

Timing of Surgical Reduction and Stabilization of Talus Fracture-Dislocations

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Abstract

Talus fractures with associated dislocations are rare but have high rates of complications, including avascular necrosis (AVN). Management of these injuries involves urgent surgical reduction and fixation, although there are no definitive data defining an operative time frame for preserving the blood supply and preventing complications.

To determine the effect of time to surgical reduction of talus fractures and talus fracture-dislocations on rates of AVN and posttraumatic osteoarthritis (PTOA), we retrospectively reviewed talus fractures surgically managed at a level I trauma center during the 10-year period 2003 to 2013. Operative reports were obtained and reviewed, and 3 independent reviewers, using the Hawkins and AO/OTA (Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association) systems, classified the injuries on plain radiographs. Analysis of AO/OTA 81 fractures with associated tibiotalar, subtalar, or talonavicular dislocations was

performed. Primary outcomes were presence of AVN/PTOA and subsequent arthrodesis of tibiotalar or subtalar joints.

We identified 106 surgically managed talus fractures. Rates of AVN/PTOA were 41% for all talus fractures and 50% for talus fracture-dislocations. Mean time to surgical reduction was not significant for development of AVN/PTOA for all talus fractures ($P = .45$) or talus fracture-dislocations ($P = .29$). There was no difference in age ($P = .20$), body mass index ($P = .45$), or polytrauma ($P = .79$) between patients who developed AVN and those who did not. Open fractures were significantly correlated with the development of AVN/PTOA ($P = .009$).

Talar fracture-dislocations are devastating injuries with high rates of complications. Our data suggest there is no effect of time from injury to surgical reduction of talus fractures or talus fracture-dislocations on rates of AVN and PTOA.

Talus fractures are rare injuries that present a significant treatment dilemma.¹⁻¹² These fractures represent <1% of all fractures⁴ and are second only to calcaneus fractures in fractures of the hindfoot. Talus fractures with associated dislocations are even rarer and may provide treating surgeons with a significant surgical quandary.^{6,13-16}

Talus fractures historically have been characterized by their anatomical location: head, neck, or body. Two systems are commonly used to classify talus fractures: Hawkins and AO/OTA (Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association). The first, developed by Hawkins⁷ and modified by Canale and Kelly² and Vallier and colleagues,¹ identifies 4 basic fracture

types with associated dislocations. The other system, published in 1996¹⁷ and republished in 2007,¹⁸ uses the combined methods of AO and OTA to systematically describe talus fractures. Although these classification systems accurately describe talus fractures with associated dislocation, both have difficulty predicting clinical outcomes.^{1,19,20}

Talus fractures commonly result in avascular necrosis (AVN) of the talus and posttraumatic osteoarthritis (PTOA) of the tibiotalar and subtalar joints.^{3,8,9,12,14-16} Hawkins⁷ initially described subchondral lucency as indicating revascularization of the talus after injury. AVN and PTOA rates traditionally have been thought to be related to a blood supply disruption, given the prognostic value of the

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Hawkins sign.^{1,7,12,21} New methods, including a dual-incision approach and expedited transfer to foot and ankle surgeons or orthopedic traumatologists, have improved reduction quality²¹⁻²⁴ but not patient outcomes.^{3,5,8,9,12,14}

Recently, time from injury to surgical intervention has been a topic of much discussion, and there have been studies on the specific effects of timing with respect to outcome.^{1,15,16} Vallier and colleagues,¹ who wanted to identify injury characteristics predictive of osteonecrosis, found that delaying reduction and surgical fixation did not increase the risk of AVN. Another study found that urgent reduction of fracture-dislocation with delayed open reduction and internal fixation (ORIF) using a dual approach may improve clinical outcomes.²¹

In this vein, we conducted a study to evaluate the effect of time to surgical reduction of talus fractures and talus fracture-dislocations on the development of AVN and PTOA. We hypothesized that time to surgical reduction of talus fracture-dislocation as classified with the AO/OTA system would have no effect of the development of AVN/PTOA.

Methods

After this study received Institutional Review Board approval, we retrospectively reviewed the records on talus fractures surgically managed at a level I trauma center during the 10-year period 2003 to 2013. Of the 119 potential cases identified using *Current Procedural Terminology* code 28445 (ORIF of talus), 13 were excluded (12 for inaccurate coding or missing documentation, 1 for being a pediatric case), leaving 106 for analysis. Using the Hawkins and AO/OTA systems, 3 independent reviewers classified the injuries on plain radiographs.

Injury dates and times were obtained from the medical records. Operating room start times were also obtained. Surgical timing was defined as time from injury to operating room start. For cases without an injury time, time of presentation to emergency department was used.

Open fracture-dislocations were managed with intravenous antibiotics, urgent surgical irrigation, débridement, and immediate fixation or temporizing external fixation after reduction. All fractures were definitively managed with standard ORIF with an anteromedial, anterolateral, or dual approach and mini-fragment implants. After fixation, weight-bearing typically was restricted for 6 to 12 weeks.

Table 1. Talar Location and AO/OTA Class (N = 106 Operative Talus Fractures)

Location	Class	n	%
Process	81-A	5	4.7
Neck	All 81-B	76	71.7
	81-B1	13	12
	81-B2	31	29
	81-B3	32	30
Body	81-C	25	23.6

Abbreviations: AO, Arbeitsgemeinschaft für Osteosynthesefragen; OTA, Orthopaedic Trauma Association.

Follow-up radiographs were evaluated. Presence or absence of Hawkins sign⁷ was noted on radiographs at 6 or 8 weeks, and all follow-up radiographs were evaluated for AVN as defined by increased radiographic density within the talar dome or collapse of the articular surface. All radiographs were evaluated for PTOA as defined by loss of joint space within the tibiotalar, subtalar, or talonavicular joint on follow-up radiographs.

Clinical outcomes were analyzed for development of AVN, PTOA, or secondary corrective surgery or arthrodesis. Continuous variables were evaluated with the *t* test, and the χ^2 test was used to compare distributions of categorical variables. The Wilcoxon rank sum test was used to compare non-normally distributed variables. Significance was set at $P < .05$.

Results

Classification Analysis (Table 1)

We identified 106 surgically managed talus fractures. Five (4.7%) were lateral process and talar

Take-Home Points

- There is a 41% rate of AVN or PTOA after operatively managed talus fracture.
- Surgical timing does not affect development of AVN or PTOA.
- Open fractures are associated with development of AVN and PTOA.
- Quality of reduction is likely more important than timing of reduction.
- Urgent surgical treatment is necessary for threatened soft tissue or neurovascular compromise.

Table 2. Patient Demographics by Talus Fracture Type (N = 106)

Demographic	Talus Fracture Type			P
	All	Fracture	Fracture-Dislocation	
n	106	74	32	—
Female/male	69/37	49/25	20/12	.71
Mean age, y	37.7	36.4	39.2	.41
Body mass index, kg/m ²	29.4	29.4	28.4	.48
Open fracture	25	13	12	.009
Polytrauma	50	36	20	.189
Timing, h	92.5	126.6	18.4	.0001
AVN/PTOA	43	27	16	.19

Abbreviations: AVN, avascular necrosis; PTOA, posttraumatic osteoarthritis.

Table 3. Overall Analysis of Avascular Necrosis/Posttraumatic Osteoarthritis

Variable	AVN/PTOA		P
	Yes (n = 43)	No (n = 63)	
Mean age, y	38.74	36.21	.20
Body mass index, kg/m ²	28.99	29.15	.45
Timing, h	107.0	81.0	.45
Polytrauma, n (%)	54 (51%)	52 (49%)	.79
Open fracture, n (%)	15 (35%)	10 (16%)	.03
Follow-up, wk	141.7	169.9	.26

Abbreviations: AVN, avascular necrosis; PTOA, posttraumatic osteoarthritis.

head fractures (AO/OTA 81-A). Seventy-six (71.7%) were talar neck fractures (81-B), which included 13 (12%) 81-B1 fractures, 31 (29%) 81-B2 fractures, and 32 (30%) 81-B3 fractures. Twenty-five (23.6%) were talar body fractures (81-C). AO/OTA 81-B3 fractures were identified and separately analyzed and compared with talus fractures of all other classes. AO/OTA 81-B talar neck fractures were classified with the Hawkins system⁷ as well: 13 (12%) were Hawkins 1 fractures, 31 (29%) Hawkins 2 fractures, 25 (24%) Hawkins 3 fractures, and 7 (7%) Hawkins 4 fractures.

Subject Analysis (Table 2)

Of the 106 patients, 69 were female and 37 male. Mean age was 37.7 years (range, 18-78 years).

Mean body mass index (BMI) was 29.45 kg/m². Of the 106 cases, 52 were managed by board-certified orthopedic trauma surgeons, 32 by board-certified foot and ankle surgeons, and 22 by orthopedic surgeons with other specialty training.

The mechanisms of injury were motor vehicle accident (70/106; 66%), fall from height (25; 24%), misstep (4), sports related (2), object falling on ankle (2), and not reported (3).

Of the 106 patients, 45 (42%) had isolated talus injuries, 35 had concomitant ipsilateral lower extremity injuries, 25 had concomitant contralateral lower extremity injuries, and 1 had a concomitant upper extremity injury.

Smoking status was everyday (14 patients), past (10), never (34), and unreported (48). Five patients reported a history of alcohol abuse, and 4 patients reported illicit drug use. Two had a history of atrial fibrillation, 9 had hypertension, 3 had hyperlipidemia, 3 had renal disease, 3 had heart disease, 4 had diabetes, 3 had lung disease, and 1 had a history of lung cancer.

Overall Analysis of AVN/PTOA (Table 3)

Of the 106 patients, 43 (41%) developed AVN/PTOA, and 63 (59%) did not, while fifty-four (51%) of the 106 patients who developed AVN/PTOA had polytrauma, and 52 (49%) of those who did not develop AVN/PTOA had polytrauma ($P = .79$). There was no significant difference in mean age (38.74 years for AVN/PTOA, 36.21 years for no AVN/PTOA; $P = .20$) or BMI (28.99 kg/m² for AVN/PTOA, 29.15 kg/m² for no AVN/PTOA; $P = .45$). Direct comparison of proportions of polytrauma to development of AVN/PTOA revealed no significant difference. Direct comparison of the proportions of open injuries to development of AVN/PTOA revealed a significant difference. Fifteen (35%) of the 43 patients who developed AVN/PTOA had open injuries, and 10 (16%) of the 63 who did not develop AVN/PTOA had open injuries ($P = .03$). There was no significant difference in follow-up between patients who developed AVN/PTOA and those who did not ($P = .26$).

Analysis of AVN/PTOA in 81-B3 Fracture-Dislocations (Table 4)

Of the 32 patients with AO/OTA 81-B3 (Hawkins 3 or 4) fractures, 16 (50%) developed AVN/PTOA, and 16 did not. There was no significant difference in mean age (41.05 years for AVN/PTOA, 37.40 years for no AVN/PTOA; $P = .29$), BMI (28.86 kg/m² for AVN/PTOA, 27.94 kg/m² for no AVN/PTOA; $P = .38$), or surgical timing (19.09 hours for AVN/PTOA, 16.65

hours for no AVN/PTOA; $P = .29$) for development of AVN/PTOA. Direct comparison of the proportions of polytrauma and open injuries to development of AVN/PTOA in patients with 81-B3 fracture-dislocations revealed no significant difference. Nine of the 16 patients (56%) who developed AVN/PTOA had polytrauma, and 11 of the 16 (69%) who did not develop AVN/PTOA had polytrauma ($P = .465$). Although open injury was found to predict AVN/PTOA overall, this was not true for talus fracture-dislocations alone. Five of the 10 patients who developed AVN/PTOA had open injuries, and 5 of the 10 who did not develop AVN/PTOA had open injuries ($P = 1.0$). There was a significant difference in follow-up time between these groups. Patients who had 81-B3 fracture-dislocations and developed AVN/PTOA were followed for a mean of 120.4 weeks, and those who did not develop AVN/PTOA were followed for a mean of 40.33 weeks ($P = .001$).

Analysis of AVN/PTOA in All Other Talus Fractures (Table 5)

Of the 74 patients with talus fractures without dislocations, 27 (36.5%) developed AVN/PTOA during the follow-up period, and 47 (63.5%) did not. There was no significant difference in mean age (37.37 years for AVN/PTOA, 35.78 years for no AVN/PTOA; $P = .33$), BMI (29.07 kg/m² for AVN/PTOA, 29.57 kg/m² for no AVN/PTOA; $P = .39$), or surgical timing (164.8 hours for AVN/PTOA, 105.41 for no AVN/PTOA; $P = .14$). Direct comparison of the proportions of polytrauma to development of AVN/PTOA in patients with talus fractures without dislocations revealed no significant difference. Fourteen of the 27 patients who developed AVN/PTOA had polytrauma, and 23 of the 47 who did not develop AVN/PTOA had polytrauma ($P = .18$). Direct comparison of the proportions of open injuries to development of AVN/PTOA in patients with talus fractures without dislocations revealed a significant difference ($P = .009$). There was a significant difference in follow-up time between these groups. Patients who had talus fractures without dislocations and developed AVN/PTOA were followed for a mean of 154.3 weeks, and those who did not develop AVN/PTOA were followed for a mean of 216 weeks ($P = .02$).

Discussion

Our results showed that time from talus fracture-dislocation to surgical reduction had no effect on development of AVN/PTOA. The findings in this

Table 4. Avascular Necrosis/Posttraumatic Osteoarthritis in AO/OTA 81-B3 Fracture-Dislocations (n = 32)

Variable	AVN/PTOA		P
	Yes (n = 16)	No (n = 16)	
Mean age, y	41.05	37.40	.29
Body mass index, kg/m ²	28.86	27.94	.38
Timing, h	19.09	16.65	.29
Polytrauma, n (%)	9/16 (56%)	11/16 (69%)	.465
Open fracture, n (%)	5/10 (50%)	5/10 (50%)	1.0

Abbreviations: AO, Arbeitsgemeinschaft für Osteosynthesefragen; AVN, avascular necrosis; OTA, Orthopaedic Trauma Association; PTOA, posttraumatic osteoarthritis.

Table 5. Avascular Necrosis/Posttraumatic Osteoarthritis in All Other Talus Fractures (n = 74)

Variable	AVN/PTOA		P
	Yes (n = 27)	No (n = 47)	
Mean age, y	37.37	35.78	.33
Body mass index, kg/m ²	29.07	29.57	.39
Timing, h	164.8	105.41	.14
Polytrauma (n = 34), n	14/27	20/47	.18
Open fracture (n = 15), n	10/27	5/45	.009

Abbreviations: AVN, avascular necrosis; PTOA, posttraumatic osteoarthritis.

largest series to date agree with earlier findings^{1,8,15,16,24} and add to the volume of literature suggesting that time to surgical reduction of talus fractures and talus fracture-dislocations does not markedly affect outcome.

Talus fractures continue to present a significant treatment dilemma. Despite recent improvements in surgical techniques and overall management of these injuries, rates of AVN and PTOA have not significantly decreased.^{1,16,23} At most treating facilities, talus fracture-dislocations are considered surgical emergencies/urgencies, and every effort is made to reduce and surgically address these injuries as soon as possible.^{1,13}

In this study, rates of AVN/PTOA were 41% (all talus fractures) and 50% (displaced talar neck fractures), and the difference was not significant (Table 3). These rates are higher but consistent with previously reported rates (range, 14%-49%).^{1,2,7-9,12,14,24} There was no difference in surgical timing for development of AVN/PTOA. We analyzed the cases

of all patients who had talus fractures and developed AVN/PTOA (43/106). Within this group, there were no significant differences in surgical timing, age, sex, polytrauma, or BMI between patients who developed AVN/PTOA and those who did not. Compared with patients who did not develop AVN/PTOA, those who developed AVN/PTOA were significantly more likely to have open injuries. This finding, consistent with those in other reports^{9,12,13} (Table 3), indicates outcome is more likely related to injury severity and not necessarily injury class.

We retrospectively analyzed talus fractures and talus fracture-dislocations to determine if urgent surgical management affects outcomes. Current practice at our institution is to routinely reduce and surgically address these fractures urgently, often during the middle of the night, when orthopedic resources are reduced. Our study found a significant difference in surgical timing for patients with talus fracture-dislocations and patients with talus fractures without dislocations (Table 2). Given our findings, urgent surgical reduction and fixation are not indicated to preserve the talus blood supply and prevent AVN/PTOA, though we still recommend urgent surgical management in the setting of an open wound, skin necrosis, or soft-tissue/neurovascular compromise.

This study had several limitations, primarily related to its retrospective nature. Surgical timing was defined as time from injury, as noted in the medical record, to operating room start. In some instances, time of injury was not noted in the medical record, and time of presentation to emergency room was used instead. Thus, surgical timing for these patients may have been longer than identified. In addition, given the rare injury pattern and the retrospective design, this study was susceptible to type II error and may have been underpowered to detect whether time to surgical reduction predicted complications. Also, the study did not address functional outcome as measured by validated outcome scores. Outcome measures were obtained in many but not all cases, making functional outcome measurement difficult. Similarly, the quality of the anatomical reductions was not assessed, potentially affecting complication rates. Postoperative reduction assessment, possibly performed with computed tomography, is an avenue of further study.

Strengths of this study include its large sample size (this was one of the largest studies of talus fractures), long follow-up (mean, 150 weeks), and novel use of AO/OTA classification.

We postulate that development of AVN/PTOA is

not necessarily related to the urgency or timing of surgical reduction and fixation and is more likely related to injury severity. This idea is supported by the finding that development of AVN/PTOA was significantly correlated to open injuries in all talus fractures, including talus fracture-dislocations and isolated talus fractures.

Conclusion

Talus fracture-dislocations are devastating injuries with high rates of complications. In this study, open talus fractures, and fractures with associated tibiotalar or subtalar dislocations, had higher complication rates. Given the evidence presented, we recommend basing surgical timing on injury severity, not necessarily for AVN/PTOA prevention. Specifically, in the absence of an open wound, skin necrosis, or soft-tissue/neurovascular compromise, talus fracture-dislocations can be surgically reduced and stabilized when optimal resources are available.

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