Vascular Abnormalities as Assessed with CT Angiography in High-Energy Tibial Plafond Fractures

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Objective: The purpose of this study was to examine the results of computed tomography angiography (CTA) obtained in patients with high-energy tibial plafond fractures and assess if the information gleaned from CTA could be useful to the treating orthopedic surgeon.

Design: Consecutive patient series.

Setting: Level 2 trauma center.

Patients: Consecutive patients treated between October 1, 2004 and June 31, 2006 for high-energy injury of the tibial plafond according to a protocol of early temporizing external fixation, CT, and elevation, followed by delayed reconstruction of the tibial plafond.

Intervention: Addition of angiography to CT scan (CTA) in treatment protocol.

Main Outcome Measurements: CTA abnormalities were identified and categorized to define the pattern of arterial lesions present. Characteristics of patients, injuries, treatments, and complications were evaluated and related to CTA findings.

Results: CTA was performed at an average of 3 days postinjury in 25 consecutive patients treated for high-energy tibial plafond fractures. Abnormalities of the arterial tree of the leg were seen in 13 of 25 (52%) patients. One patient had 2 of 3 vessels notably injured. Fourteen arteries showed acute changes at the level of injury and 1 showed significant chronic atherosclerotic disease at the trifurcation. Acute arterial abnormalities included 7 arteries with complete occlusion, 2 with partial occlusion/diminished flow, and 5 with normal flow but with anatomic disturbances (4 tenting over and 1 entrapped by fracture fragments). Open fractures were associated with arterial abnormalities ($P < 0.05$), but no other characteristics correlated with arterial injury. No patients had dye reactions or other problems relating to CTA. Patients with CTA-diagnosed vascular abnormalities were treated with more minimally invasive surgery than those without at the discretion of the surgeon, and no patients with vascular abnormalities had wound problems or infection.

Conclusions: In more than half of high-energy tibial plafond fractures, CTA identified significant abnormalities to the arterial tree of the distal leg. These injuries most commonly involved the anterior tibial artery and included a variety of lesions. CTA appears to be a safe and potentially useful tool for the assessment and preoperative planning of high-energy tibial plafond fractures.

Key Words: CT angiography, plafond, pilon, distal tibia, high-energy fracture, blood supply

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INTRODUCTION

The goal of surgical treatment for high-energy tibial plafond injuries is to reestablish the articular surface and axial alignment of the distal tibia while allowing for early mobility and predictable healing. In the past decade, surgeons have realized that soft-tissue damage must be accounted for to avoid potentially disastrous wound complications following these injuries,[1,2] presumably because of the delicate soft-tissue envelope and the limited vascular reserve supporting the distal leg. In an effort to confront the challenge of caring for these high-energy fractures, the last few years have witnessed the development of new treatment approaches that emphasize soft-tissue damage control, including temporizing external fixation, staged reconstruction, and minimally invasive surgery.

A potentially important factor in mediating soft-tissue damage is understanding the vascular function of the injured lower extremity. In the acute setting, an understanding of arterial deficiency might influence complication risk assessment or surgical tactics.[3] The arterial supply of the leg begins with the popliteal artery that typically branches into 3 vessels in a characteristic pattern. The anterior and posterior tibial arteries, which are named according to their relationships to the tibia bone, pass along their course through the leg providing the extraosseous and intraosseous blood supply to the tibia. Both cross the ankle into the foot where they anastomose in the forefoot. This relationship allows for collateral flow and explains why in situations in which 1 of the arteries is injured, ample distal pulses may still be present. The existence of this anastomotic network also means that vascular examinations at the level of the foot may not always accurately depict the competency of the proximal arterial tree. The peroneal artery, which tracks along the medial aspect of the fibula, is usually the least sizable of the 3 vessels of the leg and characteristically terminates at or above the level of the ankle.

High-energy and vascular injuries in the leg have been demonstrated to increase the risks of infection, wound

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problems, and even amputation.[1,4–6] Furthermore, vascular deficiencies may negatively affect bone healing, resulting in delayed healing, secondary surgery such as bone grafting, or other further intervention.[7–9] Until very recently, if the surgeon desired a definitive assessment of the leg's vascularity, imaging via conventional angiography was the test of choice. Unfortunately, however, this technique requires a direct arterial puncture, sizable doses of intraarterial contrast and radiation, and a highly trained radiology team to execute, and it has a relatively expensive cost.

For the past few years, the authors have used computed tomography angiography (CTA) to image high-energy tibial plafond fractures in an effort to obtain a more complete and detailed understanding of the true pathoanatomy of these injuries. CTA is a promising imaging technique for the arterial system[10–17] that avoids some of the characteristic drawbacks of conventional angiography. Contrast is given through a simple intravenous site and images are collected via a multidetector CT scanner. The testing is thus relatively "noninvasive," can be carried out quickly with minimal technical difficulty, and yields easily interpretable results.[12] In addition, standard CT imaging is already typically used by orthopedic surgeons to better understand the tibial plafond fracture and to preoperatively plan reconstructive surgeries.[18]

The purpose of this study is to characterize the vascular abnormalities resulting from high-energy injuries of the tibial plafond caused by blunt trauma using CTA. Our hypothesis is that the findings of CTA may be relevant in describing the injury "personality" and in planning the treatment of these complex fractures.

PATIENTS AND METHODS

Consecutive patients with high-energy tibial plafond fractures treated between October 1, 2004 and June 31, 2006 according to a staged treatment protocol designed to maximize soft tissue care[19,20] were included in this retrospective analysis following Institutional Review Board approval of the study design. This protocol included early temporizing external fixation and delayed reconstruction of the tibial plafond once the soft tissues returned to a quiescent condition. CT with the addition of angiography was performed during the initial hospitalization shortly after external fixation was applied. CTA was performed on an 8-slice CT scanner (General Electric Medical Systems, Milwaukee, Wisconsin) with a standard algorithm using high-speed scan mode at 2.5-mm slice with 1.25-mm spacing, 0.8-sec gantry rotation, 7.5 table speed, and 120 KVP @ 200–350 MAS technique. Total contrast per patient was 100 cc of Ioversol (Optiray 300, Mallinckrodt, Inc, Hazelwood, Missouri) and was injected at 4 cc per second using an injector (Mallinckrodt, Inc). Patients were screened for glomerular filtration rate prior to CTA as part of the protocol. Axial images were obtained at the initiation of arterial enhancement with contrast. Timing bolus software is an additional option in this procedure but was not used because of the difficulties associated with its use in the distal extremities. Both lower extremities were included in the field of view with the affected side reformatted at a field of view of 25 cm. The malleoli were used as landmarks to localize the study. Scout images were obtained 100 cm superior and 50 cm inferior to these landmarks. Axial slices were obtained from the mid-tibia to beyond the bottom of the foot. Information from the CTA was used in the preoperative planning for these injuries as the lead surgeon used a variety of surgical approaches and tactics (open and minimally invasive) determined on a case-by-case basis.

Patient and injury characteristics were analyzed. These included age, gender, medical problems, mechanism of injury, presence of ipsilateral lower-extremity injuries; AO/OTA fracture classification[21]; closed[22] and open[4] fracture types; vascular examination; and the time periods between injury and CTA, CTA and surgery, and injury and surgery. Any CTA complications, surgical approaches, and occurrence of wound problems or infections were also examined. Finally, the time to fracture union and the occurrence of secondary surgeries were evaluated.

Five radiologists were involved in the interpretation of these studies, and their descriptions were used to identify arterial abnormalities. Individual abnormalities were categorized as having either "normal flow," "diminished flow," or "no flow at all." If identified as abnormal but with normal flow, arterial abnormalities were further classified as either "tenting over" or "entrapped" between fracture fragments. "Tenting over" defined the abnormalities in which the normal course of the artery was clearly and directly altered by the position of abutting bone fragments. "Entrapped" defined the abnormalities in which the artery was flanked between bone fragments.

Patients were followed postoperatively with clinical and radiographic examination at 2, 6, and 12 weeks and every 6–8 weeks thereafter until fracture healing was achieved. Fractures were defined as healed when patients were full weightbearing without significant discomfort and when radiographs demonstrated 3 cortices of bony bridging. Time to healing was assessed.

All variables were correlated with the incidence of arterial injury using the Fisher exact test. Statistical significance was defined as $P < 0.05$.

RESULTS

Data are presented in Tables 1 and 2. Twenty-five patients with high-energy tibial plateau fractures were assessed in this study. Sixteen were male and 9 were female, and their average age was 44.2 years (range 14 to 74 years). Thirteen patients injured their right tibial plafond, and the remaining 12 injured their left. Mechanisms of injury included 17 falls from a height greater than 5 feet, 4 motorcycle accidents, 2 automobile accidents, and 2 industrial crush injuries. Three patients had ipsilateral injuries, including 1 mid-foot fracture dislocation, 1 calcaneus fracture, and 1 tibial plateau fracture, and 1 patient had lumbar spine fractures. Of the 25 high-energy tibial plafond fractures, 18 were classified as AO/OTA 43-C3, 3 as AO/OTA 43-C2, 2 as AO/OTA 43-A3, and 2 as AO/OTA 43- B3. Eighteen of these fractures were closed Tscherne type II or III fractures and the remaining 7 were open fractures (4 type GII, 1 type GIIIA, 2 type GIIIB). All patients had detectable dorsalis pedis artery pulses or biphasic Doppler

TABLE 1. Patient and Injury Data

Identifier	Side	Age (Years)	Gender	Mechanism	Ipsilateral Injury	AO/OTA (21)	Open/Closed (Type) (4)	Days to CTA
1	Left	14	Male	Fell 8′	No	B3	Closed	4
2	Left	19	Female	Fell 30′	Forefoot	C3	Open (GIIIB)	4
3	Right	59	Male	Fell 15′	No	B3	Closed	1
4	Right	42	Male	Fell 6′	No	C3	Open (GII)	2
5	Right	61	Male	Motorcycle crash	No	C2	Open (GII)	2
6	Right	26	Male	Fell 12′	No	C3	Closed	3
7	Left	55	Female	Fell 10′	Calcaneus	C3	Closed	4
8	Right	74	Male	Fell 6′	No	C2	Open (GIIIB)	6
9	Left	61	Female	Fell 6′	No	C3	Open (GII)	3
10	Left	49	Female	Fell 8′	No	C3	Closed	8
11	Right	55	Female	Fell 6′	No	A3	Closed	2
12	Left	40	Male	Motorcycle crash	L-spine	C3	Open (GIIIA)	1
13	Right	27	Male	Fell 20′	No	C3	Closed	2
14	Left	47	Male	Motorcycle crash	No	C3	Closed	1
15	Right	62	Male	Auto crash	No	C3	Closed	5
16	Left	33	Female	Fell 5′	No	C3	Closed	1
17	Right	38	Male	Fell 15′	Tibial Plateau	C3	Closed	5
18	Right	51	Male	Fell 15′	No	A3	Open (GII)	2
19	Right	33	Male	Motorcycle crash	No	C3	Closed	1
20	Left	52	Female	Fell 8′	No	C3	Closed	3
21	Right	47	Male	Crush by cow	No	C2	Closed	2
22	Left	58	Female	Fell 5′	No	C3	Closed	3
23	Left	19	Male	Industrial crush	No	C3	Closed	1
24	Right	43	Female	Auto crash	No	C3	Closed	2
25	Left	39	Male	Fell 10′	No	C3	Closed	7

tones documented on vascular examination. None were described as pulseless or documented with profound "limb-threatening" ischemia of the foot.

All received early temporizing external fixation prior to their CTA scans. CTA scans were performed an average of 3 days following injury, ranging from 1 to 8 days. Delayed reconstructions were performed at a mean of 15 days (range 3–27 days) after injury.

With regard to the safety of this method, no patients experienced any dye reactions or other problems relating to CTA.

As identified from the radiologist's report of the CTAs, the extent of apparent flow through the vessels was commented on in all 25 cases. Injuries were identified in 14 of 75 arteries in 13 of 25 patients. Included in the 14 arterial lesions, there were 9 anterior tibial artery abnormalities (Fig. 1), 3 posterior tibial artery abnormalities, and 2 peroneal artery abnormalities. One of the 14 arteries showing acute abnormalities at the level of injury also showed significant chronic atherosclerotic disease. One CTA scan documented 2 acute arterial abnormalities in the same patient: 1 on the anterior tibial artery and the other on the posterior tibial artery. Of these 14 total arterial lesions, 7 arteries were completely occluded at the fracture site (no flow, Fig. 1), 2 were partially occluded (partial flow), and 5 had no flow disturbance. Those with normal flow but characterized as abnormal included 4 arteries seen tenting over fracture fragments and 1 that was entrapped by fracture fragments. A pulse or Doppler tones were documented in the feet of all 7 patients where complete arterial occlusion of a tibial artery had occurred, and in each case distal flow was evident on CTA, likely representing retrograde collateral flow. For patients treated in this study, no limbs were thought to be at immediate risk of loss resulting from profound ischemia.

The results of the data analysis demonstrate that open fractures were more likely to be associated with arterial abnormalities ($P < 0.05$), but no other characteristics had a significant correlation with arterial injury.

None of the patients with vascular abnormalities had any subsequent wound problems, infections, or amputations. One patient, a 2+ pack per day smoker with no identified arterial abnormalities, had wound problems after an open GII open fracture and minimally invasive plating that required a free soft-tissue transfer for wound coverage. Mean time to healing was similar in patients with vascular abnormality (21.5 weeks) and those without vascular abnormality (19.9 weeks). For those with complete occlusion of a tibial artery, the mean healing time was 25 weeks, compared with 19.4 weeks for those with at least some arterial flow through both tibial arteries ($P = 0.4$).

DISCUSSION

Several authorities have stated that optimal treatment of a specific high-energy plafond fracture must include a thorough understanding of the "personality" of the injury, including the fracture pattern and the soft-tissue damage.[23] A facet of this injury "personality" must also be the associated arterial trauma. This study showed that more than half of high-energy

TABLE 2. CT Arteriogram and Treatment Data

Identifier	Abnormal Artery	Arterial Abnormality	Days to Surgery	Surgical Approach	Secondary Surgeries	Time to Union (Weeks)
1	Anterior tibial	Complete occlusion	24	MIPO	No	18
2	Anterior tibial	Entrapped in fracture	24	Anterolateral	Fasciocutaneous flap for Open GIIIB	12
3	Anterior tibial & posterior tibial	Tenting over fracture (normal flow) Complete occlusion	12	Anterolateral	No	20
4	Posterior tibial	Complete occlusion	3	MIPO AM/PL	No	18
5	Anterior tibial	Complete occlusion	16	MIPPO	Revision plate/autograft at 40 wks	60
6	Peroneal	Partial occlusion	14	Anterolateral	No	22
7	Anterior tibial	Partial occlusion	15	MIPO	No	18
8	Posterior tibial All 3 vessels	Complete occlusion Atherosclerosis (partial occlusions)	18	MIPO	Freeflap for Open GIIIB	22
9	Anterior tibial	Tenting over fracture (normal flow)	13	Anterolateral	No	20
10	Anterior tibial	Complete occlusion	22	Anteromedial	No	12
11	Anterior tibial	Tenting over fracture (normal flow)	12	MIPO	No	12
12	Anterior tibial	Tenting over fracture (normal flow)	6	MIPO	No	22
13	Peroneal	Complete occlusion	18	Anteromedial	No	24
14	None		12	Anteromedial	No	22
15	None		27	Anterolateral	No	24
16	None		11	Anteromedial	No	18
17	None		14	Anteromedial	No	23
18	None		21	MIPO	Free flap for Open GIIIB	36
19	None		9	Anterolateral	No	16
20	None		14	Anterolateral	No	11
21	None		9	Anteromedial	No	20
22	None		10	MIPO	No	18
23	None		15	Anteromedial	No	17
24	None		13	Anteromedial	No	20
25	None		25	MIPO	No	14

tibial plafond fractures resulting from blunt trauma were associated with abnormalities in the arterial system of the distal leg. In fact, in 6 of 25 legs (24%) there was complete occlusion of 1 of the 2 tibial arteries, and in 13 of 25 (52%) patients some acute arterial abnormality was notable. The impact of vascular injury on the outcomes of tibial plafond fractures remains poorly defined and there is scant information available as to how a relatively devascularized leg will tolerate tibial reconstruction. Intuitively, however, combining occlusion of 1 or more of the important arteries in a traumatized leg with a high-energy tibial plafond fracture would likely place the patient at additional risk for complications and a poor outcome after surgical treatment. This situation may be especially true if open reconstruction of the plafond fracture is considered. Furthermore, an efficient and informative vascular assessment can be complicated by several factors because vascular examination is somewhat unreliable and findings may be subtle. This study showed that occluded arteries still had distal pulses or detectable biphasic Doppler tones, presumably from collateral flow. Although the authors emphasize that a thorough vascular examination is integral to this workup, the high rate of arterial abnormality demonstrated in this study underscores the importance of establishing improved methods for evaluating the arterial system to optimize the surgeon's decision making and the patient's outcome.

By using CTA as part of the preoperative planning process in this study, we saw a variety of arterial alterations in terms of the severity of lesion (how flow was affected)and in terms of which artery or arteries were involved: of the 14 acute arterial lesions, 7 (50%) were classified as completely occluded, 2 as partially occluded, 4 as not obstructing the arterial flow in the zone of injury but tenting over fracture fragments, and 1 in which the artery was entrapped between fracture fragments. These latter abnormalities especially might be useful to the surgeon planning a careful approach to the plafond, achieving an indirect reduction, or applying implants through small incisions. Notably, none of these different types of injuries are well-delineated in most vascular studies in lower-extremity trauma. Complete occlusion of a tibial artery might be more long lasting or permanent, whereas partial occlusion, as potentially seen with arterial spasm, might be more likely to spontaneously improve. The effects then of these different types of lesions could be expected to be quite different.[24]

The anterior tibial artery was involved in 9 of the 13 (69%) legs with vascular irregularities, an observation that identifies this artery as especially vulnerable during blunt traumatic injury. Correspondingly, particular risk of the anterior tibial artery has been reported with tibial shaft fractures.[25] The functions of individual arteries in the leg have

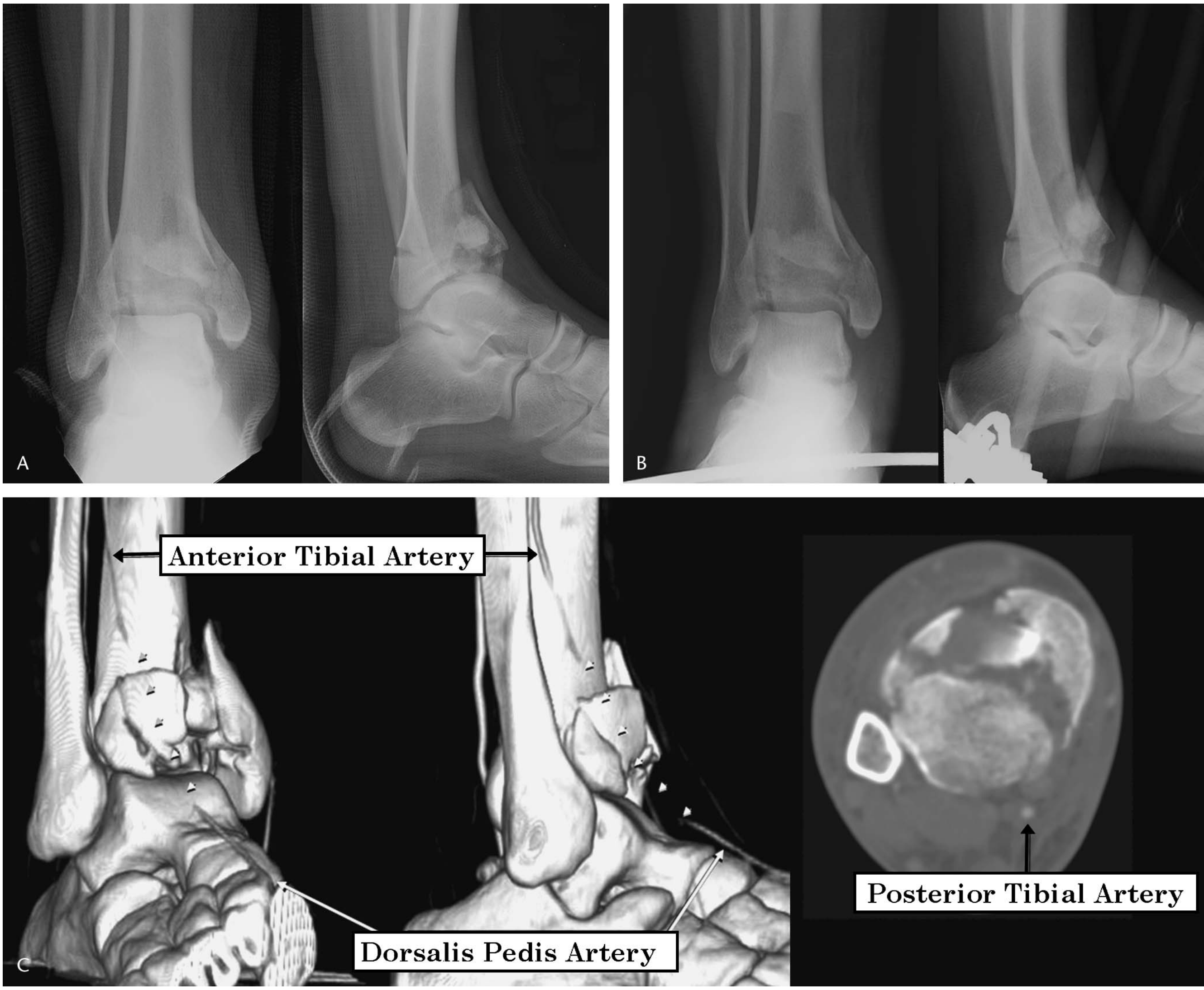

FIGURE 1. Case example. A, Injury radiographs demonstrating C3 fracture in a 24 year old man injured in a motorcross crash; B, Radiographs after application of external fixator and fixation of fibula; C, Shaded surface reconstruction of CT demonstrating perfusion deficit (arrowheads) of anterior tibal artery. Apparent collateral flow is seen in the dorsalis pedis artery via the posterior tibial artery. Corresponding axial CT demonstrating fracture pattern and arterial contrast evident only in the posterior tibal artery.

not been clearly discussed in relation to reconstructive surgery of the tibial plafond, but these findings concerning the susceptibility of the anterior tibial artery appear important because most tibial plafond reconstructions are approached anteriorly. One might expect insult to the arterial supply of the distal leg to affect the rate and scope of wound problems and infection because the skin edges and soft tissues at the surgical site may be at increased risk for necrosis. The anterior tibial artery's angiosome supplies the anterior part of the ankle, and under normal circumstances all 3 main arteries of the leg communicate with one another, providing collateral flow to the skin.[26] There must be adequate blood supply on either side of the incision to optimize healing; thus arterial flow from connecting arteries must be functional to expect good results. Attinger and associates[26] stated that when faced with abnormal blood flow in this area, collateral flow may be keeping the ischemic angiosome vascularized, and incisions must be planned such that this collateral flow is not disturbed. Furthermore, the findings of this study may help to explain the high rates of catastrophic wound complications reported when "early" open reduction and internal fixation is performed, such as during the period in which we obtained our CTA studies (average 3 days postinjury). Successful protocols using ankle-spanning external fixation and staged reconstruction, such as used in this study, may not only allow the soft-tissue edema to dissipate but may also facilitate improved blood flow to the tissues as arterial spasm resolves or as collateral flow becomes established.

No wound problems resulted in patients with vascular abnormalities who had surgically treated plafond fractures. Notably, those with vascular abnormalities were treated with a significantly higher rate of minimally invasive operations, and no vascular intervention was afforded prior to fracture surgery. The authors also attribute the lack of wound problems to the liberal use of temporizing external fixation and the timing of reconstruction; fracture repair was initiated only when the soft tissues appeared best able to tolerate surgery. Generally, treatment algorithms and outcomes for traumatic arterial injury can be categorized in the literature according to the location of the arterial lesion. Although injuries at or above the trifurcation and the corresponding high rate of catastrophic complications after reconstruction have been well described,[5,6] there are little data reflecting the incidence or effects of arterial injury below the trifurcation in the legs of patients with tibia fractures, and most relevant data are focused on limb survival.[5,6] As a result, recommended treatments of arterial injuries in the mid and lower leg are multiple, and outcomes may be unpredictable. In many cases, arterial damage below the level of the trifurcation is treated without surgery or with ligation of the vessel. These methods are advocated both because the results of arterial reconstruction are not predictably good and because collateral flow often compensates the loss of the injured artery allowing for limb survival.[27] The number of vessels injured with a tibial shaft fracture has been shown to be predictive of amputation. Whereas injury of 1 artery may be well-tolerated, 2 or 3 arterial branch injuries below the trifurcation have been correlated with amputation rates of 33% and 100%, respectively.[28] We found only 1 case where 2 of the 3 main arteries were affected, and in this instance, particular care to spare the remaining tibial artery that was tenting over fracture fragments may have been critical to a positive outcome. Finally, only 1 patient treated in this study had significant preexisting vascular disease as identified by CTA, but concerns associating poor physiologic reserve and inadequate collateral circulation to a higher risk of necrosis, wound problems, and infection appear valid.[29]

Just as the relationship of vascular damage and tibial plafond injuries has been poorly defined, little has been written specifically regarding the use of angiography or other vascular imaging techniques in the assessment of legs with plafond fractures. Rockwood and Green's classic text on fracture care recommends angiography of the leg in cases of tibia fractures if "signs of arterial blood supply are compromised, such as poor color, slow capillary refilling, or signs of muscle ischemia, even if pulses are present."[30] Thus, standard angiography is not typically a part of the evaluation algorithm for plafond fractures because the risks and logistics of obtaining the test outweigh the benefits of having its additional information in most cases. Nevertheless, by adding an angiographic component to our standard CT in the preoperative assessment of 25 high-energy tibial plafond fractures, we have found that CTA offers a reliable and safe method to visualize arterial and bony pathoanatomy in these cases. None of the 25 patients included had any CTA-associated problems. Furthermore, in other studies, problems reported with CTA have been negligible.[10–17,31] With regard to the safety of the intravenous dye, several studies have addressed the importance of patient predispositions, prophylactic treatments, and overall risk factors concerning contrast-induced nephropathy.[32–34] All patients in this study were screened prior to CTA administration, and contrast-associated renal problems were avoided. Although not specifically addressed in this manuscript, CTA also appears to have a number of potential advantages over other methods of assessing this vasculature, including physical examination and standard angiography. Successful use of CTA compared with conventional arteriography in traumatic lower limb injuries, and in other parts of the body, has been shown by several studies.[10–17,31] CTA particularly has been shown to hold great promise for imaging the arterial system in high-energy lower-extremity trauma, and some have suggested that it may soon replace standard angiography in many or most cases.[13–16]

This study showed that arterial abnormality or occlusion were not predictive of healing times, healing rates, or the need for secondary surgeries, although surgical tactics were not constant for all the patients in this study. In patients in whom blood supply was affected, more minimally invasive surgeries were used. The effects on the local vascularity of tibial plafond fracture surgery have been demonstrated by Borrelli and associates,[3] who found a rich but fragile arterial network that is disrupted through traditional open-plating methods. The study concluded that less invasive methods should lead to more optimal outcomes. The implication of this work is that if a leg is already significantly devascularized, disruption of the bone's remaining blood flow caused by traditional open plating of the tibial plafond could result in wound problems, infection, delayed union, or nonunion. Such vascular disturbance and problematic bone healing after tibia fractures have been demonstrated in animal and clinical models. Lu et al showed that an ischemic insult to the leg of mice with a tibia fracture led to delayed union or nonunion in 80% of animals at 21 days, whereas 100% of those without vascular injury were healed by that time.[9] Brinker and Bailey established that poorer outcomes and impaired healing after tibial shaft fractures were associated with injury to the posterior tibial artery.[7]

This study has several limitations. First, this analysis is a retrospective study, and thus the influence of CTA on the treatment of tibial plafond fractures remains uncertain. Clearly, the findings of CTA were included in the characterization of the "personality" of each injury, and the authors assert these findings likely did influence treatment, at least in some cases. Second, there is no alternative treatment or control group included with which to compare the results obtained from the patient population. Therefore, although surgical treatment may have been altered according to the findings of CTA, whether these differing surgical approaches made any contribution to the patients' outcomes remains unclear. Third, as in most series on tibial plafond fractures, the number of patients evaluated was relatively small, and just a few alternate findings could dramatically alter our conclusions. Finally, as with most reports involving vascular imaging, CTAs were performed only 1 time for each patient and represent a single "snapshot" view of the arterial tree. Examination many days before the staged surgery may not represent the true vascular state at the time of reconstruction and may, for example, underrepresent impending thrombosis of the injured vessels. The main strength of this study is that it presents the evaluation, treatment, and early results of a selective cohort of patients with high-energy tibial plafond fractures treated with a simple modification (CT with angiography) to a widely accepted soft-tissue–accommodating treatment protocol.

In summary, CTA appears to be a useful and safe tool in detecting and defining vascular abnormalities in high-energy tibial plafond fractures. These fractures are associated with acute vascular abnormalities in the zone of injury in more than half of cases as assessed by CTA. A variety of abnormalities were seen including injuries where arterial flow was completely occluded, partially occluded, or not affected at all. All of these abnormalities, however, were thought to be potentially important to a treating orthopedic surgeon. Most of these abnormalities involved the anterior tibial artery, a finding that may be especially notable because most plafond surgeries are performed via anterior approaches. Open fractures were directly associated with a higher incidence of arterial injury, but no other patient or injury factors appeared to be associated with vascular injury.

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