# Arteriovenous Fistula After Percutaneous Osteotomy

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**Abstract:**
While undergoing a distal femoral osteotomy to facilitate expandable femoral rod placement, a 3-year-old with osteogenesis imperfecta (OI) sustained an injury to the femoral artery and vein that subsequently led to the development of an arteriovenous (AV) fistula and overgrowth of her lower extremity. Percutaneous osteotomies performed at the apex of the typically deformed femur in OI patients place the femoral artery at risk in the distal third of the thigh. Strategies to decrease this risk are presented.

**Key Concepts:**

- Planning and safe osteotomy technique can lower risk of injury to adjacent vascular structures.
- Surgeons performing osteotomies should have plans to address vascular injury should this complication occur.
- AV fistula can cause overgrowth syndrome and may be amenable to endovascular embolization treatment.
- Families should be informed of risks of surgery, and surgeons should have strategies to communicate about errors and complications.

## Introduction

Intraoperative injury to the femoral artery and vein during a femoral osteotomy in a 3-year-old patient with osteogenesis imperfecta (OI) led to the development of an AV fistula and overgrowth of the left lower extremity. A literature review did not reveal any reports of AV fistula development after femoral osteotomy in a child or of AV fistula development in a child with OI. The purpose of this report is to highlight the risk of vascular injury when performing a distal femoral osteotomy and to present methods to prevent the injury.

## Case Report:

A 3-year-old female with OI fell and sustained a displaced left femoral shaft fracture (Figure 1) and presented to the emergency department.

She had previously undergone expandable tibial rod placement for fractures and deformities using the Frasier-Duval (FD) rod system (Peg Medical, Laval (QC) Canada), and a plan had been made that if she sustained any femoral fractures, she would be treated with an expandable rod for the femurs as well. Thus, she was splinted in the emergency department, admitted, and taken to the operating room the following day for operative treatment of her fracture. Her surgical team included an attending pediatric orthopaedic surgeon with over 20

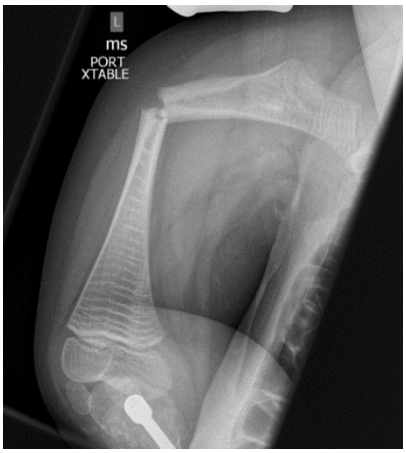


***Figure 1.*** *Injury films demonstrate left femoral shaft fracture in 3-year-old with OI. Note multiple growth lines from prior bisphosphonate treatments.*

years of experience, including extensive use of F-D rods for treatment of fractures in patients with OI, and a pediatric orthopaedic fellow in the 11th month of fellowship. They had performed many surgical procedures together, including prior F-D rod cases. The patient had a 10-degree apex posterior-lateral bowing deformity of the femur distal to her fracture (unusual as typically anterolateral bowing in OI); thus, correction of the bowing was needed in order to place the F-D rod appropriately from the greater trochanter to the center of the distal femoral epiphysis.


***Figure 2.*** *After reduction of the fracture and passing the reamer guidewire across into the distal fragment, there is apex posterior deformity of the femur needing osteotomy to allow passage of the straight rigid reamer and central positioning of the femoral implant in the distal femoral epiphysis.*

A distal femoral osteotomy was planned at the apex of the bow as determined fluoroscopically and performed by the fellow with attending guidance and positioning. A 1.0-cm incision was made laterally on the thigh, a blunt hemostat was used to spread down to bone, and a drill guide was placed on the femur. A 3.5-mm drill bit was then used to make multiple transverse passes bicortically across the femur under fluoroscopic guidance. A 1-cm straight osteotome was then placed through the incision

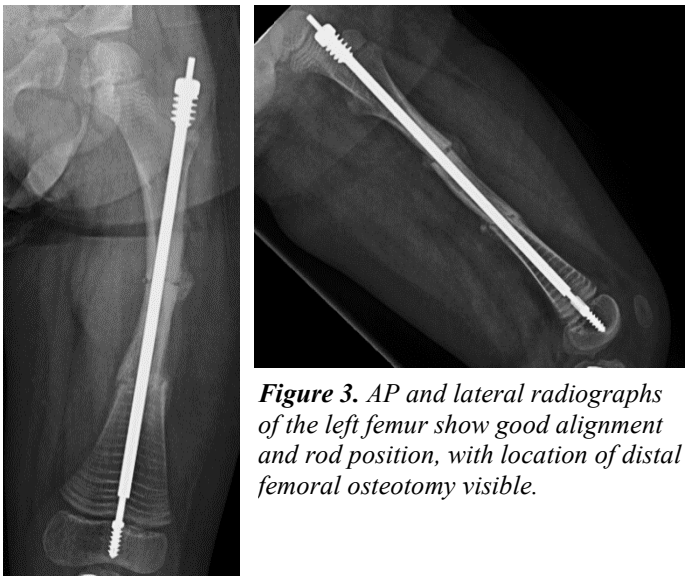

***Figure 3.*** *AP and lateral radiographs of the left femur show good alignment and rod position, with location of distal femoral osteotomy visible.*

and onto the femur at the level of the drill holes. The osteotome was struck and a greater amount of travel than planned was observed and the osteotome was noted on fluoroscopy to protrude into the medial thigh soft tissues. As the osteotome was withdrawn, a gush of bright red blood followed, more than is typically seen after completing an osteotomy. The thigh was grabbed proximal to the osteotomy and manual pressure medially resulted in cessation of bleeding. With manual pressure applied, the lateral approach was extended so that the osteotomy could be completed. While maintaining pressure medially on the proximal femoral artery, we then utilized our exposure laterally by placing varus stress on the osteotomy we could deliver the bone ends, distract them, and get some visualization medially. The medial pressure was released, and no bleeding medial to the femur was noted. The medial thigh remained soft, and an expansile hematoma was not noted. The foot had strong palpable pedal pulses, and Doppler ultrasound confirmed normal sounding triphasic signals. The anesthesiologist did not note any lability in blood pressures, and an intraoperative hemoglobin was stable. A decision was made to continue with the case, and the FD rod was placed across the fracture and osteotomy and anchored proximally and distally (Figure 3), and a long-leg splint was applied. The patient was observed carefully overnight with no changes in her distal pulses or perfusion,

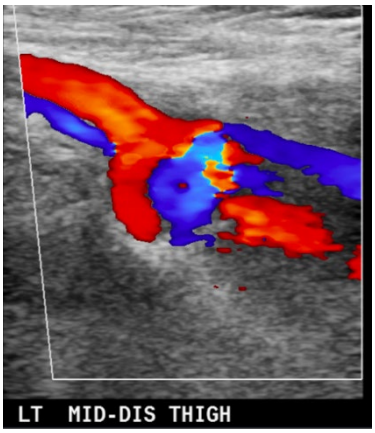


***Figure 4.*** *Vascular ultrasound study performed 3 months after surgery demonstrates an AV fistula between the femoral artery (red) and vein (blue) in the distal third of the thigh.*

her thigh was soft without swelling, and her hemoglobin remained stable. She was discharged home and returned to clinic 3 weeks after surgery for splint removal and her examination was unchanged. At 6 weeks after surgery, she returned for radiographs with no complaints—she was comfortable, moving her left lower extremity well, with normal pulses in her foot.

Her thigh remained soft without swelling, but on palpation of her medial thigh, a thrill was palpable at the junction of the middle third and distal third, and auscultation revealed a loud thrill. Vascular consultation was obtained, and an AV fistula was diagnosed with ultrasonography (Figure 4).

Observation was recommended. The fracture and osteotomy healed uneventfully over the next few months, and the patient resumed full weight-bearing and walking. At 12 months after surgery, the patient was noted to have an engorged appearance of the thigh and foot with some reddish discoloration, the circumference of the thigh and calf on the left were 2 cm larger, and the left lower extremity was 2 cm longer than the right on a standing alignment film (Figure 5).

The bruit and thrill remained. A pediatric interventional radiologist was consulted and felt treatment might be indicated, and a CT angiogram was ordered (Figure 6).

A decision was made to treat the AV fistula with interventional radiology placing coils to embolize the AV fistula. The procedure went well, and the patient recovered

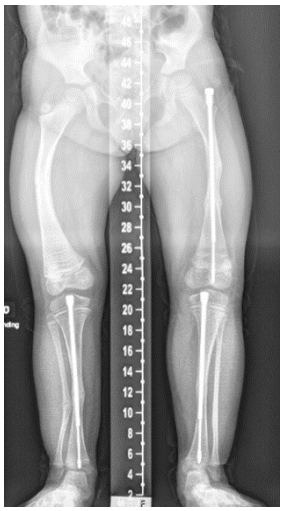

***Figure 5.*** *Standing AP of both lower extremities 1 year after surgery shows the right lower extremity is 2 cm longer than the left, and the increased circumference of the thigh and calf can be appreciated in the radiographic shadows of the soft tissues. The right femur measured 20.0 cm, and the left 21.4 cm. The right tibia measured 17.4 cm and the left 17.8 cm.*

well, maintaining normal pulses and perfusion distally. One year after her embolization procedure, her vascular ultrasound showed no AV fistula with normal arterial waveforms and flow throughout the left lower extremity, with no deep vein thrombosis. Over the next 2 years, her thigh and leg lost the engorged appearance, and her thigh and leg circumferences and limb lengths improved on standing alignment film (Figure 7). She will be followed throughout growth and development with serial vascular ultrasound studies.

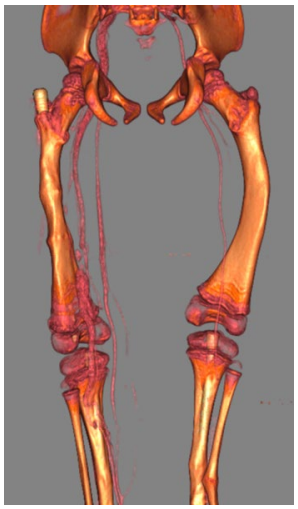

***Figure 6.*** *Posterior view of 3D CT angiogram of the lower extremities 1 year 3 months after surgery demonstrates a femoral artery to femoral vein fistula posteromedial to the left femur at the location of the prior osteotomy. Note the larger and more extensive vascular structures on the left.*

## Discussion

Children with OI are susceptible to fractures because of underlying bone fragility, but that same fragility often causes preexistent skeletal deformity. To stabilize the

***Figure 7.*** *Two years after surgery and 1 year after embolization, the limb lengths are nearly symmetric with the difference now being 1 cm longer on the left. The right femur measured 24.5 cm, the left 25.5 cm, and both tibias measured 21.5 cm. The thigh circumference decreased to 1 cm larger on the left, and calf circumferences were equal. The metal coils from the interventional radiology procedure are visible at the location of the healed distal osteotomy.*

entire length of a long bone, and to lessen the changes of recurrent fractures, persistent deformity will need to be corrected in order to span the entire bone. This often requires an osteotomy or osteotomies at locations different than the site of the fracture. Understanding that bones are dependent on attachment sites of muscles and other soft tissues for blood supply led to minimally invasive approaches in fracture care and also for identifying safe locations for performing osteotomies. These approaches do not allow for placement of large retractors on the opposite side of the bone; thus, the use of drills and osteotomes relies on surgeon control to limit travel of the drill bit or osteotome past the far side of the bone. As with incisions and surgical approaches, knowledge of anatomical structures to be protected should be considered when performing osteotomies. Great care should be taken when utilizing a minimally invasive approach with control of depth of instruments, especially when the direction of any sharp tool is towards vascular or neurologic structures. In the thigh at the junction of the middle third and distal third of the femur the femoral artery and femoral vein are in the pathway of an osteotome directed from anterolateral to posteromedial (Figure 8).

The safest approach involves making a larger incision that allows for placement of a blunt retractor such as a

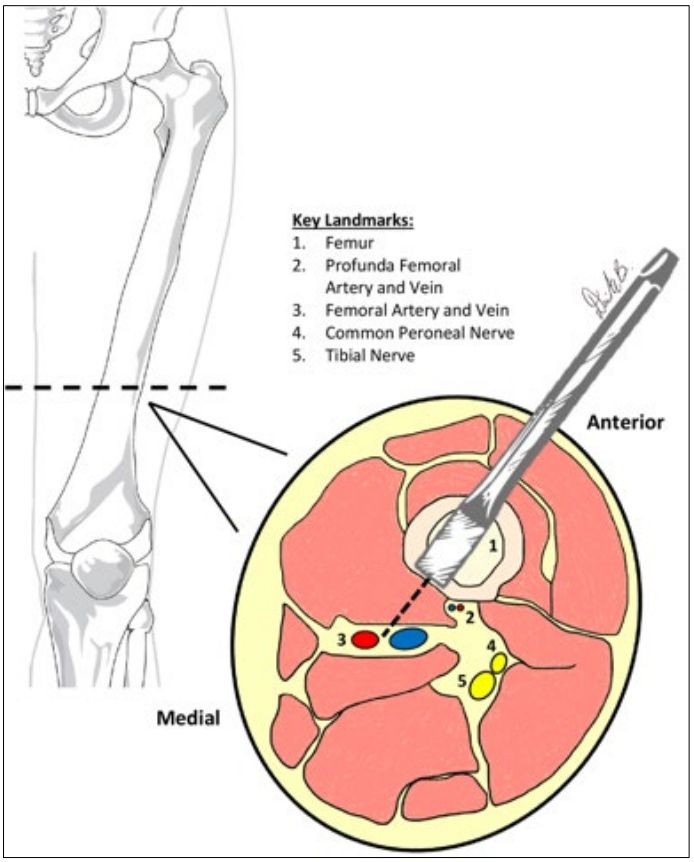


***Figure 8.*** *Cross-sectional anatomy at the junction of the middle and distal third of the femur. When performing a percutaneous osteotomy at the apex of the deformity here, the drill bit and osteotome will be advancing toward the femoral artery and vein.*

Homan retractor or Chandler elevator on the medial side of the femur to protect against injury to the medial soft tissues, vessels, and nerves. The surgeon must weigh the disadvantages of more extensive exposure (less vascularity to bone, larger scars) with the advantages of being able to place retractors on the opposite side of the bone. When using a minimally invasive approach, in addition to anatomical knowledge of structures at risk, the surgeon should test the bone with a light touch. Even experienced surgeons may not recognize that poor bone quality in OI patients can lead to less resistance when performing osteotomies; thus, mallet blows to the osteotome should start with minimal force and progressively increase as needed to advance the osteotome through the bone to the opposite cortex. A firm grip on the osteotome combined with light mallet taps to start is recommended. Fellows and residents need to be able to

perform complex operations under supervision to develop surgical skills and the ability to one day perform them independently. Orthopaedic surgeons should be prepared for the possibility for vascular injury whenever performing osteotomies and have access to vascular surgery equipment and available surgeon expertise.

Parents should know about possible complications before surgery. In this case, documentation of informed consent included possible vascular injury. After the bleeding was noted intraoperatively, controlled, and the case completed, the mother was informed of all of the events noted above, including that the fellow was performing the osteotomy at the time of vessel injury. It has always been the senior surgeon's practice to disclose the events of complications honestly with parents and to take complete and full responsibility for everything that happens in the operating room, regardless of whether a resident or fellow is performing steps of the operation when an error occurs. We need surgeon educators to develop the next generation of surgeons or in the future, there would not be surgeons to take care of their children as adults or their future grandchildren. Honest, open sharing of information, viewing images together, and discussing future possibilities and treatments has maintained a good therapeutic relationship with this family.

Rumination and second guessing are common after surgical complications and poor patient outcomes. It is unknown if operative exploration of the medial thigh would have identified a repairable vascular injury and what effect that would have had on her long-term outcome. While analyzing complications to learn and prevent future complications is important, self-compassion is needed as well as empathy for surgical learners when complications occur.

Percutaneous osteotomies performed at the apex of the typically deformed femur in OI patients place the femoral artery at risk in the distal third of the thigh. The occurrence of AV fistulas in children is rare; thus, the management of them is not standard or clear. As long as adverse consequences are not noted, observation with serial vascular ultrasounds is warranted. Operative exploration and vascular surgery may be needed, but the outcomes are unpredictable. Interventional radiology procedures are less invasive and can be successful as in this case. The long-term prognosis for this patient seems to be good, as her growth disturbances seem improved, and she has a normal vascular examination.

## References

No publications reporting on AV fistula after femoral osteotomy in children or in OI patients were found.

## Additional Links

POSNAcademy Videos of F-D Rodding for OI Patients

- *Nails in OI*—F. Fassier https://www.posnacademy.org/media/Nails%20is%20Osteogenesis%20Imperfecta/0_mm1zepx6
- *Telescoping Nail for Osteogenesis Imperfecta*—M. Caird https://www.posnacademy.org/media/Telescoping+Nail+for+Osteogenesis+Imperfecta/0_cmxra62s