Novel Technique of Intraosseous Arteriogram to Evaluate Talar Viability After High-Energy Trauma

Vikram A. Bala DPM[1,4], Gregory A. Foote DPM[1,4], Paul L. Wasserman, DO, MHCM[5]
Jason A. Piraino DPM, MS, FACFAS[1,2,3]

[1]Department of Orthopedics, Division of Foot and Ankle Surgery, [2]Associate Professor, [3]Chief of Foot and Ankle Surgery, Residency Director,
[4]PGY-3 Podiatry Resident, [5]Assistant Professor, Chief of Musculoskeletal Radiology

Purpose and Literature Review

Avascular necrosis (AVN) or osteonecrosis is cellular death of bone components due to the interruption of blood supply. Most available recent data regarding the pathology and treatment of AVN pertains to necrosis of the femoral head, which is most common; followed by proximal pole of scaphoid, body of talus, lunate, and second metatarsal head (1). Previous studies have confirmed that plain radiographs (XR) are highly specific for advanced disease but exhibit very low sensitivity for the earliest stages of the disease (2,3), however MRI remains the gold standard of diagnosis and staging.

Core decompression is accepted as an effective treatment option for AVN, most widely described for the femoral head and talus. Successful results have been reported when performed in the initial or pre-collapse phases (Ficat stage 0 through 2); however, less-than-desirable results have been reported when performed in advanced stages (Ficat stage 3 or 4) (4,5).

This study describes a unique, minimally invasive technique using interosseous (IO) arteriogram to determine the prognosis of bones susceptible to AVN after high-energy trauma. This technique was applied after an open, Hawkins III/IV talar neck fracture/dislocation to evaluate the quality of perfusion to the talar dome as a predictor of AVN and structural collapse. Based on intraoperative findings correlated to preoperative XR, area of concern was pinpointed and core decompression was performed and supplemented with implantation of autogenous calcaneal dowel and allogenic bone graft.

Case Study

A 31-year-old female was seen status-post polytraumatic motor vehicle accident with significant lower extremity injuries including comminuted medial femoral condyle and tibial plateau fractures, lateral malleolar fracture, and open talar neck fracture/dislocation (Gustillo-Anderson Type II, Hawkins Type- III/IV) (Figure 1). Upon initial presentation, 5-cm laceration was noted to postero-medial ankle. Wound was copiously irrigated, fracture/dislocation was reduced and splinted. Post-reduction CT confirmed talar neck fracture with lateral dislocation of talar head along with maintained ankle congruity (Figure 2 &3). Formal debridement and irrigation (D&I) was performed with external fixator(ex-fix) application spanning the knee and ankle, along with percutaneous pinning of the talar neck fracture (Figure 4). Patient followed up with Orthopedics for right knee and bilateral distal radii fractures as needed. XR 6-weeks from injury showed positive Hawkins sign to central and medial talar dome, however there was concern for developing lateral AVN (Figure 5). Patient returned to OR one week later for ex-fix removal and intraosseous arteriogram (IOA) of the right talus and bone biopsy due to concerns of early stage AVN.

Scan our QR code to see intra-op fluoroscopic video of the Intra Osseous Arteriogram being performed.

Preoperative Imaging

Figure 1: Initial injury XR


Figure 2: Post reduction CT

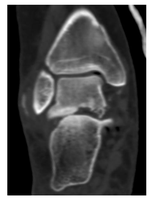
Figure 3: Post reduction CT


Figure 4: Intraop XR of ORIF

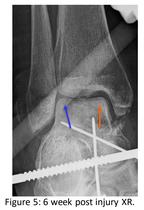
Figure 5: 6 week post injury XR. Anterolateral concern for sclerosis (blue arrow). Positive "Hawkins" sign (orange arrow)

Surgical Procedure

Patient was positioned supine with the right lower extremity (RLE) elevated on a bone foam. Intraoperative fluoroscopy was used to target the anterolateral talar dome with a 45mm IO needle/port. 5 mL of radiopaque dye was injected through the IO port and into the talus while live fluoroscopic video was recorded on AP and Lateral views (Supplement 1 & 2).
IOA revealed brisk perfusion to the central and medial talar dome, with anterolateral ischemia. Collateral vessels were noted crossing the fracture, and communicating with the talar head. 3mm trephine was used to obtain bone specimen from the anterolateral talar dome and backfilled with calcaneal dowel autograft, supplemented with allogenic rhPDGF-BB/β-TCP. Radiographic findings were correlated with pathology results along with MRI completed one month postoperatively and serial XR.

Histological Report

Bone specimens- Talus (Right):
Quantity: 2
Size: 0.5 x 0.4 x 0.4 cm, each
Result: Fragments of viable bone mixed with other nonviable appearing fragments, suspicious for focal osteonecrosis (25%). Mild chronic inflammation.
Decalcification during specimen processing may cause artifacts on bone necrosis.

Intraoperative Imaging


Figure 6: Targeting anterolateral talar dome with IO needle.


Figure 7: Mortise view during injection of radiopaque dye.

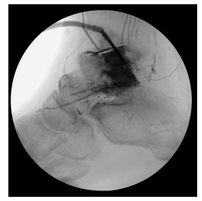
Figure 8: Lateral view during injection of radiopaque dye.

Radiographic Findings

Live Fluoroscopic Images, Figures 6-8:
Opacification of the marrow spaces of the talar dome with relative sparing of the lateral corner of the talar dome, a finding that could be secondary to osteonecrosis. Later images reveal contrast within the intra-articular space and extending into the anterior talonavicular space, possibly via prior K wire tunnels. Likewise, there is opacification of the peri-articular vasculature.

Post Operative XR:
6 weeks: sclerotic appearance of the talar dome secondary to bone graft placement. Ankle mortise remains congruent.
3 months: The talar dome is without collapse; however, exhibits mild sclerosis. (Figure 10)
6 months: Healing talar fracture, no collapse of talar dome. Possible "Hawkins" rim sign noted (red dashed line). (Figure 11)

MRI (1 month Post Operatively), Figure 9:
1.5 x 1.4 x 0.7cm (AP x Trans x CC) area of nonenhancing bone within the anterolateral aspect of the talar dome concerning for osteonecrosis (gray arrow).
1.5 x 0.9 x 1.3 cm (AP x Trans x CC) peripherally enhancing bone defect along the lateral aspect of the body of the calcaneus, possibly a bone harvest site (yellow arrow).

Postoperative Imaging


Figure 9: MRI taken 1 month postoperatively. Area of concern for AVN (white arrow), calcaneal dowel harvest site (yellow arrow).


Figure 10: XR taken 6 weeks postoperatively.

Figure 11: XR taken 3 months postoperatively with positive "Hawkins" sign (red dashed line).

Clinical Progression

	VAS	Ankle Dorsiflexion	Ankle Plantarflexion
Pre Op	9/10	0	0
1 week post	9/10	3	25
6 weeks post	2/10	3	25
12 weeks post	3/10	5	25
24 weeks post	2/10	7	25

Discussion

AVN can occur in up to 100% of cases of talar neck fracture, depending on the severity of the fracture comminution and displacement, however contemporary studies have demonstrated an overall rate of 30% to 50% of osteonecrosis, compared with a prevalence of up to 91% reported in Hawkins' landmark article (6,7,8).

Previous studies have compared MRI to scintigraphy for use in diagnosis of AVN and concluded that although scintigraphy may be useful as a screening tool, it shows the least utility in the earliest stages of the disease. (9,10) MRI remains the gold standard for assess AVN but has not been described as a prognostic tool early on (11). In this case, MRI was unavailable due to the ex-fix and concern for low quality images due to metallic artifact.

The use of core decompression has been widely studied for use in femoral head AVN and has been applied to talar AVN as well. Gangji and Hauzeur (12) reported that bone marrow implantation delayed the progression of AVN from stages 1/2 to stage 3 at 60 months of follow-up and provided a significant decrease in pain, as compared with isolated core decompression in hips. Higher functional scores were reported in the bone marrow group at the end of follow-up, and significantly fewer patients required joint replacement. In this case, core decompression followed by implantation of autogenous bone dowel supplemented with rhPDGF-BB/β-TCP proved to be effective in management of early stage (1/2) AVN and prevention of progression.

This study demonstrates the utilization of an innovative, minimally invasive operative technique to evaluate and manage talar AVN. Through combination of various imaging modalities and a novel procedure, the patient experienced a timely return to ambulation with significant improvement in function. Most recent XR revealed union across fracture site along with maintained integrity of talar dome without collapse. This unique practice offers advancement of current treatment methods in management of early stage post traumatic talar AVN.

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