The presence of associated vascular findings on noncontrast enhanced CT of fractures in diabetics

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A 44-year-old female with diabetes and end-stage renal disease suffered a nondisplaced medial tibial plateau fracture after a ground-level fall. After open reduction and internal fixation, her popliteal artery and vein occluded at the level of the fracture. Review of the noncontrast computed tomography scan completed on initial arrival to the emergency department revealed a fracture in the calcified media of the popliteal artery at the level of the arterial occlusion. The propensity of different classes of tibial plateau fractures to be associated with soft-tissue and vascular injuries is examined in the context of different imaging modalities. The pathogenesis of arterial calcification and arterial dissection (including patients with renal disease and diabetics) is reviewed.

Case report

A morbidly obese 44-year-old female with a significant past medical history for diabetes and end-stage renal disease presented to the emergency department with right knee pain and an inability to stand or walk. She reported falling down in the dialysis center parking lot and feeling a pop in her right leg.

In the emergency department, the initial two-view radiograph of the tibia and fibula showed no dislocation or gross fracture, but a fracture of the medial aspect of the lateral tibial plateau could not be excluded. Dedicated radiographs of the right knee showed a fracture of the medial aspect of the lateral tibial plateau, which extended in an oblique fashion (Fig. 1). A lower-extremity CT without contrast further characterized the fracture as a nondisplaced, non-depressed, comminuted fracture of the medial tibial plateau (Figs. 2, 3). A diffusely calcified popliteal artery was also noted, but the clearly fractured and partially compressed calcified media was initially not appreciated (Fig. 4).

The patient was splinted and referred to an orthopedic surgeon for further evaluation. Initial examination revealed...
that sensation was intact throughout her right leg. Her capillary refill was less than two seconds; decreased dorsalis pedis and posterior tibialis pulses were appreciated in her right leg, but were comparable to the pulses in her left leg. No signs of internal derangement were present.

Percutaneous internal fixation of the right tibial plateau fracture was completed without any complications the following day. Intraoperative fluoroscopy images demonstrated internal fixation of the fracture. Postoperatively, the patient developed respiratory acidosis with respiratory failure. She was admitted to the ICU and maintained on BiPAP.

On postoperative day one, the patient’s right foot was cold with a capillary refill of five seconds. Pulses in her right foot were not appreciated at bedside by either palpation or Doppler. The left foot was also cool, but it had a capillary refill of about 3 seconds, and Doppler pulses were appreciated. A new 1-2-mm ischemic lesion on the dorsal side of the second toe of the right foot was also noted. Arterial and venous Doppler ultrasounds showed an absence of flow in the right popliteal artery and post trifurcation arteries that was compatible with an occlusion of the right popliteal artery at the level of the tibial plateau fracture (Figs. 5-7). An acute clot in the right popliteal vein and post trifurcation veins was also found.

The patient was transferred to a tertiary facility with a vascular surgeon. Limb-salvage arterial thrombectomy was unsuccessful in reestablishing flow. The leg below the knee was amputated.
Tibial plateau fractures are some of the most common proximal tibia fractures. They often result when a high-energy axial load is applied with a valgus or varus force. The mechanisms of injury are often classified into low-energy or high-energy. Low-energy mechanisms of injury include falls that are more common in older patients with osteoporosis, while a high-energy mechanism like a motor vehicle accident is more common in younger patients with no chronic osseous disease. More than half of all the low-energy fractures occur in patients older than 50, with the lateral plateau being the most common fracture location. These types of fractures can be complicated by varying degrees of depression, displacement, and joint instability. The Schatzker classification is one of the most commonly used systems to classify tibial plateau fractures. Fractures are graded from class I through class VI, with the degree of injury increasing (and prognosis of complete recovery decreasing) accordingly.

In general, nondisplaced tibial plateau fractures do not raise as much of a concern for neurovascular injury when compared to displaced fractures, but this case is an example of a nondisplaced fracture with vascular injury eventually leading to arterial occlusion. The normal posterior slope of the tibial plateau can also make the fracture hard to appreciate if it has any degree of depression. The tibial plateau view, which is an AP film angled 15 degrees caudally, can be used to help better assess for depression.

In this case of a class IV tibial plateau fracture, CT was used to assess the severity of the fracture and help with orthopedic preoperative planning. CT is especially helpful in class IV, V, and VI fractures, where soft-tissue injury is a concern (1). Some studies have suggested that as many as 99% of tibial plateau fractures have some degree of soft-tissue injury, although CT has a limited diagnostic ability to evaluate soft-tissue injuries in all these cases (2). CT has been shown to improve inter- and intra-observer reliability for classification of fractures when compared to plain film (3).

Although no MR images were obtained in this case, MRI can be used to look for meniscal injury (4). When MR imaging is compared to arthroscopy, MRI has a higher negative predictive value of 92.8% for meniscal and ligament injury than arthroscopy, but it only has an 85% accuracy in diagnosis of meniscal and ACL tears (2).

In type II fractures, the risk of soft-tissue injury can be predicted based on the degree of depression and widening. There is an 83% chance of lateral meniscal injury with a depression of more than 6 mm or widening of more than 5 mm, compared to just a 50% chance when the depression or widening is less (2). Medial meniscal injury is also increased in Type II fractures when there is a depression or widening greater than 8 mm (2).

In the case of posterior displacement, neurovascular and soft-tissue injuries in the popliteal fossa are a concern, and these cases must be managed differently than nondisplaced fractures (2). Type IV, pure-medial-plateau fractures often result from a varus force occurring while an axial load is applied to the knee. These fractures represent only about 10% of tibial plateau fractures, but they are the most likely...
to result in popliteal-artery injury and generally carry the worst prognoses (2). As in this case, Type IV fractures can initially present with no signs of posterior displacement, but neurovascular injury should still be considered when a high-energy mechanism of injury has occurred, because a prior dislocation can spontaneously reduce (2). It is not uncommon for Type VI fractures (bicondylar plateau fractures with diaphyseal discontinuity) to also cause some degree of vascular injury (2). When initially evaluating for arterial injury, Redmond suggests using Doppler arterial pressure index rather than CT angiography (1). If the arterial pressure index is less than 0.9, the next recommended step is duplex ultrasonography, followed by CT angiography if the duplex ultrasonography suggested vascular injury or was inconclusive.

The pathogenesis of arterial dissection is usually multifactorial and may be spontaneous, the result of trauma or sudden jerking movements, or secondary to predisposing conditions such as diabetes mellitus, hyperlipidemia, connective-tissue disorders like Marfan syndrome, or atherosclerotic occlusive disease. Arterial calcification is a complex process that may occur independently or in conjunction with atherosclerosis. Diabetes affects the progression of atherosclerotic lesions in the lower extremities through atherosclerotic occlusive disease and arterial stiffening related to medial calcinosis (6). This patient’s end-stage renal disease could have also played a role in her arterial calcification due to the imbalances it causes in calcium homeostasis. Medial arterial calcification is an ill-defined condition leading to stiffening of the elastic layer of the arterial wall that does not obstruct the arterial lumen. This type of calcification most commonly begins in the feet and progresses proximally (6). The process is not limited to calcification by passive mineral deposition, but involves active ossification and de novo bone formation. In addition, high intracellular glucose levels potentiate arterial-wall calcification and could lead to upregulation of the pathways that promote calcification of the arterial wall (5).

In our patient’s case, diabetes and end-stage renal disease most likely contributed to her calcified popliteal and lower-extremity arteries. The minor trauma that she sustained from a ground-level fall was enough to cause a pure-medial-tibial-plateau fracture. This fracture dislocated and spontaneously reduced or generated enough force to compress her popliteal artery and fracture the calcified media within. As the prevalence of diabetes and peripheral vascular disease increases in the United States, there will likely be a rise in arterial calcification within the patient population. Calcified arteries may be at risk to become disrupted and lead to arterial occlusion in the setting of trauma. This case clearly demonstrates their propensity to undergo fracture and dissection even after a relatively low-energy trauma. The use of CT to detect the disruption of arterial calcification secondary to trauma and predict vascular compromise in a trauma setting is something that may warrant further investigation.

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