respectively. The p-value for fracture height was found to be 0.019 and that for medial clear space was 0.001 both were statistically significant.

Conclusions: This study reports that radiological parameters such as fracture height and medial clear space still hold importance in the preoperative detection of syndesmotic injuries. However, these tests need to be used in conjunction with the intraoperative stress tests in detecting and the treatment of syndesmotic injuries. We can conclude that with the current available radiological parameters and the subjective nature of the intraoperative stress tests, there is a high chance of missing a syndesmotic injury in SER and Weber Type B ankle fractures. There is a need for more objective and recordable findings.

KEY WORDS | Syndesmosis, ankle fractures, stress tests, instability, Radiograph

Introduction

Ankle fractures represent a vast majority of all fractures, accounting for 10% of the fractures being second only to hip fractures in the lower limb [1]. Ankle fractures have an incidence of 187/100000 population per year. The mean age is 45 years and the most common mechanism of injury is a simple slip and fall or twisting injury. These are, however, the statistics of the Western population. In an Indian study, Sanjay Jadhav et al found that the incidence was 8.3% with the most common cause being motor-vehicle accidents (67.34%) [2]. Amongst these 168(72.4%) were closed fractures and 63 (27.6%) were open fractures. Evaluation of only bimalleolar and trimalleolar fractures has revealed that there is a peak in the incidence of these fractures in elderly women.

'Syndesmos' meaning ligament and 'osis' meaning a condition are Greek words. It is an articulation where the ligaments unite the opposing surfaces together. The distal tibiofibular syndesmosis is one of the most important structures which keeps the ankle mortise stable. Thus, it is of utmost importance to achieve an anatomical reduction of the injured syndesmosis to maintain normal ankle biomechanics [3]. Risk factors for ankle fractures have been studied and it has been found that there is an association between ankle fractures and obesity, especially in women with a history of multiple falls [4].

Lauge Hansen Classification of ankle fractures was initially proposed by Ashurst and Bromer in 1922 and later, expanded by Lauge-Hanses in 1950 following cadaveric investigations. This classification system considers the mechanism of the injury which has led to the fracture.

The classification system used two words and a number subsequently. Amongst the two words, the first word indicates the position of the foot at the time of injury and the second word is used to indicate the deforming force occurring at the ankle.

Based on this, any ankle fracture can be classified according to the Lauge-Hansen system into these four basic types:

- Supination-Adduction (SAD)
- Supination-External Rotation (SER)
- Pronation-Abduction and (PAB)
- Pronation-External Rotation. (PER)

The number then refers to the progression through stages of bony and soft tissue injury. The most common pattern of injury is SER (60%) followed by SAD injuries (20%) and then those occurring in pronation (20%). PAB fractures and PER fractures comprise 8% and 12% of ankle fractures respectively

The Lauge-Hansen classification historically indicated the process of closed manipulation required to reverse displacement and reduce the fracture, but in the era of surgical fixation, this classification system remains helpful in directing management.

A lateral talar shift of 1mm will lead to a decreased contact area of 40% and if left untreated will result in chronic ankle pain secondary to the development of early osteoarthritis of the ankle joint [5]. MRI is more sensitive in the detection of such injuries, but the high cost is the deferring factor [6].

These injuries occur most frequently with an external rotation or a forceful abduction injury. The most associated fracture patterns are Pronation-External rotation injury, Pronation-Abduction injury, and Supination-External rotation injuries. Although the incidence of syndesmotic injuries with SER type fractures is less, when missed these will lead to a chronically unstable ankle joint with persistent pain and early osteoarthritis [7]. A detailed history, a thorough examination, and a radiographic evaluation are necessary in the assessment of any ankle fracture. It is of high importance to understand whether the injury is of low velocity or a high-velocity trauma.

A history of smoking and chronic alcohol consumption is also essential as it predisposes the patient to certain complications.

Clinical examination encompasses inspection – to look for any deformity, contusions, presence of blisters, skin integrity, and severity of swelling or any external wounds. Palpation should always begin at the fibular head and continue along its length till the tip of the lateral malleolus to look for any tenderness or crepitus. Then it is continued over to the medial aspect to look for tenderness over the medial malleolus. A careful foot examination should never be missed along with an examination of the tendon Achilles to look for signs of rupture. The examination should finally end with a detailed distal neurovascular examination. Palpation of the dorsalis pedis artery and posterior tibial artery is of utmost importance.

OTTAWA ANKLE RULES: Provide a set of guidelines to determine if a patient presenting with ankle injury should undergo a radiograph. They are highly sensitive. According to this, a patient should undergo a radiographic evaluation in the presence of ankle injury if,

Pain exists near one or both of the malleoli plus one or more of the following:

- Age >55-year-old
- Inability to bear weight
- Bone tenderness over the posterior edge or the tip of either malleolus[8]

Various methods have been described by numerous authors to detect syndesmotic injuries, both clinical and radiological. But none of these methods have been proven to be efficacious in the detection of injuries when used singly. Syndesmotic injuries of the ankle most frequently occur as a result of an external rotation injury or a forceful abduction injury at the ankle. Most commonly they are associated with Pronation-External rotation and pronation-abduction injuries, infrequently with Supination-External rotation injuries, and almost nil with Supination-Adduction injuries. This corresponds to Danis-Weber type C (PER and PAB), Type B (SER), and Type A (SAD) injuries respectively. Although the incidence of syndesmotic injury is relatively less in SER injuries as compared to PER and PAB injuries, when missed these will lead to a chronically unstable ankle joint with chronic persistent pain and early osteoarthritis [8].

Thus, the detection of syndesmotic injuries in SER type of ankle fractures is of paramount clinical importance to prevent morbidity to the patient.

In the present study, we have combined the pre-operative radiological parameters along with the intra-operative stress tests to determine the presence of syndesmotic injuries in Lauge-Hansen Supination-External rotation type ankle fractures.

Material and methods:

Institutional ethical committee clearance was obtained. A Cross-sectional study of 39 patients of either sex with SER injuries or patients presenting to the outpatient department of JSS Hospital, Mysuru from October 2016 to April 2018 with SER type of ankle fractures were included after obtaining valid written consent. Skeletally immature patients, injuries due to crush injury, and patients with any congenital abnormalities were excluded from the study. Patients who presented with Supination-External Rotation type Lauge-Hansen II-IV fracture, a plain radiograph of anteroposterior, lateral, and mortise views were taken. The following

Figure 1. *AP view of ankle joint demonstrating fracture height, fracture length and medial talar articular surface*

Figure 2: *Mortise view of ankle joint radiograph and intraoperative Cotton's stress test showing no increase in clear space*

parameters were assessed in the plain radiograph using Picture Archiving and Communication Software (PACS): Fracture height, fracture length, medial joint space, tibiofibular overlap, and the medial malleolus fracture geometry were measured.

Fracture height is the perpendicular distance between the distal tibial articular surface and the lowermost point of the fracture spike of the lateral malleolus. Fracture length is the perpendicular distance between the lowest and the highest points of the fracture spike of the lateral malleolus. Medial joint space is the perpendicular distance between the articular surface of the medial malleolus and the medial talar articular surface (Figure 1).

Intraoperatively, all patients underwent two stress tests – the external rotation stress test and the lateral hook stress test and the results were noted. (Figure 2)

Statistical analysis: Data obtained was entered in Excel sheet, sex distribution, mode of injury, type of fractures is expressed as percentages. An Independent sample t-test was applied for radiological parameters and expressed as Mean and Standard deviation. P<0.05 is considered statistically significant. Statistical analysis was done using SPSS version 23 software licensed to JSS AHER.

Results:

In our study, a total of 39 (26 Male and 13 Female) patients were included. Out of the 39 patients, 14 were in the age group of 18-40 years, 21 patients were between 41-60 years and 4 patients were above the age of 60 years. The mean age was calculated to be 45.56 years.

The commonest mode of injury was a Road traffic accident, accounting for 25 patients and 11 cases with skip and fall, 2 cases with twisting injury, and 1 fall from height. The most common anatomical configuration of medial malleolus fracture was a transverse type, which also was the commonest amongst the unstable group as shown in Table 1. In our study, we found that the Mean± SD of fracture height and the medial clear space in the group with syndesmotic injury was 6.43±1.61 and 6.8±0.79 respectively and Mean± SD in the group without syndesmotic injury was 5.28±1.23 and 5.03**±0.68** respectively. The p-value for fracture height was found to be 0.019 and that for medial clear space was 0.001 both are statistically significant as shown in Table 2.

Whereas the Mean± SD of fracture length and tibiofibular overlap were 14.20±2.63 and in 1.95±0.78 the group with syndesmotic injury and 13.20±2.36 and 2.2±0.83 in the group without syndesmotic injury. In our study, we found that the lateral hook stress test was better specific compared to the external rotation stress test in detecting syndesmotic injuries in SER fractures.

Discussion:

In the present study, we aimed at providing more ob-

Table 1: Showing types of medial malleolus fracture types and its frequency

Fracture geometry	Number	Percentage
Transverse	32	82.1%
Oblique	6	15.4%
Vertical	0	0
Comminuted	0	0
No medial malleolus fracture	1	2.6%
Total	39	100%

Table 2: Radiological parameters measurements of ankle joint injury(n=39)

Parameters	Mean±SD Syndesmotic injury Present (n=12)	Mean±SD Syndesmotic injury Absent(n=27)	p value
Fracture height(mm)	6.43±1.61	5.28±1.23	0.019
Fracture length(mm)	14.20±2.63	13.20±2.36	0.251
Medial clear space(mm)	6.8±0.79	5.03±0.68	0.001
Tibiofibular overlap(mm)	2.2±0.83	1.95±0.78	0.378

jective and recordable radiographic findings, which can be easily reproduced with less interobserver variability, to detect these syndesmotic injuries preoperatively to help the surgeons to be better prepared in handling such injuries intraoperatively. In the various previous studies and considering their observations and conclusions, the subjective nature of the intraoperative stress tests and their high interobserver variability makes them less reliable when used alone for detecting the syndesmotic instability in SER type fractures [9].

Ramsey et al, in a cadaveric study involving 23 specimens demonstrated that a lateral displacement of the talus by as much as 1mm would result in a decrease in the contact area of the articulating surfaces by as much as 42%. With a further increase in the displacement of the talus, the contact area further decreased at a much lower rate [6]. This study also signified the need for an accurate anatomical reduction, failure of which would lead to ankle giving away, persistent pain, and osteoarthritis.

The standard radiographic measurements which are in routine use to predict syndesmotic instability are the tibiofibular clear space (10mm above the joint line) should be more than 5mm on mortise view, the tibiofibular overlap (10mm above the joint line) should be less than 5mm in AP view and less than 1mm on mortise view, the media clear space should be less than 5mm on mortise view and the talocrural angle should be approximately 83 degree and symmetric with the contralateral ankle [10,11].

In the present study, the most common medial malleolus fracture geometry in the SER injuries is a transverse type followed by an oblique type. Also, the transverse type of medial malleolus fracture is more consistently associated with syndesmotic instability as compared to any other fracture patterns. Our findings are in concurrence with a study done by Nabil A et al also found that the most common fracture associated with SER injuries is a transverse pattern and also that a transverse pattern is associated more with syndesmotic injuries [12].

In our study, we found that the difference in mean fracture height and the medial clear space in the group with syndesmotic injury and in the group without syndesmotic injury was statistically significant with p-value <0.05. In a similar study done by Young Choi et al, wherein they used CT-based parameters preoperatively found that fracture height of > 7mm and medial clear space of > 4.5mm were found to be consistent with syn-

desmotic injury [13].

We also observed in our study that the Lateral hook stress test was better compared to the External rotation stress test in the detection of syndesmotic disruption in patients with SER-type ankle fractures. This is in concurrence with a study done by Stoffel et al where they concluded stating LHST is more sensitive than ERST as the latter can be positive in isolated anterior inferior tibiofibular ligament injury and deltoid ligament injury as well, and thus not being sensitive to syndesmotic disruption alone [14]. Whereas in another study done by Pakarinen et al where they had included 140 SER type of ankle injuries, they concluded that the External Rotation stress test is more sensitive than the LHST [15]. Boden et al conducted a cadaveric study in which they stated that when a fibula fracture was 3-4.5cm proximal to the ankle, syndesmotic stabilization was not necessary if an anatomic rigid medial malleolus fixation was achieved [16]. Although, this criterion is not very useful in PER fractures for syndesmotic instability assessment wherein we find high fibula fractures [14]. However recent studies based on MRI examination of the syndesmosis have shown that the level of the fibula fracture does not always correspond to the level of the tear in the interosseous membrane. The disadvantages of MRI are that it does not provide evidence of dynamic instability and is not rapidly and readily available along with the economic factors. Due to these fallacies in preoperative radiological parameters to assess for the syndesmotic instability, preoperative and intraoperative stress tests gained popularity, the important ones amongst them being the manual external rotation stress test, gravity-assisted stress test, and the intraoperative hook test or Cotton test. The use of MRI scans would be more sensitive to detect the syndesmotic instability, but the high cost and the time factors of MRI are the deferring factors for its use.

Considering the above studies, wherein we can conclude that with the current available radiological parameters and the subjective nature of the intraoperative stress tests, there is a high chance of missing a syndesmotic injury in SER and Weber Type B ankle fractures. There is a need for more objective and recordable findings.

From the findings of our study, we have deduced that a combination of pre-operative radiographic parameters along with intraoperative stress tests is better at detecting syndesmotic instability in SER type of ankle injuries. Further research along the same lines, MRI scans of the region can be done to accurately detect the exact level of syndesmosis injury and an MR arthrogram would be helpful in assessing the dynamic instability of the syndesmosis.

Limitations of the study:

Radiographic measurements may not be as accurate as CT measurements due to the more accurate imaging technique of CT scans. Furthermore, a study with a larger cohort is required to assess the reliability and efficacy of these radiological parameters used in our study.

Conclusion

From the findings of our study, we conclude that these radiological parameters such as fracture height and medial clear space still hold importance in the preoperative detection of syndesmotic injuries. However, these tests need to be used in conjunction with the intraoperative stress tests in detecting and the treatment of syndesmotic injuries. Although CT is better at measuring the parameters accurately, using plain radiographs would decrease the increased cost factor and radiation hazard associated with CT scans. **R**

Author contributions:

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Conflicts of interests:

All authors claims that there is no conflict of interest

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