

ORIGINAL RESEARCH

# Reamer/Irrigator/Aspirator (RIA) and Intramedullary Fixation for Impending Pathologic Femur Fracture

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## ABSTRACT

**Introduction:** Pathologic femur fracture is a significant cause of pain and disability in patients with metastatic carcinoma or multiple myeloma. Treatment of these fractures with intramedullary (IM) nailing has become common practice; however, there are concerns for possible complications in these patients. The aim of this study was to evaluate the use of the Reamer/Irrigator/Aspirator (RIA) with prophylactic IM fixation of impending femur fractures.

**Methods:** Eight patients with impending pathologic femur fractures who underwent IM fixation using RIA were retrospectively analyzed. The study analyzed the location and number of the lesions, pathology, presence of metastases to lung or brain, estimated blood loss, operative time, Mirels score, length of hospital stay, perioperative complications, and ambulation method.

**Results:** Average Mirels score at presentation was 11. Pulmonary metastases were present in 6 and brain metastases in 5 patients. Average operative time was 62.3 minutes, and average blood loss was 212.5 ml. No intraoperative complications occurred. Average postoperative hospital stay was 9.1 days. No patients had a decline in pulmonary or neurologic status in the perioperative period. Mean follow-up time was 24.2 months. No implant failures occurred.

**Discussion:** The use of RIA as an adjuvant therapy appears to be safe and beneficial by potentially reducing pulmonary and neurologic complications. The impending pathologic lesion with intact femoral cortices could present an ideal area of application to further minimize risks in an already compromised patient population.

**Keywords:** Pathologic fracture; Impending fracture; Intramedullary nail; Reamer/Irrigator/Aspirator.

## INTRODUCTION

Each year in the United States over 1.4 million new carcinomas are diagnosed. It has been

estimated that between 50% and 80% of patients will have bony metastases at the time of death [1]. Most metastatic carcinomas to bone will originate in the breast, prostate, lung, kidney, thyroid, and gastrointestinal tract, in decreasing frequency. Pathologic femur fractures are significant sequelae of metastatic carcinomas and multiple myeloma [2].

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Once fractures occur, patients suffer increased morbidity and mortality. Although the prognosis for patients with metastatic carcinomas or multiple myeloma continues to improve, survivability remains highly unpredictable. Regardless of treatment, the common objective is to perform one operation that allows immediate weight bearing, yet is durable throughout the patient's remaining lifetime. Current treatment options include large resections with prosthetic reconstruction, open curettage with cement/allograft/autograft reconstruction, and closed intramedullary stabilization. These operations differ in magnitude and some require extensive recovery and rehabilitation with lengthy hospital stays. Most patients with impending fractures have limited life expectancy, and an extensive postoperative recovery can drastically reduce the quality of remaining life.

For impending pathologic fractures involving the subtrochanteric, diaphyseal, and metadiaphyseal regions of the femur, closed intramedullary fixation has been shown to be a viable and beneficial treatment modality [3-7]. Although having the benefits of immediate weight bearing (load sharing), stabilization of the entire bone, and relative ease in application [8], there are still concerns with this form of treatment. These concerns include spread of tumor down the medullary canal of the femur, pulmonary complications [9], neurologic complications [10,11], hardware failure [5], and lack of tumor debulking. The concerns are especially significant in this particular patient population with multiple systemic abnormalities from metastatic disease.

The purpose of this study was to evaluate the use of the Reamer/Irrigator/Aspirator (RIA; Synthes, Paoli, PA, USA) with intramedullary prophylactic fixation

in impending subtrochanteric, diaphyseal, and metadiaphyseal femur fractures. Use of RIA is currently our protocol in management of these lesions. This device is used in place of traditional reamers, taking advantage of its irrigating and suction characteristics. The RIA is used to function as a type of "closed curettage" to aid in tumor debulking while also allowing the use of larger-diameter implants for stabilization. Also, the suctioning capabilities can potentially limit the amount of systemic embolization of fat and tumor, thereby potentially reducing pulmonary sequelae. We present a technique using the RIA in the treatment of impending pathologic femur fractures.

## MATERIALS & METHODS

After obtaining Institutional Review Board approval, we retrospectively reviewed all patients who met study inclusion and exclusion criteria. The inclusion criteria were impending pathologic femur fracture (Mirels score of 9 or greater) due to metastatic carcinoma or multiple myeloma (Table 1) [12], location of impending fracture in the subtrochanteric, diaphyseal, or metadiaphyseal region (Figure 1), and stabilization with intramedullary fixation. We excluded all patients with pathologic fractures, primary bone tumors, and patients with per-trochanteric involvement. Data collected included age, sex, location of lesion, pathology, number of lesions, presence of lung metastasis, presence of brain metastasis, type of pain, estimated blood loss, operative time, implant size, ASA class, Mirels score, intra-operative complications, length of hospital stay, discharge disposition, perioperative complications within 30 days, survival, ambulation method, pain relief (visual analog

**Table 1. Mirels scoring system for assessing pathologic fracture risk in long bones.**

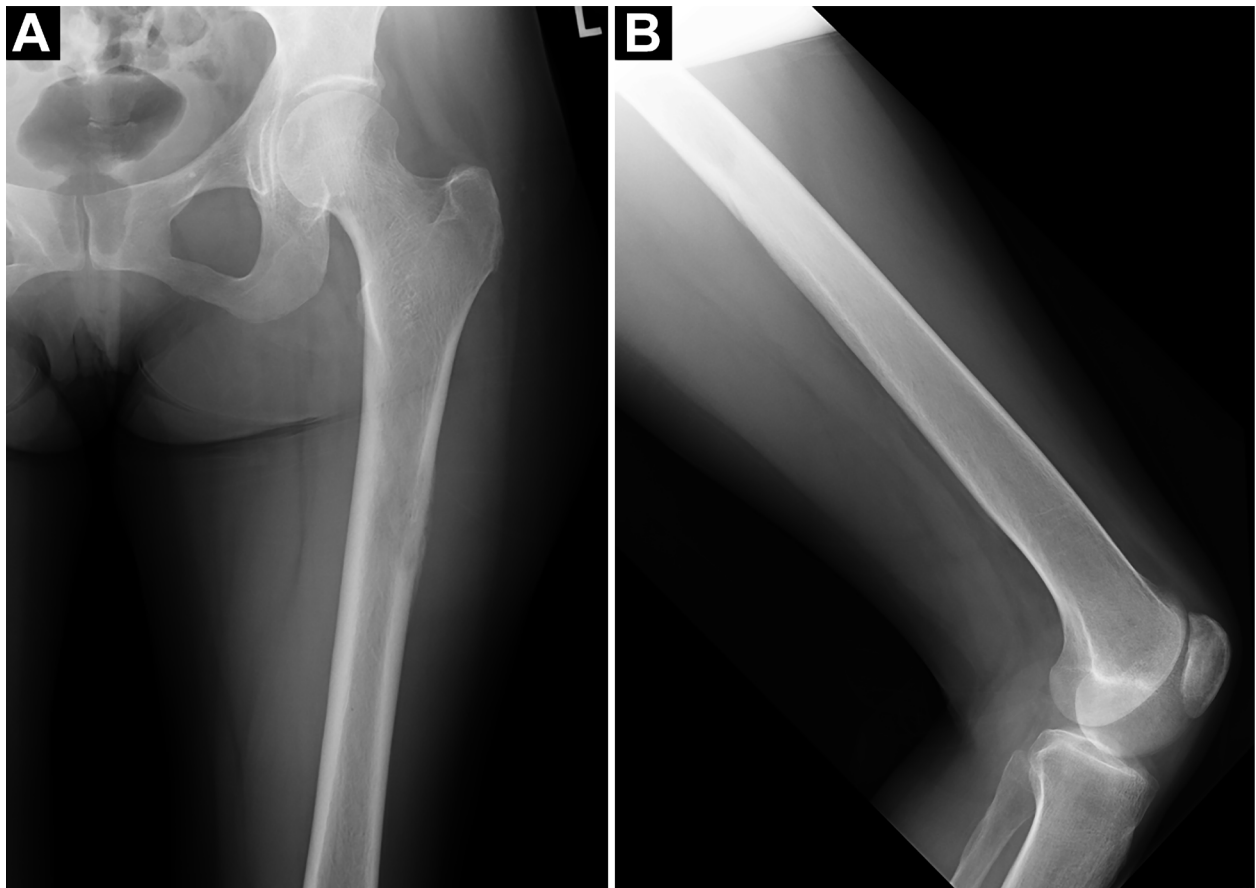
Criterion	1	2	3
Lesion site	Upper limb	Lower limb	Peritrochanteric
Pain	Mild	Moderate	Functional
Lesion type	Blastic	Mixed	Lytic
Lesion size (as a proportion of the bone diameter)	Less than 1/3	1/3 to 2/3	More than 2/3

Adapted from Mirels H. Metastatic disease in long bones: a proposed scoring system for diagnosing impending pathologic fractures. *Clin Orthop*. 1989;249:256-64.

scale), duration of follow-up, hardware failure, and status of healing. Patients were followed up in clinic at 2, 6, 12, 24 weeks. In cases of absent follow-up, telephone interviews were conducted. All patients per protocol received postoperative radiation therapy.

### Operative Technique

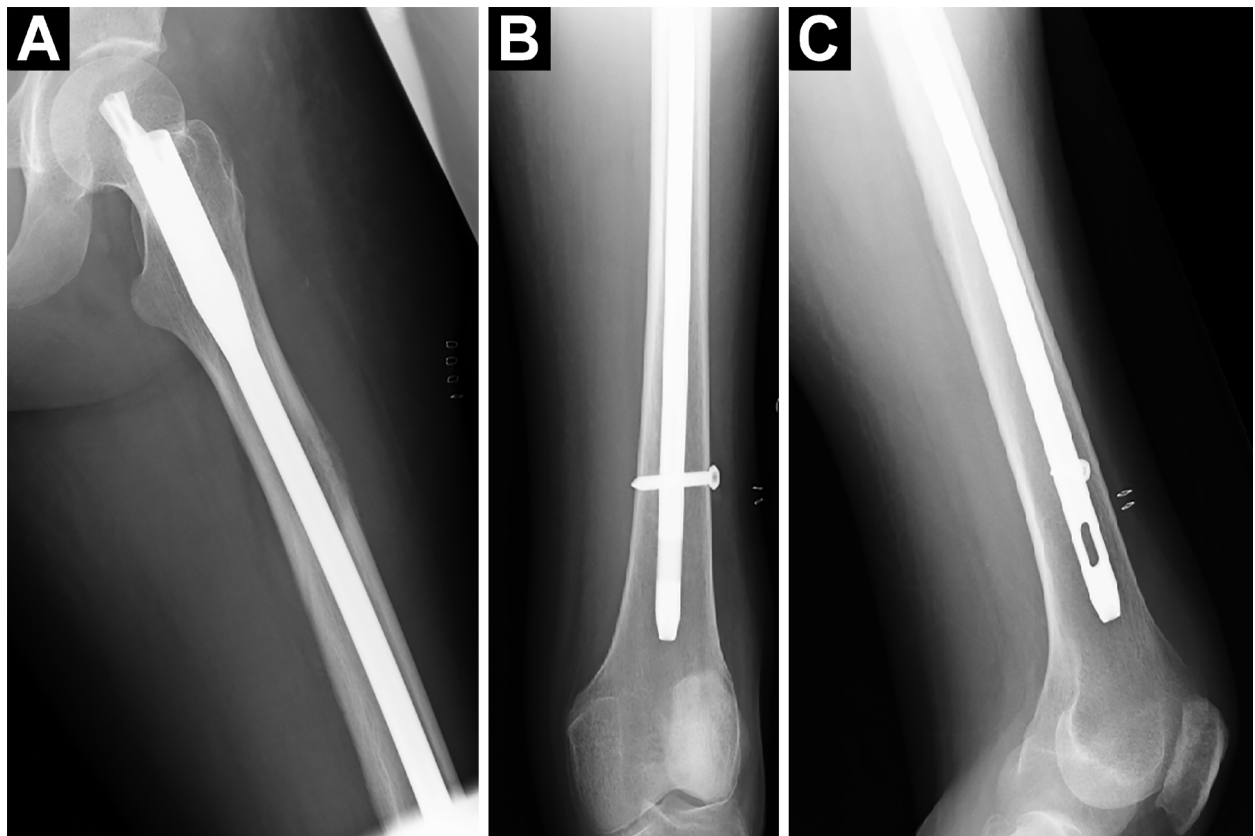
All patients were managed using a fracture table for supine positioning with intraoperative fluoroscopic assistance. Implants included the RIA and the Trochanteric



**Figure 1.** AP (A) and lateral (B) radiographs of a proximal femoral lytic lesion and impending pathologic fracture.

Fixation Nail, TFN (Synthes; Paoli, PA, USA). A closed intramedullary technique was utilized with a standard incision approximately 5 cm proximal to the greater trochanter. Entrance to the intramedullary canal was established with a threaded guide pin under fluoroscopic guidance at an angle 6 degrees off of the tip of the greater trochanter. After entry was gained into the intramedullary canal with a 10-mm entry reamer, a ball-tipped guide wire was passed to the level of the lesion. Prior to placement of the guide wire, a 20-degree bend was placed at the tip of the wire to help facilitate the reaming process. The guide wire was not advanced past the area of concern, but was used to facilitate tumor aspiration with the RIA under fluoroscopic control. Multiple passes of the RIA at the level of the lesion were performed to maxi-

mize tumor removal. Care was used not to pass the guide wire extramedullary during the reaming process. After thorough tumor debulking with multiple passes, the guide wire was then passed distally to aid in intramedullary device placement. The selected intramedullary device was then placed in standard fashion with locking into the femoral head, with proper placement confirmed using fluoroscopic guidance. A center-center position in the femoral head was used. Distal interlocking was performed using a free-hand technique. One or two distal interlocking screws were placed (Figure 2). Wound closure was completed in layers to prevent any fluid collection or medullary extravasation. All intramedullary reamings collected during reaming were sent to pathology for cytopathologic evaluation.



**Figure 2.** AP and lateral radiographs of the entire femur status post insertion of an intramedullary nail following use of the RIA.

## RESULTS

Between April 2007 and May 2009, we used this technique on 8 patients with impending pathologic femur fracture. There were 7 females and 1 male with a mean age of 61.5 years (range 34-74 years). The pathology consisted of one colon, one breast, one renal cell, one squamous cell, and two non-small cell lung carcinomas and two cases of multiple myeloma. The lesion locations included 3 subtrochanteric, 2 diaphyseal, 1 distal third, and 2 entire femoral shaft. Seven of the lesions were lytic, and 1 mixed. All patients presented with rest pain and the average Mirels score was 11 (range 10-12). ASA classification was evenly divided, with 4 patients assigned class 3 and 4 patients given class 4 preoperatively. Pulmonary metastases were present in 6 patients, and brain metastases were present in 5 patients.

Operative time averaged 62.3 minutes (range 31-133 minutes). The estimated blood loss averaged 212.5 ml (range 100-600 ml). Implant diameters ranged from 11-14 mm with RIA diameters ranging from 12-15 mm. No intraoperative complications occurred. Postoperatively, hospital length of stay averaged 9.1 days (range 2-24 days), with discharge disposition to rehabilitation in 3 patients, home in 4, and skilled nursing facility in 1 patient. Perioperative (30-day) complications included chemotherapy reaction, ileus, vaginal bleeding, and thrombocytopenia. No patients had a decline in pulmonary or neurologic status in the perioperative period. Seven patients were allowed full weight bearing immediately postoperatively with assistive devices; the remaining patient was kept partial weight bearing secondary to extensive femoral involvement by

11 separate lesions. Pain relief by visual analog scale averaged 9 preoperatively and was decreased to 2 postoperatively. The patients were followed up for a mean of 24.2 months (range 13-37 months). No implant failures had occurred at most recent follow-up. Overall survival averaged 10.1 months (range 2-23 months). Three patients are currently living with 19.3 months average follow-up, with 5 patients having since died with 4.6 months average follow-up.

## DISCUSSION

Closed, reamed intramedullary fixation for impending pathologic femur fractures is a powerful tool for achieving immediate stability; however, some important potential concerns exist. The first is the limited amount of tumor debulking that can be accomplished with standard reaming. The RIA technique provides simultaneous reaming, irrigation, and aspiration, which probably provides more tumor removal than standard reaming. More traditional open approaches with curettage and cement augmentation provide the most extensive debulking. However, open curettage requires a more extensive approach, which probably increases the risks of infection, blood loss, and operative time. Admittedly, the exact amount of tumor debulking is not known; however, in this limited series, no implant failures related to local tumor recurrence were noted, compared with reported rates of up to 21%. All patients had radiotherapy postoperatively to the entire femoral field.

Another concern is the potential pulmonary and neurologic dysfunction that can result from reamed instrumentation of the femoral canal. This can

in particular be true for patients with preoperative pulmonary compromise of function from metastatic disease. Fat embolism syndrome is typically characterized by mental confusion, hypoxia, and a petechial rash. Previous authors have shown that patients with pathologic femur fractures are at a higher risk for the development of this condition [8]. Other authors have examined venting the canal during intramedullary reaming but the significance in the oncologic population has yet to be elucidated [12-14]. Use of the RIA in animal models has demonstrated lower numbers of pulmonary emboli and lower intramedullary pressures when compared with traditional reaming [15,16]. In our small series, 6 patients had pulmonary metastases and compromised lung function, while 5 patients had brain metastases. No intraoperative, postoperative, or perioperative decline in pulmonary or neurologic function was observed.

The patient with metastatic lesions can also have other organ systems affected by the disease process. Liver metastases can alter coagulation and fibrinolytic mechanisms by damaging the necessary hepatic synthetic capabilities. Reamed nailing has been shown to potentially further alter these mechanisms [17]. Other authors have found that reaming has a stimulatory effect on the immune system, with the production of inflammatory cytokines that can have a beneficial or deleterious effect on overall outcomes [18-21]. In an animal model, the RIA has been shown to reduce fat emboli and associated systemic imbalances that are harmful after polytrauma [22]. This work, although performed in the trauma setting, could also have an impact on the cancer patient with systemic abnormalities.

The average estimated blood loss and operative times in our small series com-

pare favorably with the previously reported values, ranging from 280-500 ml and 98-125 min in the literature. Our low rate of intraoperative complications is favorable when compared with previously reported rates as high as 45%. The overall average survival of 10.1 months is consistent with this patient population, with more aggressive tissue diagnoses associated with shorter survival time.

Limitations of this study include its retrospective nature and small sample size. Despite the fact that pulmonary complications following reamed intramedullary nailing are well documented in the trauma literature, there are no proven benefits in the literature that tumor debulking will decrease the rate of tumor and fat emboli during the treatment of pathologic fractures. Further development is needed in this area. The benefits of using the RIA could be more adequately documented with the addition of a control group. Furthermore, volumetric analysis of the preoperative images compared to the aspiration retrieved during the time of surgery would provide a better understanding of the efficacy of tumor debulking using the RIA.

Impending pathologic femur fractures are common sequelae of metastatic carcinoma and multiple myeloma. Reamed intramedullary stabilization is an advantageous treatment method to reduce pain and improve ambulatory status. Although relatively safe and common to most treating orthopaedists, complications do exist and must be planned for. In our small series, use of the RIA as an adjuvant therapy appears to be safe and beneficial for potentially reducing pulmonary and neurologic complications. The impending pathologic lesion could present an ideal area of application to further minimize risks in an already compromised patient population.

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