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Ankle fractures with syndesmotic stabilisation are associated with a high rate of secondary osteoarthritis

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ABSTRACT

Background: The primary aim of this study was to present the incidence of clinically significant end stage osteoarthritis (cOA) after syndesmotic fixation of ankle fractures. The secondary aim was to and identify independent predictors of cOA.
Methods: A retrospective review of consecutive patients presenting to a single University affiliated institution between March 2008 and May 2010 was undertaken. Inclusion criteria were ankle fractures with syndesmotic stabilisation. Patients were excluded if pre or postoperative radiographs were missing or were lost to follow up. Data were gathered regarding demographics, fracture pattern, fixation methods, reduction parameters, screw removal, revision surgery, complications and cOA up to seven years post injury.
Results: Data were available for 120 patients (86%). In total, 13 patients (11%) developed cOA. Univariate analysis showed that increasing age, open fracture, malreduction of the syndesmosis, removal of symptomatic screws, revision surgery and complications were predictors of developing cOA. Cox regression analysis revealed increasing age (hazard ratio (HR) 1.09, p = 0.006), and malreduction (HR 45.5, p = 0.001) were independent predictors of developing cOA.
Conclusions: Ankle fractures with syndesmotic stabilisation represent a severe injury with a high rate of cOA. The only modifiable risk factor for developing cOA in this large series of patients was radiological malalignment. When syndesmotic stabilisation is required, careful intraoperative assessment should be undertaken to ensure the syndesmosis is reduced.

1. Introduction

Ankle fractures are amongst the most common injuries treated by orthopaedic surgeons [1], accounting for 9% of all fractures [2]. Unstable tibiofibular syndesmotic injuries presenting alongside ankle fracture arise in 10–15% of cases [3,4]. Ankle fractures with an associated syndesmotic injury represent a more severe injury pattern with poorer functional outcomes when compared to injuries that required malleolar fixation alone [5].

Biomechanical studies previously indicated that syndesmosis fixation would be required if there was a fibular fracture 3.5 cm above the syndesmosis with an irreparable deep deltoid injury [6]. However, the level of fracture does not always predict the level of tear in the interosseous ligament [7] and clinical studies have shown unstable syndesmotic injuries requiring fixation in 20–40% of transyndesmotic fibular fractures [4,8].

Radiographic post-operative malalignment of the syndesmosis has been demonstrated to result in inferior functional outcomes at 2 years post fracture [4]. There are concerns regarding the reproducibility of AP radiographic measurements due to rotational alignment [8], and recent studies have looked at criteria for radiological alignment in the sagittal plane [9,10]. Croft et al. showed good reproducibility of the measurement of the anterior tibiofibular ratio on the lateral view in normal radiographs, however this has not yet been validated for use in syndesmotic disruption [10]. Radiographic measurements on coronal radiographs are currently still the foundation for assessment and a recent study has indicated that plain coronal radiographs are sufficient to assess syndesmotic reduction and postoperative CT scanning does not change management [11].

Studies of end stage ankle arthritis have demonstrated that 65–80% of cases are post traumatic [12–14]. However, there are far fewer studies observing the long term risk of developing osteoarthritis after ankle fracture and these studies include only small numbers of syndesmotic injuries [15,16].

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The primary aim of this study was to quantify the incidence of clinically significant end stage osteoarthritis (cOA) in a large group of patients who sustained ankle fractures with syndesmotic injury and to identify independent risk factors for developing cOA. The secondary aim of this study was to evaluate a large consecutive group of ankle fracture with syndesmotic injuries and provide information on demographics, fracture pattern, fixation methods and outcomes related to revision surgery and complications.

2. Methods

The study was conducted with the approval of the South East Scotland research ethics service. All patients presenting to a single university-affiliated trauma centre between March 2008 and May 2010 who had an ankle fracture with syndesmotic fixation were eligible for the study. The study centre is the only hospital receiving adult trauma for a defined population of 834,648 [17] and managed 663 ankle fractures per year at the time of initial patient presentations [2].

A prospectively collected radiographic database was retrospectively reviewed to ensure that patients met the inclusion criteria. Exclusion criteria were missing pre or postoperative radiographs and follow-up of less than 2 months.

A comprehensive data collection proforma was developed and baseline data were collected from electronic institutional records. These included gender, age at time of injury, presence of open fracture, time from injury to surgery, surgeon grade and documentation of stress testing at time of surgery.

One of us reviewed pre and postoperative radiographs reviewed for initial dislocation, fracture pattern using the Lauge-Hansen and AO classification systems, radiological reduction parameters (tibiofibular overlap on AP, tibiofibular clear space on AP, medial clear space on AP, talo-crural angle, recreation of fibular length using “Shentons line” of the ankle), method of fixation, hardware used and distance of syndesmotic screws from the articular surface.

True syndesmotic injury was defined as either a fracture pattern that met Boden’s criteria [6]; a fracture of the fibula extending >3.5 cm above joint line with a concomitant unrepairable deltoid ligament injury or if intraoperative stress testing was mentioned in the operative record or an intraoperative stress radiograph was saved.

Criteria for an acceptable syndesmotic reduction was defined as tibiofibular overlap on the AP of more than 5 mm, tibiofibular clear space on the AP of less than 5 mm and medial clear space on the AP of less than 4 mm [4,7,11].

All patients were kept non weight bearing for 8 weeks and standard follow up was 8–12 weeks depending on the treating consultants choice. If screw removal was performed due to surgeon/patient choice, it was booked for 12 weeks post fixation.

Institutional electronic records and the national radiographic database [18] were used to gather outcome data including complications, revision surgery, syndesmosis screw removal and reason for removal and clinically significant end stage osteoarthritis (cOA) at final radiographic review. cOA was defined as symptomatic patients presenting with Kelgren and Lawrence stage 3–4 osteoarthritis of the ankle [19]. The written definition provided by Lawrence was used [20] and only such patients with at least 50% joint space narrowing were included.

Radiographic assessments were all performed using Carestream picture archiving and communication system (PACS) [18]. By using the known core diameter of the 3.5 mm or 4.5 mm syndesmosis screws all numerical measurements were adjusted to ensure standardised reporting of results. The medial clear space was measured as the distance from the medial border of the talus to the lateral border of the medial malleolus on a line parallel to the distal tibial articular surface halfway between medial distal tibial articular surface and the talar dome [21]. Tibiofibular overlap and clear space were both measured on a line parallel to the distal tibial articular surface 1 cm above the joint line [4]. Talocrural angle was measured as the angle between the intermalleolar line and a line parallel to the distal tibial articular surface [22,23]. “Shenton’s line” of the ankle was a visual assessment using freehand drawing tools on PACS to assess if the “Shenton’s line” was broken [23].

2.1. Statistical analysis

Statistical package for social sciences version 20 (SPSS Inc., Chicago Illinois) was used for data analysis. Dichotomous variables were assessed using a Chi square test or a Fishers exact test if one of the variables was less than ten. Continuous variables were measured using an independent t-test.

After initial univariate analysis, independent predictors of clinically significant end stage arthritis were identified using cox regression analysis and entering all significant factors into the model using the enter method.

3. Results

The study cohort consisted of 139 patients. 19 were excluded from the study, due to missing pre or postop radiographs [6] or follow up less than two months [15]. 120 patients were, therefore, included in the study. 54% of patients were male and the mean age was 43. 55% of patients had a dislocation on initial radiographs and 6.7% of fractures were associated with an open injury. The mean time to surgery was two days. 76% of fractures were pronation type injuries, the remaining 24% were supination external rotation injuries (Table 1). Of the 29 patients with supination external

Table 1
Baseline characteristics for the study cohort.

Demographic	Descriptive	Cohort (n = 120)
Gender (n, % of group)	Male	65 (54.2)
	Female	55 (45.8)
Age (mean, SD, range)	Years	42.7 ± 17.5 (16–85)
Open fracture (n, % of group)	Yes	8 (6.7)
	No	112 (93.3)
Dislocation (n, % of group)	Yes	54 (45)
	No	66 (55)
Lauge-Hansen classification (n, % of group)	PER3	33 (27.5)
	PER4	22 (18.3)
	PAB3	36 (30)
	SER4	29 (24.2)
AO classification (n, % of group)	44B1	14 (11.7)
	44B2	13 (10.8)
	44B3	2 (1.7)
	44C1	24 (20)
	44C2	36 (30)
	44C3	31 (25.8)
Medial malleolus fracture (n, % of group)	Yes	59 (49.2)
	No	61 (50.8)
Posterior malleolus fracture (n, % of group)	Yes	35 (29.2)
	No	85 (70.8)
Time to surgery (mean, SD, range)	Days	2 ± 1.5 (0–9)
Follow up (mean, SD, range)	Months	17 ± 23 (2–100)
Follow up over one year (n, % of group)	Yes	43 (35.8)
	No	77 (64.2)

rotation injuries 24 had a documented stress test thus at least 20% of syndesmotic injuries occurred with supination fracture patterns.

Data collection was performed in May and June 2016 giving a maximum possible follow up of 73–99 months. Mean follow up was for 17 months (SD 23.4), 51 (42.5%) patients were discharged at the end of routine follow up at 12 weeks and 43 (35.8%) patients required follow up for over one year.

Lateral fixation was with a plate and screws or screws alone depending on fracture pattern and surgeon preference. 10% of fractures were treated with two syndesmosis screws. The most common method of sysndesmotic fixation was a single 3.5 mm sysdesmosis screw through three cortices used in 50 (42%) cases. A 4.5 screw was used in 32 (26.6%) cases due to surgeon preference. The mean distance of syndesmosis fixation from the joint line was 20.4 mm (Table 2).

The mean medial clear space was 3 mm (standard deviation (SD) 1.3). The mean tibio fibular overlap was 4.1 mm (SD 1.8) and the mean tibiofibular clear space was 3.8 mm (SD 1.7). Reduction of the syndesmosis was achieved in 75% of cases. The mean talocrural angle was 12 degrees (SD 3.4) and the "shenton's line" of the fibula was recreated in 66% of cases.

Screws were removed in 45 (37.5%)cases. 17 were for surgeon/patient choice and 28 were for clinical reasons (Table 2). These were pain [11], a block to dorsiflexion [11], malalignment of the syndesmosis [3] or persistent infection [3].

There were 18 complications. Seven cases required early revision surgery for malalignment and one case required revision surgery for deep infection. The decision for revision for malalignment was made by the treating consultant and was based on syndesmotic widening and fibular shortening. Six cases were revised for excessive syndesmotic widening and fibular shortening and one case was revised for fibular shortening alone. Five cases had superficial infections treated conservatively. Three patients developed superficial infection following screw removal. There was one case of foot drop following common peroneal nerve palsy of unexplained origin and one case of syndesmotic synostosis seen at four months after injury. Of note, this patients syndesmosis screw was placed 42.6 mm above the joint line, the highest in the series.

Clinically significant end stage osteoarthritis (cOA) was seen in 13 patients at a mean of 45 months. Five patients have had ankle arthrodesis and 8 are being treated conservatively. Initial univariate analysis was performed to look for significant associations. Radiological malalignment was a significant association, however talocrural angle and recreation of fibular "shenton's line" were not. Increasing age, open fracture, revision surgery, screw removal for clinical reasons and complications were also significantly

Table 2
Technical aspects of surgery and clinical outcomes.

Demographic	Descriptive	Cohort (n = 120)
Internal fixation	Single screw	34 (28.3)
Lateral side (n, % of total)	Two screws	12 (10)
	Plate and screws	74 (61.7)
Syndesmosis screw construct (n, % of total)	1 3.5 mm screw 3 cortices	50 (41.7)
	1 3.5 mm screw 4 cotices	26 (21.7)
	1 4.5 mm screw 3 cortices	19 (15.8)
	1 4.5 mm screw 4 cotices	13 (10.8)
	2 3.5 mm screw 3 cortices	8 (6.7)
	2 3.5 mm screws 4 cotices	4 (3.3)
Distance from joint line (mean, SD, range)	Mm	20.5 ± 7.6 (6–42.6)
Syndesmosis reduction (n, % of total)	Yes	90 (75%)
	No	30 (25%)
Talocrural angle (mean, SD, range)	Degrees	12 ± 3.4 (4–18)
Screw removal (n, % of total)	Yes	45 (37.5)
	No	75 (62.5)
Reason for removal (n, % of group)	Clinical	28 (61.4)
	Patient/surgeon choice	17 (38.6)
Revision (n, % of total)	Yes	8 (6.7)
	No	112 (93.3)
Reason for revision (n, % of total)	Malreduction	7 (5.8)
	Infection	1(0.8)
Complications (n, % of total)	Malreduction	7 (5.8)
	Infection	6 (5)
	Infection > screw removal	3 (2.5)
	Foot drop	1 (0.8)
	Synostosis	1 (0.8)
	Total	18 (15%)
Coa (n, % of total)	Yes	13 (10.8)
	No	107 (89.2)
Treatment of cOA (n, % of total)	Arthrodesis	5 (4.2)
	Conservative	8 (6.7)

Table 3
Predictors of cOA using univariate analysis.

Demographic	Descriptive	cOA (13)	No cOA (107)	Odds Ratio	95% CI		P value*
					Lower	Upper	
Gender (n, % of group)	Male	7 (10.8)	58 (89.2)	0.99	0.31	3.13	1.00
	Female	6 (10.9)	49 (89.1)				
Age (mean, SD)	Years	55 ± 14	41 ± 17		4	23.8	**0.006****
Open fracture (n, % of group)	Yes	4 (50)	4 (50)	11.4	2.44	53.6	**0.005**
	No	9 (8)	103 (92)				
Dislocation (n, % of group)	Yes	9 (16.7)	45 (83.3)	3.1	0.9	10.7	0.08
	No	4 (6.1)	62 (93.9)				
Lauge-Hansen classification (n, % of group)	PAB3	6 (16.7)	30 (83.3)	Ref			
	PER3	2 (6.1)	31 (93.9)	0.32	0.06	1.72	0.26
	PER4	2 (9.1)	20 (91.9)	0.5	0.09	2.73	0.67
	SER4	3 (10.3)	26 (89.7)	0.5	0.013	2.5	0.6
Lateral fixation (n, % of group)	1 screw	1 (2.9)	33 (97.1)	Ref			
	2 screws	2 (18.2)	9 (81.8)	7.3	0.59	90.3	0.14
	Plate	10 (13.3)	65 (86.7)	5.01	0.62	41.37	0.17
Syndesmosis	1 3.5 mm screw 3 cortices	6 (12)	44 (88)	Ref			
Screw	1 3.5 mm screw 4 cotices	3 (11.5)	23 (88.5)	0.9	0.22	4.2	1
Construct (n, % of group)	1 4.5 mm screw 3 cortices	0 (0)	19 (100)	0.9	0.794	0.98	0.18
	1 4.5 mm screw 4 cotices	1 (7.7)	12 (92.3)	0.61	0.07	5.58	1
	2 3.5 mm screw 3 cortices	2 (25)	6 (75)	2.44	0.4	15	0.3
	2 3.5 mm screws 4 cotices	1 (25)	3 (75)	2.27	0.2	26.3	0.47
Distance from joint (mean, SD)	Mm	24 ± 6.3	20 ± 7.7		-0.4	8.4	0.07**
True (n, % of group)	Yes	12 (13.2)	79 (86.8)	4.25	0.53	35.2	0.19
	No	1 (3.4)	28 (96.6)				
Reduction (n, % of group)	No	8 (26.7	22 (73.3)	6.18	1.8	20.8	**0.003**
	Yes	5 (5.6)	85 (94.4)				
Screw removal (n, % of group)	No	4 (5.3)	71 (94.7)	Ref			
	Choice	0 (0)	17 (100)	1.06	1	1.1	1
	Clinical	9 (32.1)	19 (67.9)	9	2.5	32.57	**0.001**
Revision (n, % of group)	Yes	5 (62.5)	3 (37.5)	21.7	4.4	107.5	**0.000**
	No	8 (7)	104 (93)				
Complications (n, % of group)	Yes	6 (33.3)	12 (66.7)	6.79	2	23.56	**0.004**
	No	7 (6.9)	95 (93.1)				
Surgeon grade (n, % of group)	Consultant	6 (13.3)	39 (86.7)	1.56	0.49	5	0.55
	Trainee	7 (9.3)	68 (90.7)				

The bold values merely indicate significant findings (significance greater than .05).
* Fisher's exact test unless otherwise indicated.
** Students independent t-test.

associated with cOA (Table 3). Independent predictors of cOA were identified using Cox regression analysis of the significant factors. Increasing age and malreduction were identified as independent predictors of cOA (Table 4).

4. Discussion

In a review of 120 patients with syndesmotic fixation in association with ankle fractures we report the following findings; at 7 years after injury cOA occurs in 11% of patients. Increasing age and malreduction of the syndesmosis are independent predictors of developing cOA. There is considerable variation in the technical aspects of syndesmotic fixation. At least 20% of syndesmotic injuries are associated with supination external rotation fractures This in in keeping with the modern literature [4,8].

Nearly a quarter of patients require screw removal for continuing symptoms. Revision surgery is most commonly due to malreduction of the syndesmosis. The only modifiable independent predictor of cOA is malreduction using the medial clear space, tibiofibular overlap and tibiofibular clear space as radiological measures. Talocrural angle and "Shenton's line" of the ankle do not predict cOA of the ankle.

In a study of 117 patients with 67% loss to follow up of 18 years Lambers et al. [24] showed degenerate changes in 49% of patients with 5% requiring arthrodesis. In our series of 120 patients similarly 4% have required an ankle arthrodesis but at only 7 years after injury. Small cohorts and loss to follow up may underestimate the poor prognosis of these injuries.

We found increasing age to be an independent risk factor for developing cOA. In a cohort of patients presenting with end stage post traumatic ankle arthritis at a mean of 20 years post injury, increasing age was not only found to be a risk factor for developing cOA but also for a decreased latency time between injury and presentation [25]. As our follow up was only for a maximum of 7 years a larger proportion of younger patients may go on to

Table 4
Cox regression analysis for predictors of cOA using enter methodology (including all significant variables in a single model).

Demographic	Descriptive	Hazard ratio	95% CI		p value
			Lower	Upper	
Age	Years	1.09	1.02	1.14	**0.006**
Reduction	Yes	Ref			
	No	45.5	4.4	500.0	**0.001**
Removal	No	Ref			
	Choice	0.0	0.0	0.0	1
	Clinical	1.5	0.3	6.9	0.59
Revision	No	Ref			
	Yes	1.9	0.14	26.0	0.63
Complications	No	Ref			
	Yes	3.9	0.31	48.4	0.29
Open fracture	No	Ref			
	Yes	1.5	0.2	12.5	0.74

The bold values merely indicate significant findings (significance greater than .05).

develop symptomatic arthritis and the eventual disease burden may be much greater.

The only modifiable risk factor for developing cOA was malreduction of the syndesmosis using radiological parameters. CT scanning can be used to accurately measure syndesmotic reduction [26], however, minor malreduction seen on postoperative CT scanning does not affect outcome [27] and intraoperative CT scanning does not reduce the rates of malreduction [28,29]. As malreduction using tibiofibular clear space, overlap and medial clear space as reduction parameters are associated with both poor clinical outcome [4] and per our study, risk of developing cOA, it stands to reason that readily available radiological measurements should be used to assess reduction. In cases where there is doubt of syndesmotic reduction intraoperatively, we now routinely use a 2–3 cm direct incision over the anterior syndesmosis to ensure that the distal fibula is accurately reduced into the incisura [26,29].

We acknowledge that there are limitation to our study. This was a retrospective case series with a heterogenous mix of fracture patterns, treated with a variety of techniques by a number of surgeons of different grades and experience. Nevertheless, we feel that this reflects practice in a large university affiliated teaching hospital. Although we had research ethics approval for this retrospective study we were unable to gain approval for prospective follow up so we could not collect patient reported outcomes or take up to date radiographs for all patients. Due to this limitation we are unable to comment on functional outcome or provide further information on underlying asymptomatic radiographic degeneration in our cohort.

Our study has a number of strengths. We had preoperative and postoperative radiographs for 86%(120/139) of consecutively presenting patients. This allowed for in depth radiological analysis of both fracture pattern and operative management and reduction. All included patients had detailed institutional records which are held indefinitely on electronic databases. This allowed us to present data regarding reasons for screw removal, complications and revision surgery. We had access to the national radiographic database of public hospitals [18] and used this to review all ankle radiographs up to the time of data collection including patients who had moved away from our region. All patients who presented for follow-up with end stage radiographic changes did so because their ankles were symptomatic so our results reflect real practice. Less than 10% of the population has some form of private health insurance [30] and as healthcare is free at the point of delivery in Scotland, there are no financial barriers to seeking orthopaedic assessment and management and data from most symptomatic patients would have been collected.

In conclusion, ankle fractures requiring syndesmotic fixation are severe injuries. Less than half of patients are discharged at the end of routine follow up, over a third of patients require follow up for over a year and nearly a quarter of patients have ongoing symptoms requiring removal of metalwork. Syndesmotic injuries cannot be reliably predicted by fracture pattern alone and attention to the radiological parameters of syndesmotic reduction and intraoperative stress testing [31,32] to assess syndesmotic stability should be utilised. According to the results of this study the main cause of revision surgery and the only modifiable independent predictor of cOA is radiological malalignment. Over 10% of patients will have cOA at 7 years post injury. Careful intraoperative assessment and open reduction of the syndesmosis in doubtful cases may reduce the risk of longterm complications.

Conflict of interest

The authors declare no conflict of interest.

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