Diagnosing Segmental Wedge Fracture of the Tibia Before Performing Intramedullary Nailing

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Abstract

Tibial shaft fractures with a wedge butterfly segment are often repaired with intramedullary fixation. At the time of presentation, the fragment may appear benign on radiographs as a portion of the cortical bone in an acceptable position. However, a segment that includes the entire circumference of the tibial cortex can be a problem during surgical stabilization. This ring effect will demand cannulation of the butterfly segment with the guide wire before rod insertion. Since computed tomography is not always necessary for minimally displaced fractures, this issue may not be discovered until surgery. Lack of cannulation may lead to painful nonunion. Preoperative recognition of this fracture pattern and intraoperative butterfly cannulation will improve the postoperative stability of this fracture.

Tibial diaphyseal fractures have been classified into various patterns and types.[1-3] Winquist and Hansen[2] defined 5 types, with types I and II representing comminuted fractures, both of which may include a butterfly segment containing a relatively small area of cortical bone (<50% width of bone) that is often left unfixed during intramedullary (IM) fixation. This segment is typically in contact with the main fracture segments and heals uneventfully. With larger areas of cortical bone comminution, there are risks for angular deformity, limb shortening, and nonunion.[4] Type III fractures encompass butterfly segments compromising more than 50% of the width of the bone; there is also a subset called *ring butterfly fragments*.[5] In this group, the butterfly segment includes the entire circumference of the medullary canal—which poses risks for malunion and nonunion.[5,6]

The 2007 *Fracture and Dislocation Classification Compendium* of the Orthopaedic Trauma Association established a format for classifying skeletal fractures.[3] The system identifies the *wedge-fracture pattern*, a triangular segment of free bone; and the *segmented complex* fracture, the pattern occurring when a tubular portion of the tibial diaphysis includes the entire circumference of the medullary canal and is free from proximal and distal segments of the tibia. There is no reference to these 2 fracture patterns in combination, which in earlier studies had been called the *ring butterfly fragment*.[3,5,6] We, therefore, propose the designation *segmental wedge-fracture pattern* as this term describes the segmental nature of the fragment (which includes the entire circumference of the medullary canal), and the large, triangular shape that distinguishes it from the tubular shape associated with the traditional segmental fracture pattern.

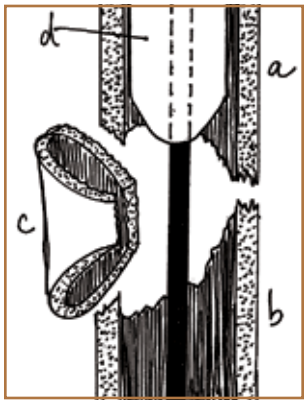

Figure 1. Intramedullary guide wire and intramedullary rod passing extramedullary to wedge segmental fragment, producing further displacement and preventing satisfactory reduction. (A) Proximal segment, (B) distal segment, (C) displaced butterfly fragment, (D) IM rod is being placed, but will miss the displaced fragment since it is not properly cannulated with the guidewire.

Recognizing the importance of a segmental wedge fracture has significant treatment implications. If the segmental wedge fragment is not satisfactorily reduced, and the IM rod fails to pass through the IM canal of the fragment, the rod itself displaces the fragment further and effectively prevents fracture reduction (**Figures 1A-1D**). Pankovich and colleagues[5] described this occurrence in cases of flexible IM rod treatment of comminuted tibial fractures; however, we found no report of a similar occurrence during use of rigid reamed or unreamed IM nails in treating displaced ring butterfly fragment segments or segmental wedge fragments.

The case we describe here emphasizes the importance of

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Figure 2. Anteroposterior (A) and lateral (B) radiographs show initial fracture pattern in which wedge segmental fragment is minimally displaced and moderately angulated.

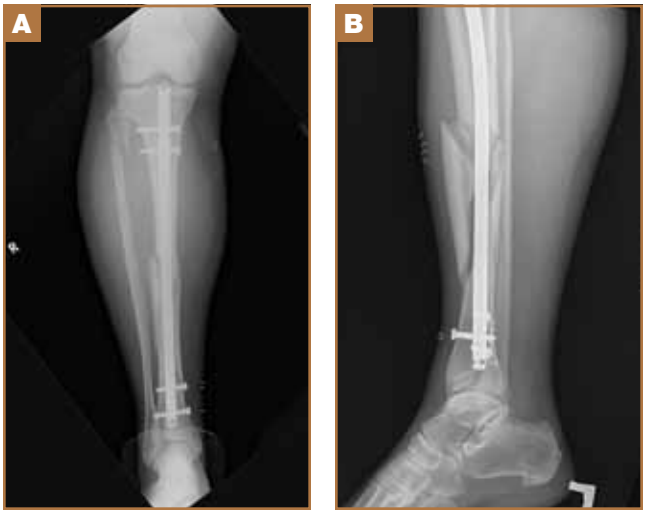

Figure 3. Immediate postoperative anteroposterior (A) and lateral (B) radiographs show improved angulation but increased anterior displacement of wedge segmental fragment secondary to rod placement posterior to intramedullary canal.

securing adequate segmental wedge-fragment reduction in 2 planes when fixating fractures that involve large segmental wedge comminution. In such cases, the surgeon must recognize the importance of the anatomy of this segment, which includes the bulk of the medullary canal, and use preoperative studies (eg, computed tomography [CT]) to elucidate the subtleties of the fracture. Failure to do so can result in malreduction, malfixation, and the potential for malunion and/or nonunion.

The patient provided written informed consent for print and electronic publication of this case report.

Case Report

A 55-year-old woman sustained a comminuted right mid-diaphyseal tibial fracture in a skiing accident. Initial radiographs showed a large, minimally displaced comminuted fracture of the middle third of the tibial diaphysis and a proximal fibular fracture (**Figures 2A, 2B**).

Twenty-two hours after injury, she underwent closed reduction and placement of a reamed interlocking IM nail. The procedure was performed under intraoperative fluoroscopic guidance. There was difficulty with fracture reduction because of persistent displacement of the segmental wedge fragment. A small accessory anterior incision was used in an attempt to manually reduce this segment and stabilize it with cerclage fixation.

Postoperative radiographs showed adequate alignment of the proximal and distal tibial segments, but the segmental wedge fragment was displaced anteriorly; this is best visualized on the lateral view (**Figures 3A, 3B**). The surgeon thought that, in light of cortical contact between the major fracture segments and the segmental wedge fragment, the alignment was acceptable.

After being discharged, the patient remained non–weight-bearing for 8 weeks. Over the next few months, she progressed to partial weight-bearing (in a cast boot), accompanied by mild pain. Radiographs showed minimal healing but no change in fracture position. The fibular fracture healed uneventfully. Over the next 6 months, there was no clinical improvement, and the weight-bearing pain persisted. Nine months after surgery, CT showed a large, anteriorly displaced nonunited segmental wedge fragment with posterior hypertrophic nonunion of bone (**Figure 4**).

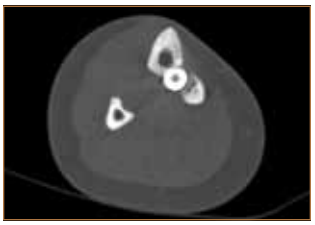

Figure 4. Six months after surgery, axial computed tomography shows wedge segmental fragment anterior displacement caused by failure of intramedullary rod to cannulate intramedullary canal of fragment properly.

On the basis of these findings, the surgeon had the patient return to the operating room. The hypertrophic segmental wedge fracture nonunion was confirmed 9 months following the original surgery. The rod was removed; the segmental wedge fragment was taken down; the fracture was anatomically reduced and maintained with 4 cerclage wires; and a standard reamed IM interlocking nail was used to anatomically fixate and stabilize the fracture. Another option for securing the butterfly fragment is to place a unicortical plate at the margin of the segment. After the free fragment was contoured to fit into the defect, the surgeon thought the cerclage fixation provided satisfactory fixation with less risk for fracture. The fracture was bone-grafted. Four months later, the patient was pain-free, ambulating without walking aids, and showing evidence of excellent callus formation about the nonunion site and excellent anterior alignment of the fracture segments (**Figures 5A, 5B, 6**).

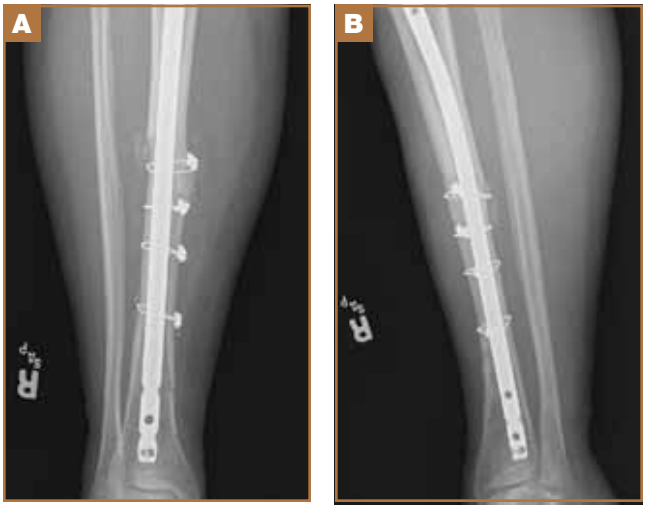

Figure 5. Anteroposterior (A) and lateral (B) radiographs show satisfactory reduction and anatomical rod fixation of revised wedge segmental fracture.

Discussion

This case illustrates the need to recognize the significance of a large diaphyseal comminuted wedge segment that may include the majority of the IM canal. This segmental wedge fragment can look innocuous on plain radiographs. In our patient's case, it became a problem during surgical reduction when the guide wire did not adequately cannulate the segmental wedge fragment and passed posterior to it. The fragment became further displaced when the nail was advanced over the guide wire and never properly transited the medullary portion of the segment. In cases in which initial radiographs of such fractures are ambiguous, CT may provide additional insight for surgeons who are planning closed IM fixation. It is less common to use CT for extra-articular tibial fractures, particularly if they appear to involve a minimally displaced fracture pattern that includes a butterfly fragment.

Figure 6. Lateral view of healed tibia 4 months after revision surgery.

When examining initial radiographs, the surgeon must be alert to the possibility of a segmental wedge-fragment. CT can be used to confirm a suspicion. It is helpful to identify this unique fracture type before surgery to ensure that the guide wire locates the medullary canal within the segmental wedge fragment and restores the proper anatomical construct of the fracture site. If this fracture pattern is overlooked on preoperative imaging studies, intraoperative signals may alert the surgeon to the presence of a segmental wedge fragment. Two signals that the fracture type may differ from what was originally assumed are (1) difficulty in placing the guide wire through the length of the medullary canal, and (2) worsening of butterfly fragment displacement on rod insertion.

During our patient's first procedure, the surgeons found it difficult to perform fragment reduction of a segmental wedge fracture, so a midshaft incision was made over the butterfly fragment to place a cerclage stitch. With an unappreciated segmental wedge fracture, the risk is higher for adjacent soft-tissue injury during reaming and rod placement, further fragment displacement, and the potential for malunion or nonunion. Describing the value of fracture classification systems, Marsh and colleagues[3] wrote that a uniquely defined fracture should have "clear clinical relevance … that relates … to treatment guidelines, to prognosis, or to risk for complications. Without clinical relevance, there is no good reason to define and separate different groups." We agree, and think that the unique clinical features of the fracture we have described warrant consideration of including the wedge segmental fracture as a distinct fracture type in classification systems.

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This paper will be judged for the Resident Writer's Award.