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Total talar fracture – Long-term results of internal fixation of talar fractures. A multicentric study of 114 cases

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KEYWORDS

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Outcomes

Summary

Introduction: Displaced talar neck and body fractures are rare and challenging for the surgeon. Results are often disappointing due to inadequate reduction or internal fixation and high rates of osteoarthritis and osteonecrosis. Very few published series describe the long-term results after internal fixation of talar fractures. One of the goals of the 2011 SOO meeting symposium was to specifically evaluate the long-term results after internal fixation of talar fractures. This study included only central fractures.

Material and methods: We reviewed the results of 114 central talar fractures that had been treated by internal fixation between 1982 and 2006 in nine hospitals in the Western part of France. The clinical and radiological follow-up was 111 months on average. All the patients with a radiological assessment had at least 5 years of follow-up.

Results: Poor reduction was apparent in 33% of cases. The average Kitaoka score was 70/100, which corresponds to an average functional level. At the last follow-up evaluation, 34% of cases had osteonecrosis and 74% had peritalar osteoarthritis. Secondary fusion was required in 25% of cases with an average follow-up of 24 months.

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Discussion: The complication rate for talar fractures was high, mostly due to osteonecrosis and osteoarthritis; these conditions had an impact on the final outcome. The outcome could be improved by better evaluating these fractures with a CT scan, developing dual surgical approaches to best preserve the bone vascular supply and achieve better reduction, and improving the internal fixation hardware, especially the use of plates for comminuted fractures.

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Introduction

Talar neck and body fractures are rare; they make up 0.5% of all fractures and 3% of foot fractures [1]. Surgical treatment is a challenge for the surgeon: analysis of the fracture pattern, choice of approaches and choice of internal fixation hardware.

Very few published series have described the long-term results after internal fixation of talar fractures [2–5]. One of the goals the SOO symposium was to specifically evaluate the long-term radiological and clinical results after internal fixation of talar fractures.

Materials and methods

This is a retrospective study performed at nine hospitals in the Western part of France, including nine university hospitals. We were specifically interested in the outcome of central fractures with at least 2 years of follow-up. Our centres had 287 of these fractures, of which 48 were treated conservatively. Only fractures that had been treated with internal fixation and had at least 5 years follow-up were included in the current study. If an internal fixation case was subsequently revised with fusion before 5 years it was included. The follow-up for these cases ended on the fusion date, which sometimes resulted in the follow-up time being less than 5 years. Cases with partial or osteochondral fractures of the talus, visible epiphyseal cartilage, primary peritalar fusion or talectomy were excluded.

Thus, 162 fractures were included. Forty-four patients were lost to follow-up and four died before the 5-year follow-up period. Thus we reviewed 114 talar fractures that were treated by internal fixation in 111 patients (36 women and 75 men). These cases were distributed throughout the participating centres (Table 1).

The average follow-up was 111 months, with a median value of 91 months; the minimum was 7 months (one case of early secondary fusion) and the maximum was 351 months.

The average age at the time of injury was 34 years (range 15–71). The injury mechanism was a motor vehicle accident in 62 cases, a fall in 39 cases, a sports injury in four cases and other trauma in six cases.

We first classified the fractures according to Inokuchi et al. [2], who defined talar body fractures as having a fracture line posterior to the lateral process of the talus on the inferior face of the talus; neck fractures are those located in front of this process. Based on these criteria, there were 53 neck fractures and 61 body fractures. Among these, the upper part of the fracture line went through the neck and the lower part went through the body in 28 cases; we labelled these as neck-body fractures. Thus there

Table 1 Patient sources.

Centre	Surgeon	Number of cases
Rennes	D. Hutten	29
Tours	P. Rosset and L. Favard	17
Brest	C. Lefèvre	15
Nantes	F. Gouin	14
Quimper	G. Allard	11
Poitiers	L.E. Gayet	10
Angers	P. Bizot	10
Rouen	F. Dujardin	5
Caen	C. Hulet	3

were 53 neck fractures, 33 body fractures and 28 neck-body fractures.

Although the Hawkins classification [3], as modified by Canale and Kelly [4], was only intended to be used with neck fractures, we used it with all the fractures to determine the displacement. There were 33 Hawkins Type I fractures, 48 Type II fractures, 29 Type III and four Type IV fractures.

The open fractures were classified according to Gustillo [5], with seven in Stage I, 13 in Stage II and two in Stage IIIA.

The posterior tibial vascular pedicle was involved in three cases, the posterior tibial artery alone in one case and the anterior tibial vascular pedicle in one case; in none of these cases was the foot completely devascularized.

There were associated skeletal lower leg injuries in 54% of cases: medial malleolus fracture (11%), bimalleolar fracture (6%), lateral malleolus fracture (6%), calcaneal fracture (6%). In 8% of cases, the patients had suffered multiple trauma, thus injuries were present in other locations.

For each patient, the time before the injury was treated, the approach routes, the type of internal fixation used and any complications (infection, complex regional pain syndrome, osteonecrosis, non-union and osteoarthritis) were recorded.

The outcome was evaluated using the Kitaoka score out of 100 points [6], which takes into account pain (45 points), function (40) and alignment (15 points). A score between 95 to 100 was considered excellent, 80 to 94 was good, 50 to 79 was average and under 50 was poor. The overall satisfaction with the final outcome was assessed on a five-point scale: 1 (very satisfied), 2 (satisfied), 3 (average), 4 (dissatisfied) and 5 (very dissatisfied).

The quality of the reduction was evaluated on X-rays a short time after surgery. Any offset of more than 2 mm or angulation of more than 5° between the fragments was labelled a poor reduction.

Necrosis of the talus was evaluated on A/P X-rays at week 6 (sometimes with the leg still in a cast) and then on X-rays

at the last follow-up visit; an MRI was performed in six cases. The Hawkins sign consists in the appearance of subchondral bone resorption in the body of the talus on A/P X-rays without a cast at 6 weeks post-injury, which indicates that the talus is well vascularized. The absence of the Hawkins sign at that time point suggests the presence of osteonecrosis. At the last follow-up, we differentiated between necrosis without collapse (sclerosis with and without geodes) and necrosis with collapse of the talar dome.

Post-injury peritalar osteoarthritis was determined based on X-rays taken at the last follow-up visit. The arthritis was not classified based on its severity.

Statistical evaluations were performed with tests suitable to the sample size and any differences were determined with a 5% chance of making a Type I error ($P < 0.05$).

Results

Clinical results

The procedure occurred within 24 hours of the fracture in 81% of cases. In 7% of cases, more than 1 week passed because of a skin problem.

An anterior approach was used in 35 cases, anteromedial in 28 cases, anterolateral in 14 cases, posteromedial in four cases, posterolateral in four cases and percutaneous in six cases. When dual approaches were used, the anteromedial and anterolateral approaches were combined in 10 cases and other approaches in 12 cases. In three cases, an osteotomy of the medial malleolus was performed because of body fractures or neck-body fractures. In 13 cases, the medial malleolus fracture was used to approach the fracture site (trans-fracture approach).

Fixation was performed with K-wires in 24 cases, screws in 86 cases, an external fixator in three cases and a plate in one case. The anterior and posterior tibial pedicles were not subjected to a procedure.

All the patients were casted, except for those with an external fixator. The average duration of no weight-bearing after the surgical procedure was 83 days. Seventeen patients presented with symptoms suggestive of complex regional pain syndrome not long after the procedure.

Complications such as infection, osteonecrosis, osteoarthritis and non-anatomical reduction occurred and required an additional procedure:

- nine times before month 3: four for skin coverage (three skin grafts and one free gracilis flap), two because of infection (excision, lavage and drainage), three because of secondary displacement or poor reduction (revision of fixation);
- 45 times after month 3 (39.5% of cases): 40 for removal of fixation hardware, three for removal of foreign bodies (two via arthroscopy), two for ankle arthrolysis;
- 29 fusions (25.4% of cases) were performed at month 24 on average (range 7–90) because of osteonecrosis in 14 cases, osteoarthritis in 13 cases and infection in two cases. Of these fusions, 10 were subtalar, nine were talocrural, two were talonavicular and eight were mixed. Beforehand, these had been six Type I fractures, nine Type II fractures, 12 Type III fractures and two Type IV fractures.

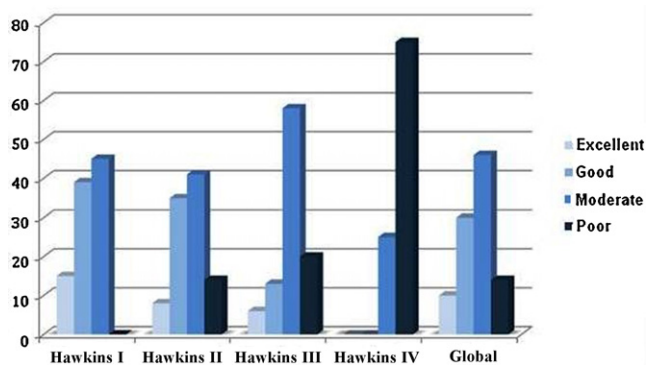


Figure 1 Kitaoka score as a function of the Hawkins grade.

Functional results

The average Kitaoka score was 70 (range 9–100). The average range-of-motion for the tibiotalar joint was 8° in extension and 26° in flexion. The subtalar range-of-motion was reduced in 61% of cases, but we could not determine to what extent.

Satisfaction scores were distributed in the following manner:

- very satisfied: 10%;
- satisfied: 36%;
- average: 40%;
- dissatisfied: 14%.

The Kitaoka score was affected by the Hawkins fracture type in a statistically significant manner (Fig. 1). The Kitaoka score decreased from Type I to Type IV fracture ($P = 0.036$). Conversely, the approach had no effect.

Radiological results

A preoperative CT scan was performed in 25% of fractures (Fig. 2). The reduction was labelled as poor in 33% of cases (Fig. 2). We found that reduction quality was worse when K-wire fixation than when screws were used ($P = 0.012$). At the same time, the average Kitaoka score for K-wire fixation (56) being lower than the score for screw fixation (75) ($P = 0.002$). Note that for the entire series, the quality of the reduction had no effect on the Kitaoka score ($P = 0.313$). On the other hand, the type of approach did not affect the quality of the reduction.

Osteonecrosis of the talus was a long-term complication in 39 cases (34%), with the Hawkins signs having a sensitivity of 91% and a specificity of 59%. Osteonecrosis occurred more often in cases of a combination neck-body fractures, than in cases of isolated body or neck fractures ($P = 0.004$). In 41% of cases, the osteonecrosis was symptomatic, with a Kitaoka score that was statistically lower than in cases without osteonecrosis ($P = 0.015$). The talar dome had collapsed in eight cases. The Kitaoka score was very low in cases of osteonecrosis with collapse (average of 45.5/100), while it was average (70/100) in cases of osteonecrosis without collapse ($P = 0.004$).

At the last follow-up visit, osteoarthritis was present in 74% of cases: 32% in the subtalar joint, 28% in the



Figure 2 A 35-year-old male, motorbike accident, Type II neck fracture. The preoperative CT scan showed that the distal fragment was rotated, which was not visible on standard X-rays. Poor fracture reduction can be seen on the postoperative CT scan (the subtalar dislocation was not completely reduced).

talocrural joint, 4% in the talonavicular joint and 36% in two or more of the peritalar joints (Fig. 3). There was a trend towards a higher frequency of osteoarthritis with a higher Hawkins fracture grade ($P=0.06$) (Table 2). The osteoarthritis rate was 64% after an isolated talus injury and 78% in cases with associated skeletal injuries (difference not significant). Osteoarthritis was more common after fixation with K-wires (87%) than screws (68%), which goes hand in hand with the reduction not having been as good, as noted above

($P=0.075$). The Kitaoka score was 80 in cases of osteoarthritis and 67 when no arthritis was present ($P=0.002$).

The chosen approach (anterior, anteromedial, dual) did not have an effect on the osteonecrosis and osteoarthritis rates.

Overall, the survival was 74% at 10 years when using fusion as the event of interest (Fig. 4). As shown in Fig. 4, almost all the fusions were performed before year 5 (28 of 29 cases).

Table 2 Results as a function of the Hawkins classification.

	Hawkins 1	Hawkins 2	Hawkins 3	Hawkins 4	<i>P</i> value
Number of cases	33	48	29	4	
Poor reduction	24% (8)	37% (18)	38% (11)	0	
Infection	1	2	3	0	
Complex regional pain syndrome	2	21% (10)	14% (4)	25% (1)	
Osteonecrosis	15% (5)	35% (17)	48% (14)	75% (3)	0.008
Osteoarthritis	60% (20)	75% (36)	83% (24)	100% (4)	0.06
Average Kitaoka score	78.3	70.8	63.4	43.2	0.056
Fusion	18% (6)	19% (9)	41% (12)	50% (2)	



Figure 3 A 27-year-old male, motorbike accident; Type I fracture. Anterior approach; reduction seems to be good. At 5 years post-surgery: Kitaoka score of 82, subtalar and talocrural osteoarthritis.

Discussion

The distinguishing feature of this study was the fairly long follow-up (average of 9.3 years) done on more than 100 cases of central talar fractures treated by surgical fixation. Few published series have reported on such long-term results. The studies published by Ohl et al. (20 cases) [7], Saudan

et al. (40 cases) [8], and Canale and Kelly (71 cases) [4] had a follow-up of 7.5, 9 and 12.7 years, respectively. However, the number of patients in these series was less than in our series, and Saudan et al. and Canale and Kelly had included conservative treatments in their series (11 and 38 cases, respectively).

A CT scan was performed before surgery in only 24% of cases in our series; we now systematically request this imaging mode with our patients. The fracture pattern and the fracture displacement can better be analysed on a CT scan (Fig. 2) and it is easier to plan the surgical fixation [9].

It is difficult to assess the quality of the reduction intra-operatively and on postoperative X-rays. Rotation errors are particularly hard to pick up [9]. This likely had a significant influence on the osteoarthritis rate, but we were not able to prove it in this study. Adelaar suggested that a surgical revision was necessary if the reduction was defective by more than 5 mm or 5° [10]. A postoperative CT scan could be requested in uncertain cases to quickly diagnose any poor reduction, help with the prognosis and then schedule a potential surgical revision.

Multiple surgical approaches were used, but we could not find a difference between them. The anterior approach does not provide good exposure and increases the likelihood of poor reduction [9] and devascularisation [9]. A

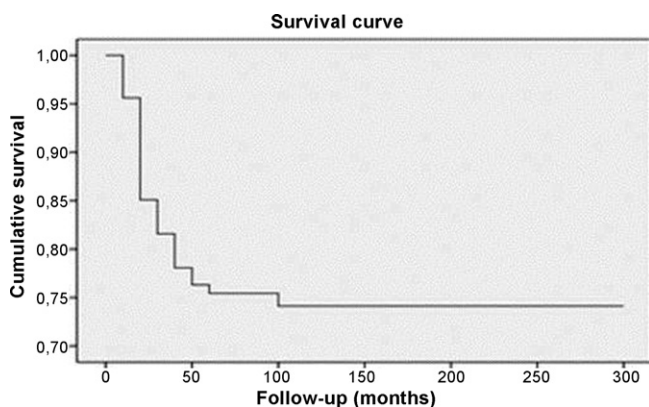


Figure 4 Overall survival curve.



Figure 5 A 22-year-old woman, fall from a height; Type III fracture. Dual approaches (anteromedial and anterolateral); anatomical reduction. At 5 years post-surgery: Kitaoka score of 90, osteonecrosis and talocrural osteoarthritis.

dual approach would provide better control during reduction because the medial and lateral faces of the talar neck are exposed and less of the blood supply is removed from the talar fragments [9], however experience is required to use the dual method. The posterior approach, which was not used often in our series, provides good stability during posterior to anterior screw placement [11–13], but there is a risk that the screw could penetrate into the subtalar joint or tarsal sinus. The medial transmalleolar approach was used 16 times in our series (13 times via a fracture and three times with an osteotomy) in cases of talar body fractures. A medial malleolus osteotomy was suggested by other surgeons for this type of fracture [14], especially in cases of comminutive fractures, because it provides good exposure of the medial aspect of the talus.

Screws were used most often in our series, however they can induce excessive compression in cases of comminuted talar neck fracture [9]. Internal fixation with a plate provides better control over the comminuted fracture site and restores the length of the talus, especially on the medial aspect of the neck. Varus reduction errors could be avoided [15]. However, this fixation technique was only used once in our series.

The average Kitaoka score in our series was 70/100, which corresponds to an average functional score. The Hawkins fracture type and the presence of osteonecrosis or osteoarthritis had a direct effect on this score. The score was better in cases of a body fracture than in cases of a

neck fracture or combined neck-body fracture, as previously demonstrated by Elgafy [16]. This could be due to combined neck-body fractures being heterogeneous and difficult to reduce because of their comminuted nature.

Our rate of osteonecrosis (34%) and its distribution relative to Hawkins fracture type is consistent with published data. The presence of osteonecrosis was not systematically associated with poor clinical results because 59% of patient with osteonecrosis were asymptomatic (Fig. 5). Any collapsing of the talus resulted in a significant drop in the Kitaoka score. The Hawkins sign had a sensitivity of 91% in our study. Thus the Hawkins sign is a good indicator of talus blood supply at 6 weeks [17]. MRI, which was not often performed in our series, is typically done later on. It allows the volume and exact location of the osteonecrosis to be determined, as long as the fixation hardware is made of titanium (which regrettably was not the case in our series) or has been removed [18,19]. We did not find that the surgical approach used had an effect on the osteonecrosis rate. However, the published literature emphasizes that the anterior approach results in devascularisation; this approach is well known and was used most often our series [20].

Our lengthy follow-up allowed us to find a high rate of osteoarthritis (74%) at our last follow-up, with the subtalar joint most often involved. This rate is consistent with reported osteoarthritis rates of 78 to 100% in the long-term (Table 2). There was a trend towards a higher frequency of osteoarthritis with a higher Hawkins fracture

Table 3 Kitaoka score and osteoarthritis rates in various talar fractures series where internal fixation was used.

Series	Number of cases	Average follow-up in months	TC osteoarthritis (%)	ST osteoarthritis (%)	Kitaoka
Sanders et al. [22]	70	62	40	78	71/100
Lindvall et al. [21]	26	74	61	100	61/100
Ohl et al. [7]	20	90	76	86	67/100
Current series	114	111	41	50	70/100

grade ($P=0.06$). Among other factors that could affect the occurrence of osteoarthritis, we found K-wire fixation which provides less stability than screw fixation [11,12]. K-wire fixation had more reduction defects and fewer good functional results. However, this observation must be tempered because K-wire fixation is more commonly used with comminuted fractures, which are harder to access with a screw; this may have distorted the analysis.

Ankle and hindfoot trauma were common in our study. The possibility that these injuries can lead to osteoarthritis must also be taken into consideration. In our series, only 46% of the fractures were isolated; among these fractures, the osteoarthritis rate was 64% (mainly subtalar). This rate might appear to be high, but in a series of 26 isolated talar neck or talar body fractures, Lindvall et al. found a 100% rate of subtalar osteoarthritis at an average follow-up of 74 months, which is similar to ours. This observation suggests that the potential for arthritis is high for these talar fractures [21] (Table 3).

In our series, 29 fusions (25.4% of cases) were performed at 24 months on average, and most were performed within 5 years of the initial injury. Fusion was required more often in cases of Type II, III, IV fracture-dislocations (nine, 12 and two cases, respectively). These patients presented with osteonecrosis, osteoarthritis or infection. Primary fusions were excluded from this series. This procedure is not well standardized; it is poorly documented and apparently has disappointing functional outcomes [3,4,22–24]. Its role in emergency wards seems to be very limited. It could be indicated in cases of highly comminuted fractures that cannot be accessed for internal fixation and/or significant skin damage without adequate coverage solutions [25,26].

Conclusion

This study confirms the significant challenges associated with treating displaced talar neck and body fractures, as these often have average long-term functional and radiological results. This could explain our high rate of complications including non-anatomical reduction (33%), osteonecrosis (34%) and osteoarthritis (74%).

Given the limitations of our series, it seems logical to recommend the following actions to reduce the frequency of these complications:

- systematic preoperative CT scan to fully analyse the fracture line and fracture displacement;
- dual approach routes that would better preserve the soft tissues and provide a more precise reduction, as long as the technique has been learned beforehand;

- stable fixation with screws in cases of simple fractures and plates in cases of comminuted fractures.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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