



Case Report

Antegrade intramedullary fixation of humeral shaft fractures by Rush pins

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A B S T R A C T

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Most humeral shaft fractures (>90%) heal with nonsurgical management, which is practiced by the use of hanging cast, but it is most effective only in spiral or oblique fracture pattern. During this immobilization period, the patients must remain upright or semi-upright at all times, even while sleeping, with the cast in a dependent position for effectiveness. It causes suffering to most patients. Intramedullary flexible nailing used for displaced transverse humeral shaft fracture was advocated decades ago. Now, we try to use Rush pins to fulfill the theory of “filling-up” and “3-point” fixation. Nine patients (five men and four women) underwent this closed reduction and internal fixation with Rush pin procedure between July 2007 and June 2009. Their average age was 43.2 years (range, 19–68 years). The union status was checked by radiologic and physical examinations. The shoulder function was evaluated by Oxford Shoulder Questionnaire. The surgery was performed with an incision on lateral cortex of humeral surgical neck. The size and number of Rush pins were decided according to the inner diameter and length of the humeral shaft. The Rush pins were prebent before insertion. The whole procedure of pin insertion was carried out under C-arm guidance. None of these patients had radial nerve injury or pin migration. Two complications were noted, one with proximal hook prominence and the other one with nonunion of fracture because of overdistraction. Otherwise, all the other patients regained pretraumatic shoulder range of motion, union of fracture, and were satisfied with the shoulder function and clinical result. Although it is technique demanding, it has the benefits of avoiding damaging rotator cuff and exposing radial nerve, saving operating time, minimizing soft tissue dissection, and being cost-effective. Furthermore, patients had a better life quality during the period of immobilization because of fracture.

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1. Introduction

Although humeral shaft fracture represents only 3–5% of all fractures, it always is a challenge to orthopedic surgeons because of its special correlative structure. Numerous treatment options for humeral shaft fractures have been presented for decades, including closed means, such as functional bracing and hanging casting, and open reduction with internal fixation. When uncomplicated diaphyseal fractures of the humerus are treated conservatively by reduction and subsequent immobilization of the arm, successful healing occurs in more than 90% of the cases.^{1–4} However, most patients who receive hanging cast fixation suffer a lot from sleeping in semi-upright position for at least 6 weeks.

The indications for surgical intervention include poorly aligned fractures, open fractures, arterial injuries requiring vascular repair, polytrauma, ipsilateral elbow or forearm fractures, bilateral upper extremity injuries, and pathological fractures. Two major implants are used in treating humeral shaft fractures these days. Use of dynamic compression plate requires extensive dissection and is complicated by the proximity of the radial nerve and the risk of mechanical failure in osteopenic bone.^{5–9} As a result of recent technical advances, there is growing interest in the use of the humeral interlocking nail.^{10–12} In theory, fixation by this nail requires less-invasive surgery and indirect reduction techniques and improves load-sharing biomechanics,¹³ but devastating rotator cuff is a major concern.

Early intramedullary implants, such as the Ender nail, allowed for alignment in the anteroposterior and lateral planes; however, they failed to provide optimal rotational control.² They can replace some conservative treatment and operation options. It is hard to get this implant in Taiwan at present, probably because of little profit to manufacturers. Recently, we used antegrade intramedullary fixation with Rush pins to offer similar qualities.

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2. Case report

Between July 2007 and June 2009, nine patients (five men and four women) were treated for humeral shaft fractures using the antegrade intramedullary fixation with Rush pins. The average patient age was 43.2 years (range, 19–68 years). The fractures were located 5 cm distal to the surgical neck to 5 cm proximal to the olecranon fossa. Seven fractures were in the middle third of humeral shaft and the other two were in the junction between middle third and distal third of humeral shaft. The indications for operation included displaced fracture, polytrauma, and periprosthetic fracture. We excluded those with pathological fractures, long spiral and oblique fractures, too comminuted fractures, open fractures, and a history of previous fractures of humeral shaft. All the patients were skeletally mature, and the operations were performed within 48 hours of the injury.

This operation is carried out with the patient in a beach chair position with a sandbag under the ipsilateral scapula and the shoulder over the edge of the table. A 3-cm anterolateral incision is made through the deltoid muscle in surgical neck region. The rotator cuff is not touched. The medullary canal is opened with an awl. The fracture is reduced closely by gentle manual power. The pin should be as long as the distance between the entry point and 1 cm proximal to the lateral epicondyle. Alternate gentle hammer tapping and side-to-side movements facilitate its introduction. At the time of impaction, counterpressure at the elbow is necessary to avoid distraction of the fracture. The whole procedure is carried out under image intensification. The pin can be removed during the procedure and its curvature modified to pass through the medullary canal. We can check the pin length corresponding to humeral shaft length through the C-arm guidance. The ideal position of Rush pin is the distal end resting on supracondylar region and the proximal hook resting on the lateral side of the surgical neck cortex.

In early period, we advocated “filling-up” fixation method by inserting two Rush pins into the medullary canal in an antegrade direction after closed reduction of the fracture. Lately, we advocated “3-point” fixation method by inserting only one prebent Rush pin.

Most patients used arm sling fixation after operation, and long arm splint was used only in one unstable comminuted fracture case. Patients were usually discharged on the third day after surgery. Patients could sleep on bed in supine position, with the upper arm immobilized with arm sling for 4–6 weeks, and then active exercise was prescribed.

The Oxford Shoulder Questionnaire¹⁴ was used to assess subjective shoulder function after a mean follow-up period of 22.8 months (range, 9–32 months). The questionnaire contained 12 questions, four related to pain and eight related to activities of daily living, each with five responses (1–5 in ascending order of severity). A total score of 12 was the best possible score and 60 the worst; patient satisfaction was classified as very satisfied (score, 12–20); moderately satisfied (score, 21–40); and not satisfied (score, 41–60).

3. Results

All nine patients required a single surgical procedure for humeral shaft fracture. Excluding one case involving multiple fracture, average length of stay was 4.5 days (range, 2–7 days) (Table 1). Average operation time was 103 minutes (range, 65–175 minutes), and average estimated blood loss was 63 mL (range, 10–300 mL).

Of the patients included in this study, one was arranged to removal of one of two inserted Rush pins because of prominence of proximal hook 3 months after initial closed reduction and internal fixation, and then he was lost to follow-up. Another patient was found to have nonunion of fracture because of overdistraction

Table 1

Result summary.

Age (yr), sex	Length of stay (d)	Operative time (min)	Estimated blood loss (mL)	Body height (cm)	Pin length (cm)	AO fracture classification
19, M	5	90	15	171	24, 26	A3
52, M	4	80	30	160	26, 27	A2
66, F	4	120	300	154	20, 20	A2
29, M	6	75	50	176	28, 26	B1
42, F	4	65	10	154	18	A3
43, F	4	80	10	158	22	A3
68, F	7	175	100	144	21	A3
32, M	2	75	20	178	28	A3
38, M	41	165	30	180	28	B1

F = female; M = male.

2 years after operation, and he refused to receive autogenous bone grafting because the range of motion and function of upper limb were both normal (Fig. 1). Of the remaining seven cases, all regained original range of motion of shoulder and elbow, and their humeral fractures healed without evidence of infection, malunion, hardware failure, or the need for a second operation (Figs. 2 and 3). No migration of pins was noted in this series. Union was judged to have occurred in all the remaining seven fractures based on the presence of a bone bridging the fracture in two radiological views and the absence of pain and tenderness on stressing the bone. Obvious callus formation was noted at an average of 3 months after operation.

No patient sustained iatrogenic injury of the radial nerve. All pins were inserted under C-arm guidance without reaming the humeral canal. One patient was found to have shorter pin fixation, but this did not affect the outcome because stable fixation was achieved by “filling-up” effect (Fig. 4). One senile patient with periprosthetic fracture also attained bony union by using this technique (Fig. 5).

Two of the nine patients were older than 65 years. Of the eight patients who completed the Oxford Shoulder Questionnaire, seven were very satisfied and one was moderately satisfied. The only patient who was moderately satisfied was a 66-year-old woman with a periprosthetic humeral shaft fracture, with limited range of motion of shoulder already noted after her previous shoulder operation.

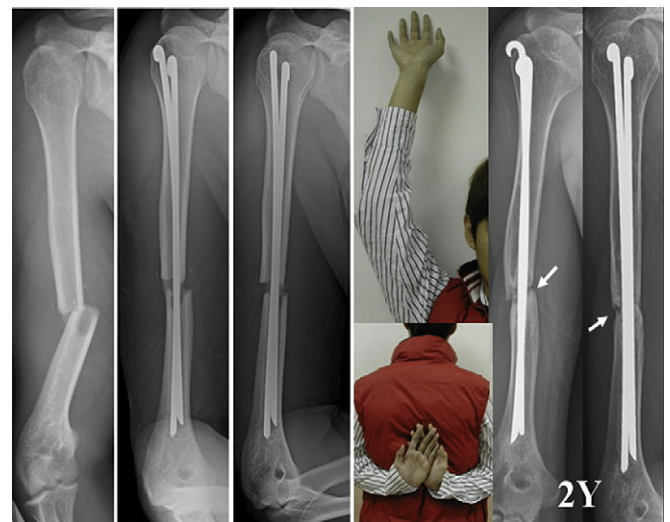


Fig. 1. Radiographs of a 19-year-old, 171-cm-tall man who sustained an isolated AO type A3 humeral shaft fracture secondary to a scooter accident. Operation was done by closed reduction and intramedullary fixation using 24-cm and 26-cm Rush pins. Nonunion was noted 2 years after operation; the patient refused to receive autogenous bone grafting because of normal function of upper arm. Overdistraction of fracture is the reason for nonunion.



Fig. 2. Radiographs of a 29-year-old, 176-cm-tall man who sustained an isolated AO type B1 humeral shaft fracture secondary to a scooter accident. Operation was done by closed reduction and intramedullary fixation using 26-cm and 28-cm Rush pins. Removal of implants was performed 1.5 years later because of union of fracture, and his upper arm function was excellent.

4. Discussion

Most humeral shaft fractures (more than 90%) will heal with nonsurgical management because 20° of anterior angulation, 30° of varus angulation, and up to 3 cm of bayonet apposition are acceptable and will not compromise function or appearance. But the patient must remain upright or semi-upright at all times, even while sleeping, with the cast in a dependent position for effectiveness. It causes suffering to most patients.

Relative indications for surgical management include poorly aligned fractures, open fractures, arterial injuries requiring vascular repair, polytrauma, ipsilateral elbow or forearm fractures, bilateral upper extremity injuries, and pathological fractures. However,

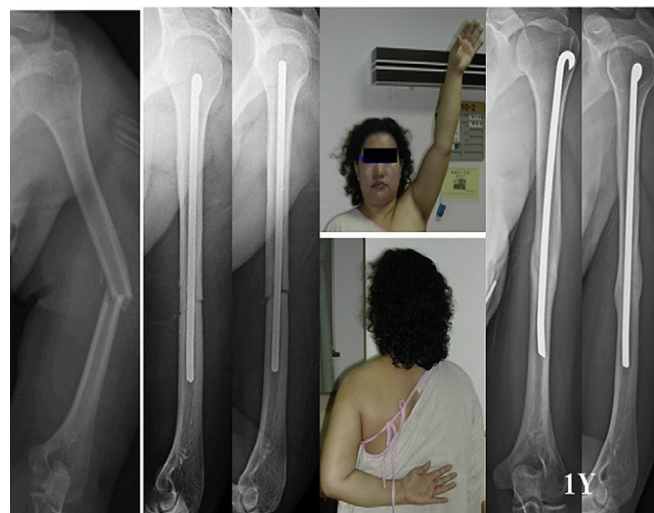


Fig. 4. Radiographs of a 42-year-old, 154-cm-tall woman who suffered an isolated AO type A3 humeral shaft fracture secondary to a motor vehicle accident. Operation was done by closed reduction and intramedullary fixation using one 18-cm Rush pin. Although the pin was shorter than the desired length, it still “filled up” the medullary canal to achieve a stable fixation. Removal of implants was performed 1 year later because of union of fracture, and her upper arm function was excellent.

a consensus regarding the ideal mode of operative intervention is yet to be reached.

The humeral interlocking nail, despite being specifically designed to treat humeral fractures, encountered several problems. Its size necessitated reaming, resulted in additional fractures, and violated rotator cuff structures at the insertion point.¹⁵ Poor rotational control was also noted.¹² Retrospective studies of locked intramedullary nail fixation quote incidences of nonunion ranging from 0% to 8%, and reports of the functions of the shoulder and elbow differ widely.^{10,12,16–19} Shoulder pain and malfunction have been reported for as many as 16–37% of the patients in recent studies.^{16,20–22} In a study of 50 fractures, Hems and Bhullar¹⁶ found that 30% of the nonpathological fractures had failed to unite after 8 months and that

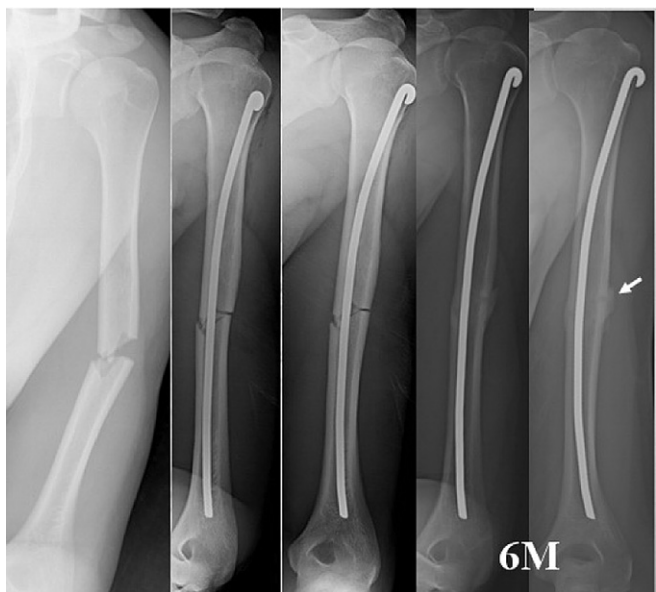


Fig. 3. Radiographs of a 32-year-old, 178-cm-tall man who sustained an isolated AO type A3 humeral shaft fracture secondary to a motor vehicle accident. Operation was done by closed reduction and intramedullary fixation using one 28-cm Rush pin; a typical “3-point” fixation was achieved. Obvious union with callus formation was found 6 months after operation, and the patient regained almost normal function of the shoulder.

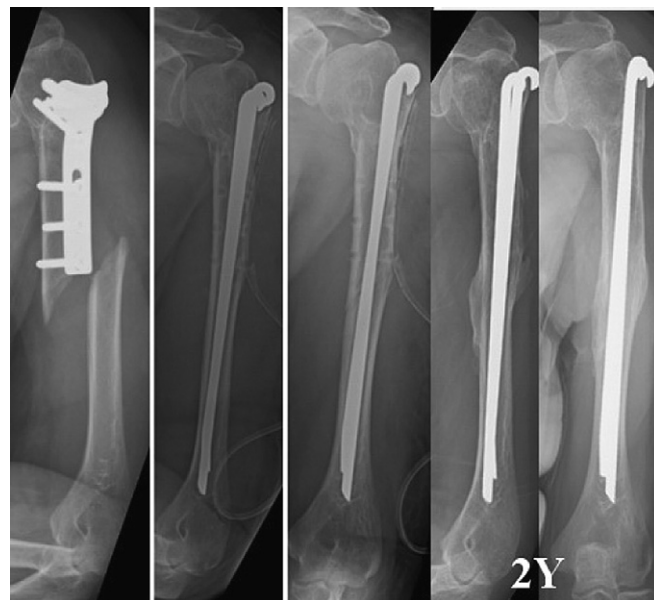


Fig. 5. Radiographs of a 66-year-old, 154-cm-tall woman who suffered an AO type A2 humeral shaft fracture secondary to a slip accident. Operation was done by removal of original plate and intramedullary fixation using two 20-cm Rush pins. Last radiographs were taken 2 years after operation, and bony union was noted. Patient regained satisfactory function of the upper limb.

Table 2
Length choice of Rush pin.

Body height (cm)	144–155	156–160	160–170	171–175	176–180
Length of pin (cm)	20	22	24	26	28

a similar percentage of their patients had poor or unsatisfactory function. They concluded that intramedullary locking nails should be used cautiously in treating acute nonpathological fractures.

Plate osteosynthesis is associated with negative features, including the need for a direct exposure of the fracture, increased blood loss, a risk of radial nerve injury, and disruption of the periosteal blood supply.^{5,9,22–25} In previous reports of dynamic compression plate fixation, the incidence of nonunion has ranged from 2% to 10%, infection has ranged from 2% to 4%, and iatrogenic palsy of the radial nerve has ranged from 2% to 5%.^{5,6,8}

Flexible nails for the fixation of long bone shaft fractures already had their place in the armamentarium of fracture fixation even in the era of rigid fracture fixation. The Rush pin was initially introduced to the orthopedic community by Rush,²⁶ and it has already been used in fixation of humeral shaft fractures in 1960s.^{27–29} Recently, there are some surgeons still using this old implant for humeral fracture treatment. In 2007, Chaarani³⁰ reported his series of using Rush pin for distal humeral fractures. In 2008, Mallick and Hearth²⁹ reported successful results of using Rush pin for proximal humeral fractures. Their entry points were all on the greater tubercle of humerus, not rigid fixation; pin migration and injury of rotator cuff were major complications. Our series has a different entry point, the surgical neck region, and uses prebent Rush pin to fix the humeral shaft fractures after closed reduction.

Initial data regarding this series of Rush pin fixation for humeral shaft fracture treatment suggest that good reductions are achieved and maintained, with no hardware-related complications and minimal operative complications. Three-point fixation is essential for maximum stability. This is achieved by inserting a slightly curved pin into the straight humerus, which also provides greater stabilization of the proximal fragment to control rotation and prevent proximal migration of the pin. The fracture hematoma is not violated, which may enhance healing and reduce the incidence of infection. The estimated blood loss is within acceptable limits. Our operative time (average, 77.5 minutes) of isolated fracture cases is comparable or superior to previously reported results, which range from 76 to 140 minutes.^{31,32} Our preliminary results, although limited by sample size, may indicate the relationship between Rush pin length and body height, as in Table 2; the variation is about 1 cm.

5. Conclusion

Advantages of this alternative method of closed reduction and internal fixation include less extensive soft tissue dissection and a smaller skin wound, thereby, theoretically decreasing blood loss and the likelihood of iatrogenic nerve or vessel injury. Furthermore, the smaller diameter of the Rush pin offers easier insertion into the canal and easier adjustment once placed. This same feature allows for a more lateral starting point, for antegrade nailing, as it is more flexible, thereby decreasing the likelihood of injuring rotator cuff structures in antegrade insertion. Of note is the small size of this series, which still may be an alternative option for treatment of AO type A2, A3, and B1 humeral shaft fractures.

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