



CASE REPORT

Failure of Intramedullary Expandable Tibial Nail and Fragmentation During Extraction

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Introduction

The tibial shaft is the most commonly fractured long bone in orthopaedics.¹ Depending on the characteristics of the fracture and the patient, various treatment options have been successful. These include closed reduction and immobilization, intramedullary nailing, external fixation, flexible Ender nailing, compression plating, interfragmentary screwing, and functional braces.² Intramedullary (IM) nail fixation of the tibial shaft has become the preferred method of definitive treatment in open and closed diaphyseal fractures.³ The degree of soft tissue and bony injury must be evaluated as contraindications for IM nailing of open tibial fractures. Interlocking forms of IM nailing with or without reaming have been the most extensively studied and advocated methods of fracture fixation of the tibial shaft.⁴⁻⁸

As an alternative to the interlocking forms of IM nail fixation, a more recent nail design that incorporates an expandable chamber for fixation of the humerus, femur, and tibia is now available (Fixion nail, Disc Orthopaedic Technologies Inc, Monroe Township, NJ). To our knowledge, there have been no reports of expandable tibial nail breakage and only one report of humeral nail breakage, in which no complications were noted during removal of the nail.

We present a case of a young male who sustained an open tibial shaft fracture and was treated with an expandable nail. The patient developed a nonunion of the tibia, bending of the IM rod, breaking of tines and fragmentation.

Case Report

A 19-year-old male sustained an injury to his right leg in a motocross accident. Upon evaluation by an orthopaedic surgeon, the patient had a comminuted fracture of the diaphysis of the tibia and fibula (Figure 1). A 2-cm laceration was noted over the tibial fracture. A nondisplaced fracture of the medial malleolus also was noted. The patient underwent debridement and irrigation of the open fracture and placed in a long leg cast the day of the injury. Intravenous antibiotics were given postoperatively.

Eighteen days after the injury, the patient underwent removal of the cast and IM nailing of the tibia using the (Fixion) expandable nail. A patellar splitting approach was used and an 8.5mm x 340mm expandable tibial nail was placed after a second incision over the fracture was used to remove interposed soft tissue from the fracture site. The nail was expanded using sterile saline and reduction of the fracture was observed. He continued non-weight bearing activities after surgery.

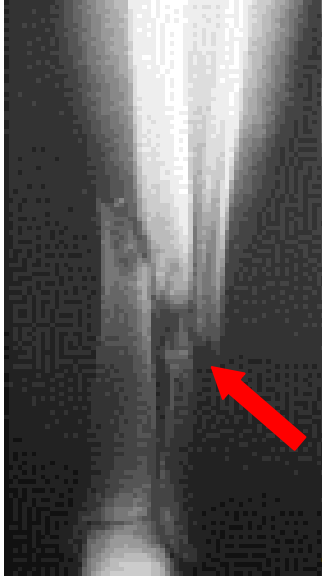


Figure 1. A comminuted fracture of the diaphysis of the tibia and fibula.

Eight days after the IM nail was placed, the patient was fitted with an air cast splint and continued non-weight bearing. Eleven-week post-operative radiographs showed callus formation at the tibial shaft fracture and weight bearing as tolerated was advised. Twenty-five week post-operative radiographs showed a persistent fracture line. Weight bearing as tolerated was continued and he was advised to avoid high impact activities. Thirty-week post-operative radiographs showed bending of the IM nail and gross motion of the fracture site (Figure 2). He was placed back in an air splint and advised he would need further surgery to obtain union of the fracture.

The patient moved out of state and presented to an orthopedic surgeon (SJH) for treatment of the tibial nonunion. Radiographs revealed that the nail was bent and a tine was broken at the nonunion site (Figure 3). It was elected to proceed with exchange nailing of the tibial nonunion. The previous patellar tendon splitting incision was used and bone was removed over the nail to engage the Fixion extractor. The nail was extracted and examination confirmed that the tines were broken and bent (Figure 4).



Figure 2. Bending of the IM nail and gross motion of the fracture site.

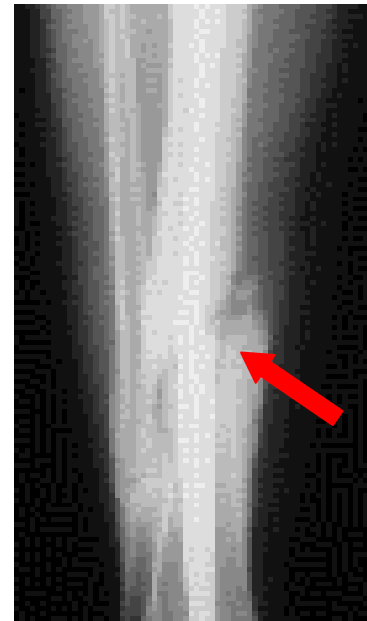


Figure 3. Bent nail and a broken tine at the nonunion site.

Portions of the tines were believed to be missing. Fluoroscopic images showed a portion of a tine at the nonunion site (Figure 5). The previous incision over the fracture was used, a portion of the nonunion was debrided, cultures were taken, and the distal tine removed.

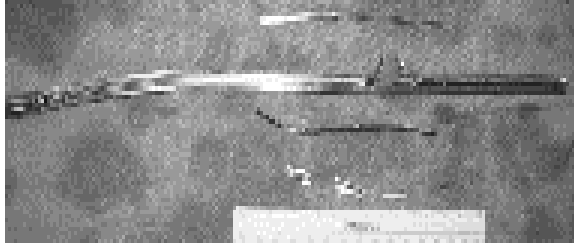


Figure 4. Extracted nail with broken and bent tines.



Figure 5. Fluoroscopic images immediately after surgical removal of the largest pieces of the nail, showing a portion of the tine remaining at the nonunion site.

An incision over the fibula was utilized and an osteotomy of the fibula proximal to the previous fracture was performed to aid in reduction of the tibia. A guide rod was passed down the tibia and a reamed 12mm x 345mm dynamically locked IM nail (Synthes, Paoli, PA) was passed. Reamings were placed at the nonunion site and standard closure was done. Fluoroscopy of the knee showed a tine to be protruding through the lateral tibial plateau and into the lateral femoral condyle (Figure 6). An arthrotomy was made to remove this tine and a small 1mm x 2mm defect in the condyle was debrided of loose cartilage. The lateral tibial plateau was inspected and the lateral meniscus was intact. Tourniquet



Figure 6. Fluoroscopic images after static locked nail placed, showing a tine protruding through the lateral tibial plateau and into the lateral femoral condyle.

time was 128 minutes and intraoperative cultures showed no growth.

The patient showed radiographic and clinical healing of the fracture without further complications. At last follow-up, the patient had no complaints of knee pain and had resumed all activities.

Discussion

IM fixation of fractures has seen many advances in both technique and implant design since Stimson described IM ivory pegs in an 1883 textbook.⁹ Hey-Groves used metallic IM pegs in a femur fracture from a gunshot in World War I.¹⁰ Küntscher popularized IM fixation with metal rods beginning in 1939. Since the work of Küntscher, IM rods have been developed for use in virtually all long bones.¹¹⁻¹³

IM fixation of tibial shaft fractures has increased in popularity as studies have shown decreased malunion rates, decreased joint stiffness, shorter time to union, and faster return to work.¹⁴ IM nailing of open fractures yields increased time to union and higher incidence of nonunion than IM nailing of closed fractures. At 4-month

follow-up, approximately 23% of open fractures and 60% of closed fractures reach union.¹⁵

The technique of reaming has gained popularity. An international survey published in 2002 showed 79.7% of surgeons performed some reaming in closed tibial shaft fractures prior to nail insertion.⁶ Concerns of reaming the IM canal have ranged from increased distal IM pressure, risk of embolic phenomenon, decreased endosteal blood supply, compartment syndrome, and thermal bone necrosis. Techniques of slow incremental reaming, sharp reamer tips, and release of any tourniquet have decreased the rate of complications from reaming.

Complications of implant failure are widely reported. The most common failure is the interlocking screw breaking from a fatigue fracture. This is more common in unreamed nails with a smaller interlocking screw diameter and has a 10-20% incidence.¹⁷⁻²¹ Use of larger diameter reamed nails allows for a larger locking screw and has decreased the incidence of screw breakage to 0-4.5%.²¹⁻²⁴ Fatigue fracture of the IM nail is a much less common complication seen in up to 6% of nails, mostly from smaller unreamed nails in the presence of a nonunion.²⁵

The Fixion expandable nail was first used clinically in 1999.²⁶ The current usage in tibial fractures is for diaphyseal fracture, comminuted diaphyseal fracture, osteoporotic and pathologic fracture, and tibial nonunion. Advantages of the Fixion nail over standard interlocking nails include shorter operative time, decreased fluoroscopy exposure, no risk of reaming, and decreased risk of fracture through a locking screw hole.

The Fixion nail is made of a 316 stainless steel sealed pressure tube with four longitudinal bars connected to four stainless steel membranes (Figure 3). Proximally, the

nail has a valve that allows the tube to be inflated with saline to expand the diameter of the rod and allow the four longitudinal bars or tines to abut the endosteal surface and conform to the medullary canal. The rod diameter can be increased up to 65% with expansion. The relative flexibility of the uninflated nail aids in its insertion, and the nail becomes rigid with saline expansion. The nail can be placed with or without reaming and is available with proximal and distal interlocking screws. Nail extraction is accomplished with removing the saline and deflating the nail. The nail resumes its preinflation shape and attachment of an extractor to the proximal cap.²⁷

Review of the available human studies on expandable nails resulted in complications of nonunions, anterior knee pain, propagation of fracture lines, fracture shortening, infection, and compartment syndrome.²⁸⁻³² Ozturk reported a case of humeral nail breakage, but did not mention any complications in its removal.³³

Our case report identified a complication with the extraction of the nail due to bending and breakage of the tines in the presence of a nonunion. The nail suffered catastrophic failure during the removal process. Recognition of the tines in the fracture site and lateral femoral condyle allowed careful removal and treatment of the nonunion which went on to an uneventful healing with no apparent sequelae in the knee.

Conclusions

Tibial nonunion and implant failure is a recognized complication of all treatment options for diaphyseal tibial fractures. As designs of IM devices change, new complications are recognized through clinical use. Failure of the expandable tines was a previously unrecognized complication in the literature.

Comminuted diaphyseal fractures may best be treated with locked IM nailing. Placement of a non-interlocked expandable nail in this comminuted fracture pushed the limitations of the device. Perhaps earlier recognition of the nonunion and removal of the nail prior to the tines breaking would have avoided this intraoperative complication. Further clinical use of the Fixion nail may confirm the difficulty in removing the nail in the presence of implant failure.

References

- ¹ Lang GL. Fractures of the tibial diaphysis. In: JF Kellam, TJ Fischer, P Tonetta III, MJ Bosse, MB Harris (Eds). *Orthopaedic Knowledge Update: Trauma 2*. Rosemont, IL: American Academy of Orthopaedic Surgeons, 2000, pp. 177-190.
- ² Garbuio P, Gérard F, Ridoux PE, Tropet Y, Vichard P. Intramedullary nailing of open and closed tibial shaft fractures. A report of 551 cases. *Eur J Orthop Surg Traumatol* 1997; 7:153-157.
- ³ Trafton PG. Tibial shaft fractures. In: BD Browner, J Jupiter, A Levine, P Trafton, (Eds). *Skeletal Trauma: Fractures, Dislocation, Ligamentous Injuries*. Philadelphia, PA: Saunders, 2003, pp. 2131-2255.
- ⁴ Winquist RA, Hansen ST, Clawson DK. Closed intramedullary nailing of femoral fractures: A report of five hundred and twenty cases. *J Bone Joint Surg Am* 1984; 66:529-539.
- ⁵ Ekeland A, Thoresen BO, Alho A, Strömsöe K, Follerås G, Haukebø A. Interlocking intramedullary nailing in the treatment of tibial fractures: A report of 45 cases. *Clin Orthop Relat Res* 1988; 231:205-215.
- ⁶ Court-Brown CM, Christie J, McQueen MM. Closed intramedullary tibial nailing. Its use in closed and type I open fractures. *J Bone Joint Surg Br* 1990; 72:605-611.
- ⁷ McQueen MM, Christie J, Court-Brown CM. Compartment pressures after intramedullary nailing of the tibia. *J Bone Joint Surg Br* 1990; 72:395-397.
- ⁸ Mawhinney IN, Maginn P, McCoy GF. Tibial compartment syndromes after tibial nailing. *J Orthop Trauma* 1994; 8:212-214.
- ⁹ Törnqvist H. Tibia nonunions treated by interlocking nailing: Increased risk of infection after previous external fixation. *J Orthop Trauma* 1990; 4:109-114.
- ¹⁰ Ilizarov GA. Clinical application of the tension-stress effect for limb lengthening. *Clin Orthop Relat Res* 1990; 250:8-26.
- ¹¹ Leunig M, Hertel R. Thermal necrosis after tibial reaming for intramedullary nail fixation. A report of three cases. *J Bone Joint Surg Br* 1996; 78:584-587.
- ¹² Levy AS, Bromberg J, Jasper D. Tibia fractures produced from the impact of a baseball bat. *J Orthop Trauma* 1994; 8:154-158.
- ¹³ Lin CH, Wei FC, Levin LS, et al. Free composite serratus anterior and rib flaps for tibial composite bone and soft-tissue defects. *Plast Reconstr Surg* 1997; 99:1656-1665.
- ¹⁴ Hooper GJ, Keddell RG, Penny ID. Conservative management or closed nailing for tibial shaft fractures: A randomised prospective trial. *J Bone Joint Surg Br* 1991; 73:83-85.
- ¹⁵ Finkemeier CG, Schmidt AH, Kyle RF, Templeman DC, Varecka TF. A prospective, randomized study of intramedullary nails inserted with and without reaming for the treatment of open and closed fractures of the tibial shaft. *J Orthop Trauma* 2000; 14:187-193.
- ¹⁶ Bhandari M, Guyatt, GH, Tonetta P 3rd, et al. Current practice in the intramedullary nailing of tibial shaft fractures: An international survey. *J Trauma* 2002; 53:725-732.
- ¹⁷ Gregory P, Sanders R. The treatment of closed, unstable tibial shaft fractures with

- unreamed interlocking nails. *Clin Orthop Relat Res* 1995; 315:48-55.
- ¹⁸Henley MB, Chapman JR, Agel J, Harvey EJ, Whorton AM, Swiontkowski MF. Treatment of type II, IIIa, and IIIb open fractures of the tibial shaft: A prospective comparison of unreamed interlocking intramedullary nails and half-pin external fixators. *J Orthop Trauma* 1998; 12:1-7.
- ¹⁹Krettek C, Schandelmaier P, Tschene H. Nonreamed interlocking nailing of closed tibial fractures with severe soft tissue injury. *Clin Orthop* 1995; 315:34-47.
- ²⁰Sanders R, Jersinovich I, Anglen J, DiPasquale T, Herscovici D Jr. The treatment of open tibial shaft fractures using an interlocked intramedullary nail without reaming. *J Orthop Trauma* 1994; 8:504-510.
- ²¹Larsen LB, Madsen JE, Høiness PR, Øvre S. Should insertion of intramedullary nails for tibial fractures be with or without reaming? A prospective, randomized study with 3.8 years' follow-up. *J Orthop Trauma* 2004; 18:144-149.
- ²²Blachut PA, O'Brien PJ, Meek RN, Broekhuysen HM. Interlocking intramedullary nailing with and without reaming for the treatment of closed fractures of the tibial shaft. A prospective, randomized study. *J Bone Joint Surg* 1997; 79:640-646.
- ²³Court-Brown C, McQueen M. Compartment syndrome delays tibial union. *Acta Orthop Scan* 1987; 58:249-252.
- ²⁴Keating JF, O'Brien PJ, Blachut PA, Meek RN, Broekhuysen HM. Locking intramedullary nailing with and without reaming for open fractures of the tibial shaft. A prospective, randomized study. *J Bone Joint Surg* 1997; 79:334-341.
- ²⁵Whittle AP, Russell TA, Taylor JC, Lavelle DG. Treatment of open fractures of the tibial shaft with the use of interlocking nailing without reaming. *J Bone Joint Surg Am* 1992; 74:1162-1171.
- ²⁶Ascherl R, Tauber M, Albersdorfer H, Werding. Fixion IM Nail - An inflatable selflocking intramedullary nailing system: The experience with 54 cases of long bone fracture treated with a new biomechanical concept of fixation. *J Bone Joint Surg Br* 2002; 84(Suppl II):116.
- ²⁷Shasha N, Blumberg N, Tauber M, Dekel S. An expandable intramedullary nail for fixation in osteoporotic bone. In: YH An (Ed). *Internal Fixation in Osteoporotic Bone*. New York: Thieme, 2002, pp. 301-309.
- ²⁸Steinberg EL, Geller DS, Yacoubian SV, Shasha N, Dekel S, Lorich DG. Intramedullary fixation of tibial shaft fractures using an expandable nail: Early results of 54 acute tibial shaft fractures. *J Orthop Trauma* 2006; 20:303-309.
- ²⁹Smith WR, Ziran B, Agudelo JF, et al. Expandable intramedullary nailing for tibial and femoral fractures: A preliminary analysis of perioperative complications. *J Orthop Trauma* 2006; 20:310-314.
- ³⁰Ben-Galim P, Rosenblatt Y, Parnes N, Dekel S, Steinberg EL. Intramedullary fixation of tibial shaft fractures using an expandable nail. *Clin Orthop Relat Res* 2007; 455:234-240.
- ³¹Fortis AP, Dimas A, Lamprakis AA. Expandable nailing system for tibial shaft fractures. *Injury* 2008; 39:940-946.
- ³²Jago ER. Intraoperative failure of expansion of the Fixion® nail. *Injury Extra* 2008; 39:34-35.
- ³³Ozturk H, Unsaldi T, Oztemur Z, Bulut O, Korkmaz M, Demirel H. Extreme complications of Fixion nail in treatment of long bone fractures. *Arch Orthop Trauma Surg* 2008; 128:301-306.

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