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Long-term follow-up after surgical treatment of talar fractures

Twenty cases with an average follow-up of 7.5 years

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Abstract Displaced talar neck and body fractures are rare and serious injuries with important outcomes. The aim of our study was to evaluate the long-term outcomes of these fractures after operative treatment in our centre between 1993 and 2005. Displaced talar fractures have a high rate of long-term complications. This was a retrospective study concerning 20 patients with an average follow-up of 7.5 years. The final follow-up examination included determination of the AHS score (ankle–hindfoot scale) from the American Orthopaedic Foot and Ankle Society (AOFAS), range of motion evaluation and radiological analysis. Mean age at the time of trauma was 38.8 years. This study comprised ten talar neck fractures and ten talar body fractures. We always used a single surgical approach and obtained anatomical reduction in 30% of the whole series of both groups. Four early complications were noted in four patients (20%). We noted no skin complications and the rate of consolidation was 100%. Four patients (20%) developed avascular necrosis of the talus, and at final follow-up seven patients (35%) had undergone secondary surgery. Radiographic analysis showed an osteoarthritis rate of 94% and a malunion rate of 59%. The mean AOFAS score was 66.9/100 and range of motion was systematically decreased. Contrary to undisplaced talar fractures, displaced talar fractures are a therapeutic challenge with many early or late complications. The outcome often revealed stiffness and osteoarthritis.

Therapeutic study, Level IV

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Introduction

Talar fractures are rare and represent 3% of foot fractures [1]. The fractures are severe and occur after high energy trauma with frequent associated injuries. Talar neck or body fractures arise from an excessive dorsiflexion of the foot with an axial compression [2–4]. Many authors recommend conservative treatment for undisplaced talar fractures, but displaced fractures require stable fixation and early physiotherapy [3–7].

Avascular necrosis, malunion and osteoarthritis are the most frequent complications with variable incidences in the literature. Follow-up periods in most studies are too short to analyse precisely those complications.

The purpose of this retrospective study was to evaluate clinical and radiological outcomes with a long follow-up of displaced and operatively-treated talar fractures.

Materials and methods

Description of patients

We limited this study to displaced talar neck or body fractures treated operatively between 1993 and 2005 and reviewed with more than two years follow-up. Undisplaced talar fractures with conservative treatment and isolated peripheral fractures of the talus (lateral or posterior process, osteochondral fractures) were excluded.

Twenty-six patients were included in this study, of which 20 were reviewed in 2007 by an independent observer (one patient was dead, one had undergone amputation and four patients were lost to follow-up). Among the reviewed patients, there were 12 men and eight women with an average age of 38.8 years (range 17–76 years). High-energy injury occurred in most of the cases (ten road traffic accidents and seven falls from height).

Preoperatively, X-rays and CT-scans were used to locate talar neck and talar body fractures. Talar neck fractures were defined as fractures anterior to the lateral process, whereas talar body fractures were defined as fractures extending to the lateral process or posterior to it [8]. Talar neck fractures were classified according to the Hawkins classification [2] modified by Canale and Kelly [9]. For talar body fractures, we distinguished coronal and sagittal fractures. There were ten talar neck fractures and ten talar body fractures. Six fractures were open (30%) and classified according to Gustilo (two type I, three type II and one type IIIa) [10].

There were no preoperative nerve or vascular injuries. Nine patients presented an associated injury of the ipsilateral ankle including six distal tibia fractures and three lateral malleolar fractures. Patient data can be found in Table 1.

Surgical procedures

Thirteen patients (including six open fractures) underwent operative treatment within 12 hours, while the others were treated after 24 hours (transfer in our institution or soft tissue recovery).

All patients were positioned supine on a radiolucent table and a tourniquet was applied. Manipulative reduction

Table 1 Demographic data, fracture type, procedures and AOFAS score

Patient number	Gender, age (years)	Type of fracture	Initial reduction	Early complication	Indication for secondary surgery	Secondary surgery	Hindfoot alignment	AOFAS score
1	F, 76	Neck (III)	Poor				12° valgus	64
2	M, 41	Body (sagittal)	Nearly anatomical		AVN	TT arthrodesis	N/A	56
3	M, 57	Body (sagittal)	Nearly anatomical	Superficial infection	AVN (failure of a TAA at 4 years)	TC arthrodesis	N/A	64
4	M, 35	Body (coronal)	Nearly anatomical				3° valgus	77
5	M, 34	Neck (III)	Anatomical		Stiffness	Arthrolysis	2° varus	72
6	M, 61	Body (coronal)	Anatomical				0°	56
7	M, 27	Body (sagittal)	Nearly anatomical		Osteochondral fragments	Arthroscopy	4° valgus	64
8	M, 26	Neck (III) Gustilo I[a]	Nearly anatomical				0°	64
9	M, 30	Neck (IV) Gustilo IIIa[a]	Poor		AVN	ST arthrodesis	10° valgus	49
10	F, 54	Neck (II)	Nearly anatomical				4° varus	61
11	M, 20	Neck (IV)	Anatomical				4° valgus	68
12	M, 25	Neck (II)	Poor				3° valgus	79
13	F, 21	Neck (III) Gustilo II[a]	Poor	Initial lack of reduction	Arthritis and malunion	ST arthrodesis and osteotomy	8° varus	59
14	F, 32	Body (sagittal)	Anatomical				6° valgus	88
15	M, 22	Body (sagittal)	Nearly anatomical				8° valgus	71
16	F, 59	Body (coronal) Gustilo II[a]	Anatomical				7° valgus	60
17	M, 17	Body (coronal) Gustilo I[a]	Poor				6° valgus	81
18	F, 50	Body (sagittal)	Nearly anatomical	Initial lack of reduction			8° valgus	75
19	F, 43	Neck (II)	Anatomical				0°	85
20	F, 47	Neck (III) Gustilo II[a]	Nearly anatomical	Secondary displacement	AVN	TC arthrodesis	N/A	45

AOFAS American Orthopaedic Foot and Ankle Society, *F* female, *M* male, *AVN* avascular necrosis, *TAA* total ankle arthroplasty, *TT* tibiotalar, *TC* tibiotalocalcaneal, *ST* subtalar, *N/A* not available (hindfoot alignment was not measured)

[a] Open fractures according to the Gustilo classification [10]

was always attempted initially under fluoroscopy. If the reduction was satisfactory, a percutaneous fixation with two or three K-wires (four patients) was done. In cases of unsatisfactory reduction a surgical approach was made depending on the fracture localisation (Table 2). Two medial malleolar osteotomies were performed via a postero-medial approach for two talar body fractures in order to increase the visualisation of the talus.

No dual approaches were used in this study. All open wounds were initially debrided and irrigated according to a local protocol. No arthroscopic techniques were used in this study.

The choice of the osteosynthesis material was made according to the size of the fragments and to the stability of the reduction. K-wires were used in 40% of cases (eight patients), cannulated screws (3.5 mm or small Herbert screws) in 35% (seven patients), and a combination of K-wires and screws in 25% (five patients). Mini-plates were not used and no bone grafting was used in this series.

All patients were immobilised in a non-weight-bearing cast in neutral alignment for a period of three months. Progressive weight-bearing combined with physiotherapy was started after this period.

Postoperative evaluation

On postoperative radiographs, we evaluated the quality of reduction in the anteroposterior and lateral views according to the criteria proposed by Lindvall et al. [11]. An anatomical reduction meant that there was no step-off at the neck or body and no frontal angulation. A nearly anatomical reduction was defined as a 1- to 3-mm step-off of any fracture fragment or slight varus angulation (≤5°). A poor reduction was an articular or neck mismatch, a step-off or gap of >3 mm, or neck angulation of >5° [11]. Analysis of the subtalar joint was also used to rate the quality of the reduction.

Radiographs of the foot and ankle were made at approximately six-week, 12-week, six-month, and twelve-month intervals postoperatively and were used to look for a secondary displacement, time to union and avascular necrosis. Osteonecrosis was defined on plain radiographs as any area of increased density of the talar dome relative to the adjacent structures (Hawkins sign) [2, 12]. No magnetic resonance imaging (MRI) was used to diagnose avascular necrosis.

At final follow-up, anteroposterior, lateral and mortise radiographs were made. Hindfoot alignment was measured [13] and was considered:

- Normal between 4° and 8° of valgus
- A varus malunion if the angle was inferior to 4° of valgus
- A valgus malunion if the angle was superior to 8° of valgus

The hindfoot alignment was not measured in cases of tibiotalar or tibiotalocalcaneal arthrodesis.

Post-traumatic osteoarthritis was defined as any loss of joint space, formation of osteophytes, or development of subchondral sclerosis or cysts. We noted which joint was affected by osteoarthritis (subtalar, tibiotalar or talonavicular joint).

At final follow-up, clinical examination was made in our institution by an independent observer and all subjects gave their informed consent prior to their inclusion in the study. Range of motion (ROM) was assessed with a goniometer, and the American Orthopaedic Foot and Ankle Society (AOFAS) ankle–hindfoot score [14] was also determined. This scoring system classified the evaluated items into three major categories: pain, function and alignment. In this scale, 50 points were assigned to function, 40 points to pain, and ten points to alignment. Usually, a score between 90 and 100 is excellent, 75–89 good, 50–74 fair and <50 poor [15, 16]. The subtalar joint mobility was evaluated with the ankle in the neutral position. Normal or mild restriction (75–100% normal) was assessed three points, moderate restriction (25–74% normal) was assessed two and severe restriction (less than 25% normal) was assessed one point.

Statistical analysis was performed with the SPSS software package (SPSS Inc., Chicago, IL). The chi-square test and Fisher′s exact test were used to analyse qualitative data. When quantitative values were evaluated, ANOVA and Kruskal-Wallis tests were performed to determine significance. A p value of 0.05 or less was considered significant.

Table 2 Surgical approaches according to the fracture type

Fracture type	Antero-medial	Antero-lateral	Postero-medial	Percutaneous
Talar neck fracture	8	0	1	1
Talar body fracture	1	3	3	3

Results

The minimum follow-up was 24 months with an average follow-up of 90 months (±36 months). Postoperative radiographic analysis confirmed the difficulty of obtaining an anatomical reduction for talar neck or body fractures. Reduction was anatomical in six cases (30%), nearly anatomical in nine cases (45%) and poor in five cases (25%).

Early complications

Four patients (20%) presented an early surgical complication (in the first three months) (Table 1). Two patients presented an initial lack of reduction: one of these patients underwent a second surgery to improve the reduction (on the second day) and the other was paraplegic and has not been revised. One secondary displacement occurred after fixation with K-wires and screws and the patient underwent revision surgery (on the fifth day) with anatomical reduction. One patient developed an early superficial infection and required surgical irrigation and debridement and appropriate antibiotic treatment.

There was no skin necrosis and nonunion was not observed.

Three medical complications occurred in the postoperative period: two reflex sympathetic dystrophies and one deep vein thrombosis. All patients recovered with medical treatment.

Late complications

Avascular necrosis of the talus

Four patients (20%) presented an osteonecrosis of the talus; two of them occurred after a closed talar body fracture and two after an open talar neck fracture (one type III and one type IV) (Table 1). The radiographic finding of osteonecrosis was made within the first six months after injury (mean of 9.8 months and range 6–15 months).

No signs of revascularisation were seen despite the non-weight-bearing cast for three to six months, and those four patients needed secondary surgery.

Secondary surgery

At final follow-up, seven patients (35%) had undergone secondary surgery (Table 1).

Among the four patients who developed avascular necrosis of the talus, one patient underwent a subtalar arthrodesis at 15 months. Three patients who developed a major collapse of the talar dome underwent secondary surgery: one tibiotalar arthrodesis at 16 months, one tibiotalocalcaneal arthrodesis at seven months and another tibiotalocalcaneal arthrodesis at four years after the failure of a total ankle arthroplasty. Tibiotalar arthrodeses were fixed with internal screws, and tibiotalocalcaneal arthrodeses were performed with a retrograde intramedullary nail.

One patient with an initial lack of reduction required an osteotomy for a serious valgus malunion associated with a subtalar arthrodesis at five months.

One patient required an ankle arthrolysis at ten months and another underwent an ankle arthroscopy at 12 months to excise osteochondral fragments.

Post-traumatic osteoarthritis

At final follow-up, 94% of the patients presented post-traumatic osteoarthritis in at least one ankle joint. Subtalar arthritis affected 87% of the patients (14 in 16), 76% of patients developed tibiotalar arthritis (13 in 17) and talonavicular arthritis affected 20% of patients (4 in 20).

Malunion

Seven patients (41%) had a normal hindfoot alignment at final follow-up. In eight cases (47%) there was a varus malunion (from 8° of varus to 3° of valgus) and in two cases there was a valgus malunion (10° and 12° of valgus) (Table 1). Hindfoot alignment was not measured in cases of tibiotalar or tibiotalocalcaneal arthrodesis (three patients).

The fracture type (neck or body) significantly influenced the malunion rate. Varus malunion was found in 67% (six of nine cases) of the talar neck fractures and in 25% (two of eight cases) of the talar body fractures ($p<0.04$).

The quality of the initial reduction also influenced the malunion rate. At final follow-up, the hindfoot alignment was normal in 50% of the anatomical reductions and in 36% of the nearly anatomical or poor reductions (this difference was not significant $p=0.48$).

We studied the influence of the osteosynthesis material type on the malunion rate at final follow-up. In our study, after using compression screws (alone or with K-wires), we noted seven varus malunions (78%) and two normal hindfoot alignments (22%) at final follow-up. With K-wires we assessed five normal hindfoot alignments (63%), two valgus malunions (25%) and one varus malunion (12%) ($p<0.05$).

Clinical outcomes

Using the AOFAS ankle–hindfoot scale, the average functional score was 67 points (range 45–88 points). Results were good in seven cases, fair in 11 and poor in two cases. There was no excellent result. The average pain score was 25±5.1 points, function score was 35±7.8 points and the alignment score was 7±2.9 points.

Comparisons between clinical and radiological data and functional outcomes are showed in Table 3. The AOFAS score was not significantly different in relation to the fracture type (64.6 for the talar neck fractures and 69.2 for the talar body fractures and $p=0.39$).

At final follow-up the injured foot demonstrated a significant loss of range of motion ($p<0.01$) compared to the healthy foot for ankle dorsiflexion (7.6° against 17.0°), ankle plantar flexion (24.0° against 32.0°) and subtalar movements (1 point in eight cases, 2 points in six cases and 3 points in two cases).

Table 3 Comparison between clinical and radiological data and functional outcomes (AOFAS score)

Outcomes	Yes	No	*p* value
Initial anatomical reduction	71.5	64.9	0.26
Early complication	60.8	68.4	0.11
Initial skin injury	59.7	70.0	0.06
Malunion	66.6	72.4	0.12
Presence of an arthrodesis	58.0	70.7	<0.05

AOFAS American Orthopaedic Foot and Ankle Society

With the numbers available, we did not find any correlation between stiffness and fracture type, osteosynthesis type or initial quality of reduction.

Discussion

In 1919, Anderson described for the first time a series of fracture dislocations of the talus after aircraft crashes and described the mechanism of injury. He called this injury *aviator's astragalus*. In 1952, Coltart collected a larger series after World War II and attempted to classify these fractures and to track their outcomes [17]. Such fractures classically result from high-energy trauma to the lower extremities such as that which occurs in airplane crashes, motor vehicle accidents or falls from a height [18]. The most commonly proposed mechanisms are an excessive ankle dorsiflexion with a cantilever effect for the talar neck fracture and an axial compressive load for the talar body fractures [4, 6, 7, 18, 19].

The management of these fractures is complex and there is a high complication rate. Undisplaced talar neck or body fractures are treated conservatively in most cases with very good results. However, for displaced fractures, open reduction and internal fixation is the rule for most authors [3, 5, 6, 11, 20].

In this retrospective study of displaced talar fractures, we preferred a fast and slightly aggressive operative treatment to avoid wound complications and avascular necrosis. However, we noted a high rate of surgical failure (two initial lack of reduction and one secondary displacement) and only 30% anatomical reduction.

For a better initial reduction, some authors recommend a dual anteromedial and anterolateral approach. This dual approach is sometimes associated with a medial malleolar osteotomy [7, 21]. This technique permits good visualisation of the talus but increases the risk of skin necrosis or infection (10–20% depending on authors) and increases the duration of surgery [21, 22]. In our experience, no dual approach was used and fractures were treated through a single approach and sometimes in a percutaneously. This would explain the low rate of infection in this study (5%).

Avascular necrosis is a common complication after talar fractures. In recent papers, the osteonecrosis rate was variable from 11–50% [11, 12, 18, 23, 24]. All authors agree that initial degree of fracture displacement is an important risk factor for osteonecrosis [11, 18, 23]. The surgical delay also seems important and most authors recommend urgent reduction and stabilisation of displaced talar fractures [7, 11, 12]. For us, the operative management may also be a factor of risk. In 2004, Vallier et al. presented a study where 91% of the talar neck fractures underwent a dual anteromedial and anterolateral approach. At final follow-up, 49% developed avascular necrosis of the talus. We thought that an aggressive operative treatment with a systematic dual surgical approach might be harmful for the blood supply of the talus. In our experience we found a low osteonecrosis rate of 20%.

Risk of malunion is a classical complication in this fracture type and is mostly a varus malunion. This risk is mainly influenced by the initial quality of reduction or the fracture type but also by the osteosynthesis technique. For talar neck fractures, Juliano et al. insist on the restoration of the talar length and particularly the medial side; they recommend avoiding compression screwing across an area of comminution at the origin of a talar neck shortening [7]. For talar body fractures, Thordarson recommends the use of neutralisation (non compression) screws for cases with comminution at the fracture site [4]. In our experience, we observed similar results with a high rate of varus malunion (all fracture types taken together) with compression screws. According to the literature and our experience, caution is necessary with the use of such screws. Some authors, as Fleuriau-Château, prefer plate fixation on

Table 4 Comparison of the AOFAS score and arthritis rate of several studies

Studies	Number of cases	Follow-up (months)	Rate of TTA	Rate of STA	AOFAS score
Elgafy et al. [15]	60	30	N/A	53%	77/100
Vallier et al. [12]	39	36	18%	15%	N/A
Sanders et al. [25]	70	62	40%	78%	71/100
Lindvall et al. [11]	26	74	61%	100%	61/100
Our study	20	90	76%	86%	67/100

AOFAS American Orthopaedic Foot and Ankle Society, *TTA* tibiotalar arthritis, *STA* subtalar arthritis, *N/A* not available the side with the most severe comminution in order to restore the neck length which permits control of the compression in the fracture site [25]. We have no experience with such plates.

In this study, we used slightly aggressive operative treatment, which is why we obtained fair radiological results, i.e. 30% anatomical reduction and 59% malunion at final follow-up in comparison with the literature [6, 25]. However, we found an average AOFAS score similar to other studies [11, 25]. The lack of good or excellent results may be explained by the exclusion in this study of the undisplaced fractures because such fractures have an excellent prognosis [3, 6, 7]. We did not find significant differences between functional outcomes after talar neck and talar body fractures, contrary to Elgafy et al. who found worse results for talar neck fractures [15].

The majority of the talar surface is articular cartilage [7]. This explains the high risk of osteoarthritis after a talar fracture. Many authors have demonstrated a relation between hindfoot misalignment or osteonecrosis and osteoarthritis [6, 7]. However, arthritis of the ankle and subtalar joint can occur in the absence of osteonecrosis or joint incongruity. Chondral damage can result only from the initial injury or from prolonged immobilisation [4]. At long-term follow-up, we observed a very high rate of post-traumatic osteoarthritis (all joints taken together). This arthritis mainly affected the tibiotalar joint and the subtalar joint. Our results may be explained by the high rate of malunion and also by the long follow-up of this study. Indeed, a non-exhaustive review of the literature showed that the osteoarthritis rate increases with the follow-up [11, 12, 15, 25] (Table 4).

Salvage procedure possibilities are multiple after these adverse outcomes. When avascular necrosis is limited or for isolated tibiotalar arthritis, a total ankle arthroplasty may be proposed. We used this technique for one patient, but we observed serious radiographic loosening at four years. Major collapses of the talar dome require a tibiotalar or tibiotalo-calcaneal arthrodesis. The site and number of joints for surgical arthrodesis must be decided in each individual case. In the same way, arthrodesis may be considered for symptomatic arthritic joints if conservative treatment is not sufficient [6].

In order to optimise the initial reduction and to decrease the rate of malunion, we believe that a single approach can be used with the help of new fluoroscopic systems. Indeed, some fluoroscopic systems can generate 3D images directly in the operating room [26]; therefore, remaining incongruities can be recognised and corrected intraoperatively. This may avoid an aggressive dual surgical approach. In the same way, arthroscopy can help with anatomical reduction of those fractures but it requires a well-trained surgeon.

Conclusion

Displaced talar fractures remain a therapeutic challenge for orthopaedic surgeons. According to the literature, these fractures are often associated with a high complication rate, including malunion, osteonecrosis or osteoarthritis [4, 6, 7, 24, 25]. The operative treatment of such fractures seems to require a balance between an aggressive treatment with a strictly anatomical reduction and essential respect of soft tissues to limit skin complications or osteonecrosis.

Conflict of interest The authors declare that they have no conflict of interest.

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