Journal of Orthopaedic Trauma
Vol. 7, No. 4, pp. 320–324

Synovial Metallosis Resulting From Intraarticular Intramedullary Nailing of a Distal Femoral Nonunion

Eric E. Johnson, *Carlos E. Marroquin, and *Nir Kossovsky

*Departments of Orthopaedic Surgery and *Pathology, University of California, Los Angeles, Los Angeles, California, U.S.A.*

Summary: An 80-year-old man sustained a T-shaped supracondylar fracture of the femur associated with distal one-third shaft comminution. Initial failure of a 95° angle blade plate was followed by insertion of an intraarticular intramedullary nail stabilized with static locking-screw fixation. A second failure of the implant was treated by extraarticular tension band condylar buttress plate osteosynthesis. Severe knee synovial metallosis was found at the time of removal of the intraarticular nail device. **Key Words:** Synovial metallosis—Intraarticular intramedullary nail.

The management of distal femoral nonunions or comminuted fractures may be extremely difficult, and significant skill is required to achieve acceptable results. There are several well-established indispensable implant designs that facilitate the stabilization of complex distal femoral fracture and nonunion morphology (7,10–15,17). These implants rely on extraarticular fixation of the distal femur and offer acceptable union rates with a low incidence of complications if proper technique is followed. Antegrade locked intramedullary fixation of the femur is the standard treatment of choice for fractures of the middle two thirds of the femoral shaft. This technique may be extended to supracondylar femur fractures with minimal displacement when associated with separate extraarticular intercondylar lag-screw fixation (2).

A more recent development is the supracondylar intraarticular retrograde intramedullary nail. This implant is inserted through a knee arthrotomy and penetrates the mid-portion of the distal femoral intercondylar notch near the cruciate ligament origin. The nail is inserted retrograde through the medullary cavity of the distal femoral metaphysis. The implant is then stabilized to the distal femur by static locking screws placed from the lateral femoral cortex. The manufacturers and proponents of this technique imply that this implant can both stabilize intraarticular fractures (something not routinely recommended with intramedullary devices) and preserve the advantage of intramedullary fixation of distal femoral fractures and nonunions (3–5).

We report a significant complication, synovial metallosis, with this technique and specifically with this implant. We are unaware of prior documentation of synovial metallosis following this type of intramedullary implant.

CASE REPORT

An 80-year-old man sustained a displaced T-shaped intraarticular fracture of the distal femur associated with an ipsilateral comminuted distal-third femoral shaft fracture. Initial stabilization of this fracture complex was performed using a fixed-angle (95°) blade plate device (Fig. 1). The articular

Accepted December 17, 1992.
Address correspondence and reprint requests to E. E. Johnson, M.D. at Department of Orthopaedic Surgery, UCLA, 10833 LeConte Avenue, Los Angeles, CA 90024, U.S.A.

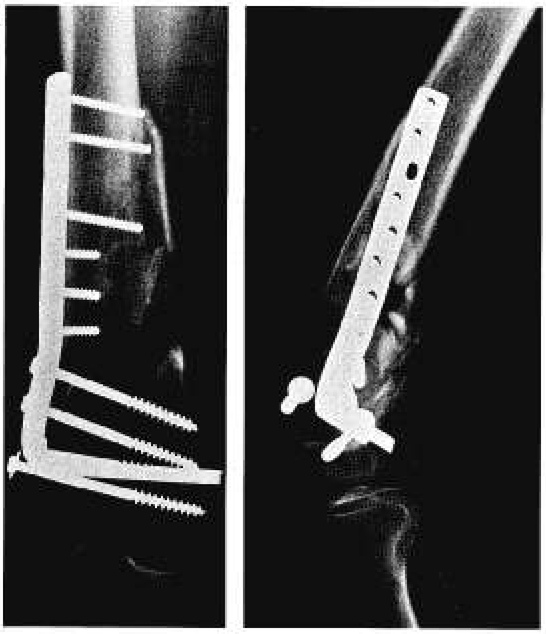

FIG. 1. (A) Anteroposterior (AP) and **(B)** lateral radiographs of the initial fixation of an intraarticular T-shaped fracture with distal shaft comminution. A fixed-angle blade plate was placed in varus, resulting in valgus malalignment of the distal femur. The distal fragment is in extension in relationship to the femoral shaft.

portion of the fracture was well-reduced, but the blade portion of the plate was placed in extension and varus positions with respect to the distal femoral tibial joint axis. With reduction of the plate to the shaft, a malalignment of the fracture occurred resulting in valgus shortening and extension of the distal articular fragment. A large distal-third medial cortical defect developed from the valgus malalignment, and the defect was not grafted. The plate eventually sustained fatigue fracture at 4 months (Fig. 2).

A second procedure at 5 months involved removal of the lateral failed angled blade plate implant combined with a medial arthrotomy and retrograde intramedullary nailing through the intercondylar notch using an intramedullary supracondylar nail (150 × 11 mm, Smith & Nephew Richards, Memphis, TN, U.S.A.). Three proximal and two distal locking screws were placed through specific nail screw holes, providing a static lock to this nonunion. The T-shaped articular fracture of the distal femur healed uneventfully. The metaphyseal portion of the distal femur fracture developed an oblique distal-anterior–proximal-posterior nonunion (Fig. 3). The supracondylar intramedullary nail eventually failed by fatigue fracture at 4 months after insertion.

The patient was referred at 4 months after placement of the intramedullary nail but wasn't seen until 5 months after nail insertion due to extensive travel distance. The 1-month interval between referral and repeat radiographic evaluation revealed evidence of fatigue fracture of the intramedullary device. At the time of implant removal, the synovium appeared very darkened, extremely inflamed, and friable. Small black specs of debris were seen throughout the joint space. The synovium directly below the intraarticular portion of the nail was black in appearance. A synovectomy was performed and sent for pathology (Fig. 4). The synovial biopsy revealed synovial metallosis with local areas of inflammation.

The hypertrophic femoral nonunion was debrided, and correction of posterior displacement and extension deformities of the distal fragment was accomplished by anterior-to-posterior 6.5-mm lag-screw fixation. An extraarticular tension band condylar buttress plate osteosynthesis of the femoral nonunion was performed along the lateral femoral cortex without additional bone graft (Fig. 5). Union occurred at approximately 10 weeks after re-

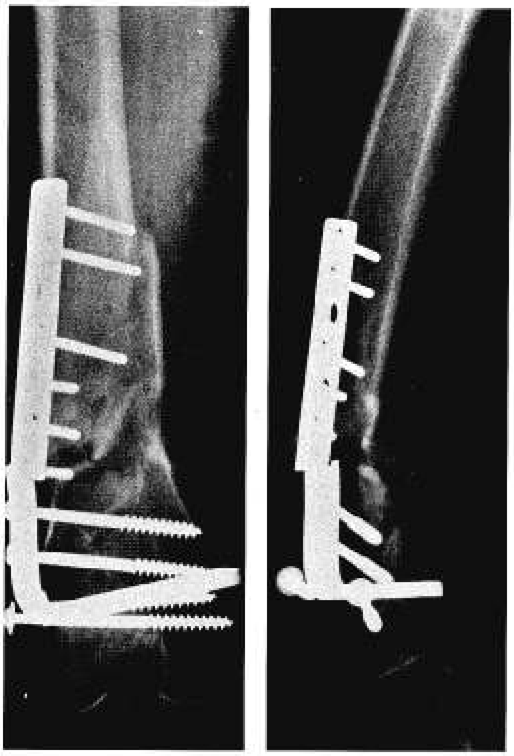

FIG. 2. (A) AP and **(B)** lateral radiographs showing fatigue fracture of the blade plate at 4 months with more anatomic alignment of distal femur.

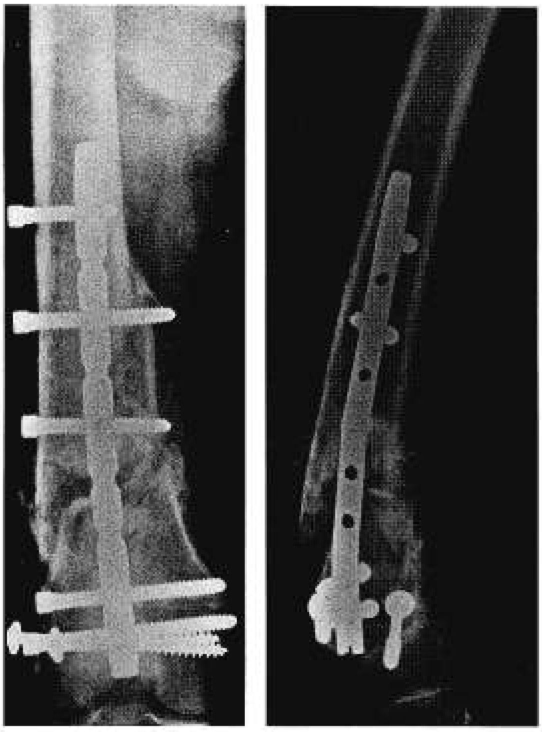

FIG. 3. (A) AP and **(B)** lateral radiographs showing the failed intramedullary supracondylar nail with fatigue fracture at the level of the fifth screw hole (third-most-proximal screw). The distal fragment is posteriorly displaced, and femoral nonunion is evident on the lateral radiograph.

moval of the supracondylar intramedullary nail and buttress plate osteosynthesis.

DISCUSSION

The pathophysiology of synovial metallosis results from the accumulation of wear debris from prosthetic devices in the synovium due to abrasive loads between components (metal–metal, metal–bone, metal–polyethylene, and metal–cement) that continually shed wear particles or as an outright mechanical failure. Metallic debris usually produces a gray-black discoloration of the synovial tissue and in some instances green or brown discoloration (1). Microscopic examination demonstrates irregular metal fragments in the synovium as well as within phagocytic cells (Fig. 4).

Microscopic metal fragments deposited within the synovium may produce a wide spectrum of pathology over time. Initially, a fulminant inflammatory response capable of producing irreversible damage is seen. Metal particles have been shown to stimulate a chronic inflammatory response characterized by tissue infiltration with macrophages, lymphocytes, and multinucleated giant cells. Persistence of particles may lead to necrosis for unknown reasons. Fibrosis replaces the necrotic debris with permanent damage to the synovial tissue (6).

Synovial tissues that accumulate metal-filled histiocytes or multinucleated giant cells may become aggressive bone lytic membranes. Debris containing synovium has the ability to invade bone and cause cyst-like lesions on radiography. These cyst-like lesions can be associated with the spread of an inflammatory process through the marrow spaces and osteoclastic activation, which may result in bone dissolution (8). Finally, loss of metal into tissue can lead to sensitization and or sensitivity reactions. Metal sensitivity usually develops to metal salts as haptens. The binding of metal ions to body proteins causes the sensitivity to the metal ion (9). Sensitivity reactions involve the accumulation of inflammatory cells at the implant site and can eventually produce regional areas of necrosis.

In this patient, the time between placement of the supracondylar intramedullary nail and eventual implant removal was 5 months. A significant amount of synovitis developed within that time period. With the development of metal fatigue fracture and fretting between the fractured ends of the nail and from multiple potential screw thread–nail interfaces, metal particles were allowed direct access to the intrasynovial space. At the time of implant removal, there was no evidence of bony overgrowth of the distal intercondylar insertion site, and the lower end of the nail was in direct contact with synovium and joint fluid. The nonunion was completely enclosed with fibrotic tissue, and there was no evidence of direct communication between the nonunion and the synovial space.

The introduction of the technique of retrograde intraarticular intramedullary nailing was as a rarely performed technique for the management of combined femoral shaft, neck, and distal femur fractures (16). This technique is reserved for the unusual fracture configuration and not indicated as a standard technique for routine fracture management. The initial fixation of this patient's distal femur fracture was unstable, leading to the eventual fatigue fracture of the fixed-angled blade plate. The resulting long oblique distal femoral nonunion configuration was not easily stabilized by intramedullary nailing, and fatigue of the implant occurred. There is no current recommendation that this implant is indicated in the treatment of distal femoral

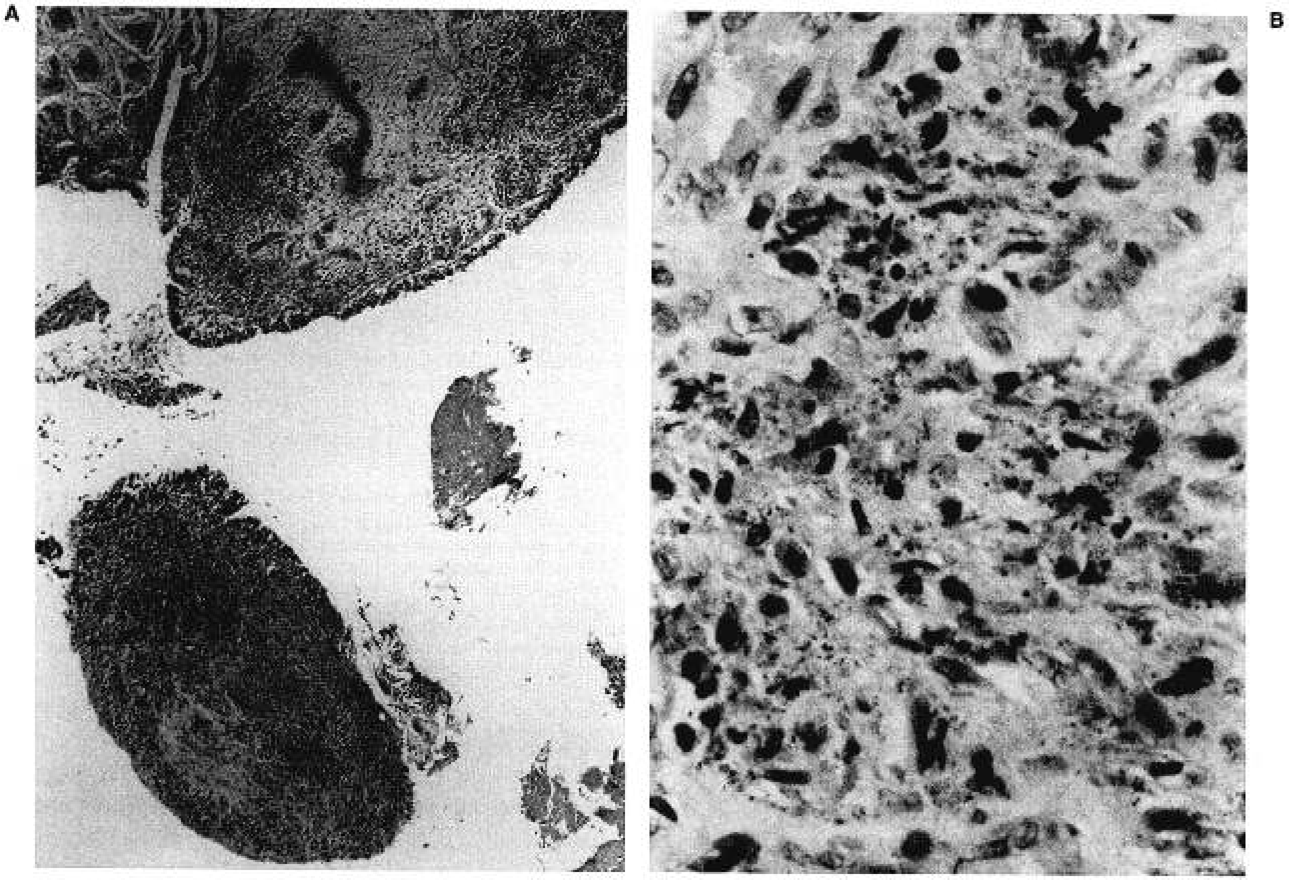

FIG. 4. A: Histological photomicrograph of synovial biopsy of knee, exhibiting pigmented villous folds and a dense cellular infiltrate (original magnification, ×25). B: Histological photomicrograph revealing a florid histiocytic infiltrate. The macrophages are heavily laden with alloy debris (metallosis) (original magnification, ×100).

nonunion following failed extraarticular fixation. Implant failure occurred at the level of the fifth screw from the top of the nail located slightly proximal to the nonunion. Under the specific conditions of an oblique distal femoral metaphyseal nonunion, the design of this supracondylar intramedullary nail using static locking technique most likely produces a load-sparing construct. Improper use of any implant may increase the likelihood of implant fatigue and related complications.

This device comes in one diameter, 11 mm, and two lengths, 150 and 200 mm. Second-generation designs of the implant have reduced the size of the locking screw hole from 6 to 5 mm and increased the nail wall thickness to prolong the fatigue life of the implant. In the application of this technique at the level of the distal femoral metaphysis, the major beneficial effects of an intramedullary device of 11 mm in diameter and 150 mm in length may be lost compared with midshaft femoral diaphyseal cortical intramedullary nailing due to great anatomical variation in the metaphyseal medullary canal and associated soft cancellous bone. At the supracondylar level of the femur, the major stabilization of the nail occurs through the locking screws and not from a tight fit provided by close contact with cancellous bone of the distal femoral metaphysis. This is especially true if there is an associated T-shaped supracondylar fracture or severe osteopenia.

Fretting will occur at the nail–screw interface and may be a constant source of wear debris. The distal nail insertion site provides direct communication of this debris with the intraarticular space. This patient ambulated on the fractured implant for several months before implant removal. It is conceivable that this constant motion may have increased the friction and wear between the fractured nail ends and also between the nail–screw hole interfaces. This increased motion may have augmented the amount of wear debris accumulating within the synovial space.

This implant design and insertion technique re-

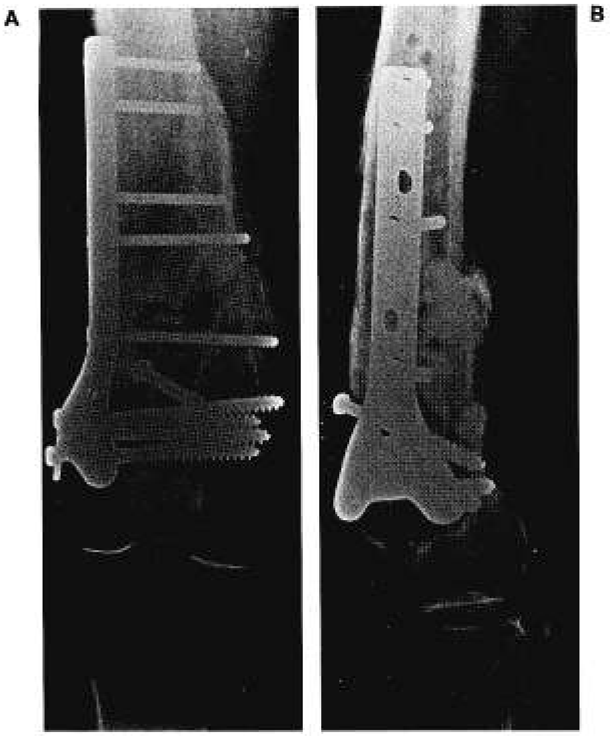

FIG. 5. (A) AP and **(B)** lateral radiographs of condylar buttress tension band plate osteosynthesis of distal femur nonunion at 8 months. Anteroposterior lag-screw fixation reduces posterior displacement of femoral condyles. No bone graft was used on this hypertrophic nonunion. There is slight valgus deformity of the distal femur with mild shortening secondary to previous treatment.

quired intraarticular penetration of the distal femoral cortex. The resultant open conduit created by the nail from the intramedullary canal to the knee joint allowed the flow of implant wear debris into the synovial space. The potential for significant articular damage from wear debris cannot be eliminated as long as there is direct communication between the synovial space and the intramedullary cavity. The implant also requires a second arthrotomy for nail removal.

The surgeon is required to preserve the function and integrity of the articular surface and joint space from damage, provide anatomic reduction of the articular surface, and adequately stabilize the fracture. This device may play a role in certain fracture and reconstruction problems, such as a distal femur fracture below an ipsilateral total hip replacement or in the hands of experienced trauma surgeons who are familiar with the technique of intraarticular intramedullary nailing. Synovial metallosis may become more prevalent with the increased application of intraarticular intramedullary nailing, and the findings in this case should stimulate investigation into the potential incidence of the complication.

REFERENCES

1. Bullough PG: Joint diseases. In: *Diagnostic Surgical Pathology*, ed by SS Sternberg, New York, Raven Press, 1989, pp 201–215.
2. Butler MS, Brumbeck RJ Jr, Ellison TS, Polka A, Bathon GH, Burgess AR: Interlocking intramedullary nailing for ipsilateral fractures of the femoral shaft and distal part of the femur. *J Bone Joint Surg* [*Am*] 73:1492–1502, 1992.
3. Green S: Distal intramedullary fixation of supracondylar fractures of the femur. *Tech Orthop* 3(3):71–76, 1988.
4. Henry SL, Green S, Trager S, Seligson D: Management of supracondylar fractures of the femur with the GSH intramedullary nail: Preliminary report. *Contemp Orthop* 22: 631–640, 1991.
5. Henry SL, Innacone WM, Born CT, et al.: Management of supracondylar fractures of the femur with the GSH intramedullary nail [Abstract]. Orthopaedic Trauma Association Annual Meeting, Seattle, WA, 1991.
6. Howie DW, Vernon-Roberts B: The synovial response to intra-articular cobalt chrome wear particles. *Clin Orthop* 232:244–254, 1988.
7. Johnson EE: Combined direct and indirect reduction of comminuted four-part intraarticular T-type fractures of the distal femur. *Clin Orthop* 231:154–162, 1988.
8. Kossovsky N, Mirra JM: Biocompatibility and bioreactivity of arthroplastic material. In: *Hip Arthroplasty*, ed by HC Amstutz, New York, Churchill Livingstone, 1991, pp 571–611.
9. Merrit K, Brown SA: Tissue reactions and metal sensitivity to orthopaedic implants. *Int J Dermatol* 20:89, 1981.
10. Mize RD, Bucholtz RW, Grogan DP: Surgical treatment of displaced, comminuted fractures of the distal end of the femur. An extensile approach. *J Bone Joint Surg* [*Am*] 64:871–879, 1982.
11. Müller ME, Allgöwer M, Schneider R, Willeneger H: *Manual of Internal Fixation*. New York, Springer-Verlag, 1991, pp 254–271.
12. Sanders R, Regazzoni P, Rüedi TP: Treatment of supracondylar-intracondylar fractures of the femur using the dynamic condylar screw. *J Orthop Trauma* 3:214–222, 1989.
13. Schaztker J, Horne G, Waddell J: The Toronto experience with supracondylar fracture of the femur, 1966–72. *Injury* 6:113–128, 1975.
14. Schatzker J, Lambert OC: Supracondylar fractures of the femur. *Clin Orthop* 38:77–83, 1979.
15. Siliski JM, Mahring M, Hofer HP: Supracondylar intercondylar fractures of the femur. *J Bone Joint Surg* [*Am*] 71:95–104, 1989.
16. Swiontkowski MF, Hansen ST Jr, Kellam J: Ipsilateral fractures of the femoral neck and shaft. A treatment protocol. *J Bone Joint Surg* [*Am*] 66:260–268, 1984.
17. Zickel RE, Hobeika P, Robbins DS: Zickel supracondylar nails for fractures of the distal end of the femur. *Clin Orthop* 212:79–88, 1986.324–325