

HOSTED BY



ELSEVIER

Contents lists available at ScienceDirect

Chinese Journal of Traumatology

journal homepage: <http://www.elsevier.com/locate/CJTEE>

Case report

Management of humeral fracture nonunion in severe osteoporosis by a combination of locking plating and intramedullary fibular grafting

Shabir Ahmed Dhar*, Mohammed Farooq Butt, Tahir Ahmed Dar, Reyaz Ahmed Dar, Zameer Ali

SKIMS MC, Bemina Srinagar, Kashmir, Srinagar 190001, India

ARTICLE INFO

Article history:

Received 12 May 2015

Received in revised form

12 October 2015

Accepted 16 November 2015

Available online 13 May 2016

Keywords:

Osteoporosis

Bone plates

Humerus

Fractures, ununited

ABSTRACT

Nonunion of the humerus in a severely osteoporotic bone is a likely event especially if the fracture is transverse. The management of such a combination is a challenge. Most of the conventional fixation methods are unlikely to succeed as the bone failure precedes implant failure in osteoporosis. The challenge is further compounded in severe osteoporosis when the cortical thickness is affected more severely. We used a combination of an intramedullary fibula with a locking plate in 5 cases. The results show that it may be a good combination in such situations as the bone strength is augmented and the plate pullout is less likely.

© 2016 Daping Hospital and the Research Institute of Surgery of the Third Military Medical University. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

Osteoporosis is defined by the WHO as a bone mineral density (BMD) of 2.5 standard deviations or more below the young normal mean. On this basis 26 million people in America are osteoporotic.^{1,2}

Most of the fractures in the osteoporotic individuals occur in the proximal humerus, distal forearm, vertebrae, pelvis, hip and tibial condyles. However diaphyseal fractures are also common. With nearly 120,000 osteoporotic humerus fractures occurring annually, it is important to understand the methods of treatment and indications for such treatments of these fractures.^{3,4}

Nonunion of the humerus is an uncommon complication of diaphyseal fractures. Its reported rate in the literature is quite variable, ranging from 1% to 10%.^{5,6} It can be successfully managed by various surgical methods with the principles being open reduction, freshening of edges and stabilization using plate and screws, interlocking nails, or an external fixator.⁷

Nonunion in the osteoporotic bone is an even bigger surgical challenge as the degree of osteoporosis increases during the period of immobilization and can complicate osteosynthesis significantly.

Locking plates are quite useful in the management of fractures of the osteoporotic bone. Reports about the management of nonunion of the humeral diaphysis in severely osteoporotic bone are uncommon.

The purpose of this study is to highlight the use of a combination of a locking plate and an intramedullary fibula in the management of nonunion of the humerus in a severely osteoporotic bone.

Case report

We included 5 patients in the study due to the relative rarity of this type of combination in patients. The average age of the patients in our study was 57 years (range, 51–67). There were three females and two males. Three patients had involvement of left humerus and two of the right side. All the patients had a midshaft involvement and radiologically the nonunion could be classified as atrophic. All patients had mild pain, tenderness and gross abnormal mobility at the nonunion site, and limitation of activities of daily living. All patients had stiffness of the shoulder and elbow to varying degrees. All patients had undergone a trial of conservative treatment initially. The average delay at presentation from the time of injury was 14 months (range, 12–18 months). Preoperative disability of arm, shoulder and hand (DASH) score averaged 84 ± 5 (range, 79–91).

The preoperative assessment included a dual energy X-Ray absorptiometry (DEXA) scan and a radiogrammetric measurement of

* Corresponding author. Tel.: +91 9419489933.

E-mail address: shabirdhar@yahoo.co.in (S.A. Dhar).

Peer review under responsibility of Daping Hospital and the Research Institute of Surgery of the Third Military Medical University.

the humerus for osteoporosis assessment. All patients had a T score below -3.5 . However we were aware that disuse would have worsened the condition of the humerus even further. Therefore we used simple radiographs to assess the osteoporosis at the local level. We added the thickness of the two cortices and divided it by the width of the bone at a relatively unaffected level of the humeral diaphysis. In all cases this measurement was less than 31%. The five cases had been operated on at least once with an average of 1.2 (range 1–3 times).

All patients underwent surgery under general anaesthesia after administration of prophylactic antibiotics. The fractures were exposed through an anterolateral approach. Fracture fragments were freshened and debridement carried out until bleeding bone ends, and the medullary canal were exposed. Both fragments were then reamed progressively using serial hand reamers gently to open the canal for the placement of the fibula.

The mid-shaft of the fibula was harvested and shaped to fit the medullary canal. The procedure should be done meticulously to avoid postoperative discomfort. The length of the fibula harvested was equal to the length of the plate that was planned to be used preoperatively. In all the females, the graft had to be split longitudinally. The graft was slid up the medullary canal of one fragment and then slid backwards down the other fragment after the fragment was held in slight distraction in an aligned position. The two fracture fragments were then telescoped over the graft into a stable position.

Osteosynthesis across the fracture site was achieved by using locking plate and screws. We used 4.5 mm locking compression plates in all the cases. At least three screws on each side of the fracture were used. The remaining excess pieces of fibular graft were packed longitudinally bridging the fracture site. None of the patients had iliac crest bone grafting.

All patients were protected in an arm sling for a period of three weeks after the surgery. Elbow and shoulder mobilization was initiated carefully and under supervision after three weeks. Lifting of weights using the operated limb was deferred for a period of three months or until osseointegration of the fibular ends or fracture healing.

At final follow-up, the patients were assessed clinically and radiologically. Fractures were considered united if at least three of the cortices on radiographs showed evidence of bony trabeculae crossing the fracture site.

All fractures had solid clinicoradiologically evident fracture union by the six month follow-up. This was assessed when 3 of the four cortices on seen on 2 plane radiographs showed bridging. There were no wound problems. The average arm shortening was 2 cm (range, 1–3 cm).

The duration of follow-up was from 12 to 36 months. None of the patients had pain over the fracture site and the DASH score at the last follow-up averaged 27.

Interestingly 2 patients complained of some amount of discomfort at the graft harvest site in the immediate postoperative period only due to peroneal muscle movement. One patient continued to have significant stiffness of the shoulder at final follow-up. In the other four there was an average loss of 15° abduction and 5° flexion of the shoulder. There was minimal restriction in shoulder rotation at final follow-up in these four cases. All the patients had a full range of motion at the elbow at final follow-up (Figs. 1–4).

Discussion

Nonunion of long bones is likely to be related to the severity of initial injury, transverse pattern of fracture, or soft-tissue interposition. Failure to unite after surgical treatment may be due to

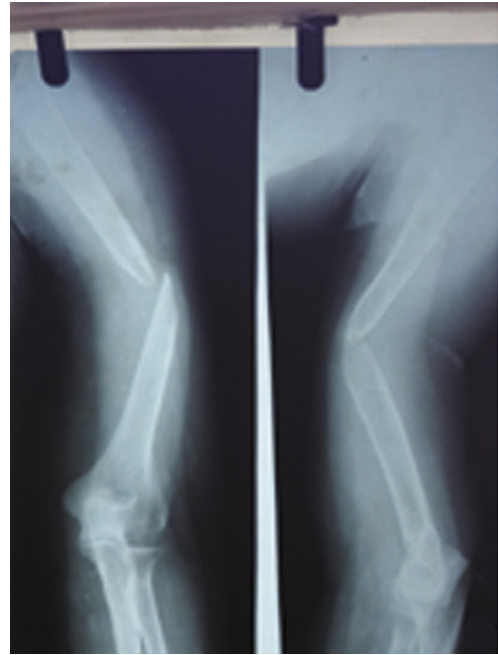


Fig. 1. Nonunion in an extremely porotic humerus. The thin cortices can be appreciated.

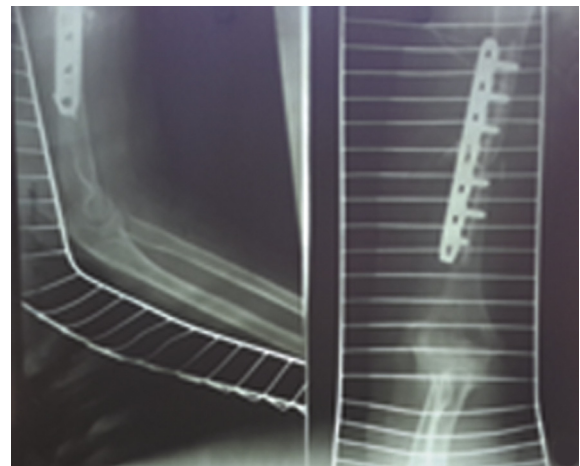


Fig. 2. Postoperative radiograph showing the intramedullary fibula with locking plate fixation.

poor contact between the bone ends, inadequate stabilization, devitalization of bone, osteopenia, and bone defects. Obesity, alcoholism, and method of treatment may also be contributory factors.⁵

The lack of mechanical stability due to a flail arm may interfere with personal hygiene, dressing, and simple activities of daily living. The goal of surgery is to achieve a stable fixation and institute early mobilization of stiff joints. Humeral nonunion in osteoporotic bone presents a reconstructive challenge for the treating orthopaedic surgeon.⁸ While a number of methods of managing atrophic fracture nonunion have been suggested, each has its drawbacks. Most surgeons favour the use of an interlocking nail, Ilizarov external fixator, or locking compression plate (LCP) for stabilization and vascularised fibular graft or cancellous iliac crest bone graft for enhancement of fracture union.⁹



Fig. 3. Radiograph showing union of the fracture.

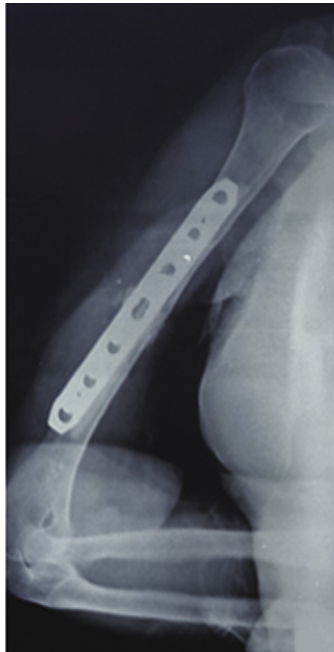


Fig. 4. The lateral view of the united humerus.

Interlocking nailing of the humerus is complicated by problems of the rotator cuff. Disadvantages of Ilizarov fixation include the presence of a bulky implant on the arm, pin track infection; painful impingement of the frame on the chest wall and the possibility of neurovascular injury due to the wires. Dynamic compression plates often result in sequential loosening of screws in the osteoporotic bone. The use of a long compression plate requires extensive tissue stripping in the upper arm causing considerable impairment of blood supply and a significant risk of radial nerve injuries.¹⁰

Double plating using two dynamic compression plates at right angles to each other has been described.¹¹ On-lay grafts and double

plating entail more extensive soft tissue stripping and devascularization of the humerus. Vascularized fibular grafts increase the complexity and cost of the osteosynthesis procedure.¹²

Locking plates are designed with screws that thread into the plate creating fixed-angle anchorage of the screws into the plate. Locking plates behave mechanically more like external fixators in that they achieve stability without the need for direct contact with the periosteal surface. In addition, the screws act in concert gaining purchase in regions of bone rather than individual sites as with traditional screws. In locking plates, screw failure is an all or nothing event.

Locking plate designs do provide enhanced fixation in fragile bone but cannot be expected to perform in situations where the applied loads to the fracture repair exceed the strength of the host bone. Locking-plate technology has renewed interest in plate fixation for treating proximal humerus fractures. Complications associated with these devices, including loss of reduction, screw cutout, and intra-articular penetration, are frequent. Establishing a second column of support may reduce complications and improve clinical outcome scores.¹³ Laboratory studies have also shown that locking plate constructs were superior to unlocked plate and screw constructs in osteoporotic diaphyseal humeral fracture models tested in vitro using cyclical torsional loading.¹⁴

Fixation of fragility fractures often results in failure of osteosynthesis. The primary mode of failure of internal fixation in osteoporotic bone results from bone failure rather than implant breakage. Since bone mineral density correlates linearly with the holding power of screws, osteoporotic bone often lacks the strength to hold plates and screws securely.¹⁵ Optimal management of osteoporotic proximal humeral fractures has evolved and may now include use of locking plates and augmentation with intramedullary fibular grafts, calcium phosphate or sulfate cement, and iliac crest bone graft.¹⁶

The cortical bone affords immediate structural continuity and stability at the fracture site. It also has some osteogenic potential in addition to acting like a strut across the fracture site when used as an intramedullary bone graft. Fibula is probably the most suitable donor bone for reconstruction of defects in a long bone because of its length, geometrical shape, and mechanical strength. However grafts of cortical bone revascularise slowly and incompletely.¹⁷

In our series of five cases we included cases whose T score on DEXA scanning was less than -3.5 . The radiogrammetry methodology of the humeral bone cortices also was supportive of the fact that the affected bones had severe osteoporosis. In all the cases the bone was unlikely to provide a good screw purchase. We chose to put an intramedullary fibula to enhance both healing and plate hold. The DEXA scan scores prove that all the patients were primarily osteoporotic. Immobilization of the humerus in itself tends to cause disuse osteoporosis in all the nonunion cases. However in all our cases it can be safely said that disuse osteoporosis is an addition to the already existent osteoporosis. This is the reason that we used locking plates with the intramedullary fibula.

Our results show that this combination is useful and reproducible for the management of nonunion of the humerus in a severely osteoporotic bone.

References

1. WHO. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis. Report of a WHO study group. *World Health Organ Tech Rep Ser.* 1994;843:1–129.
2. Melton 3rd LJ. How many women have osteoporosis now? *J Bone Min Res.* 1995;10:175–177.

3. Bengner U. *Epidemiological Changes Over 30 Years in the Urban Population*. Lund: Lund University; 1987.
4. Hildebrand GR, Wright DM, Marston SB, et al. Use of a fibular strut allograft in an osteoporotic distal humerus fracture. *Geriatr Orthop Surg Rehabil*. 2012;3:167–171.
5. Epps Jr CH, Grant RE. Fractures of the shaft of the humerus. In: Rockwood Jr CA, Green DP, Bucholz RW, eds. *Rockwood and Green's Fractures in Adults*. Philadelphia: J B Lippincott Co; 1991:843–869.
6. Ilizarov GA. *Transosseous Osteosynthesis: Theoretical and Clinical Aspects of the Regeneration and Growth of Tissue*. Berlin: Springer; 1992.
7. Jupiter JB. Complex non-union of the humeral diaphysis: treatment with a medial approach, an anterior plate, and a vascularized fibular graft. *J Bone Jt Surg Am*. 1990;72:701–707.
8. Alho A. Mineral and mechanics of bone fragility fractures. *Acta Orthop Scand*. 1993;64:227–232.
9. Rosen H. The treatment of nonunions and pseudarthroses of the humeral shaft. *Orthop Clin North Am*. 1990;21:725–742.
10. Schatzker J, Sanderson R, Murnaghan JP. The holding power of orthopaedic screws in vivo. *Clin Orthop*. 1975;108:115–126.
11. Vidyadhara S, Vamsi K, Rao SK, et al. Use of intramedullary fibular strut graft: a novel adjunct to plating in the treatment of osteoporotic humeral shaft nonunion. *Int Orthop*. 2009;33:1009–1014.
12. de Boer HH, Wood MB, Hermans J. Reconstruction of large skeletal defects by vascularized fibula transfer. Factors that influenced the outcome of union in 62 cases. *Int Orthop*. 1990;14:121–128.
13. Neviasser AS, Hettrich CM, Beamer BS, et al. Endosteal strut augment reduces complications associated with proximal humeral locking plates. *Clin Orthop Relat Res*. 2011;469:3300–3306.
14. Gardner MJ, Griffith MH, Demetrakopoulos D, et al. Hybrid locked plating of osteoporotic fractures of the humerus. *J Bone Jt Surg Am*. 2006;88:1962–1967.
15. An YH, Young FA, Fang Q, et al. Effects of cancellous bone structure on screw pullout strength. *Univ S. C Orthop J*. 2000;3:22–26.
16. Namdari S, Voleti PB, Mehta S. Evaluation of the osteoporotic proximal humeral fracture and strategies for structural augmentation during surgical treatment. *J Shoulder Elb Surg*. 2012;21:1787–1795.
17. Trader JE, Johnson RP, Kalbfleisch JH. Bone-mineral content, surface hardness, and mechanical fixation in the human radius. A correlative study. *J Bone Jt Surg Am*. 1979;61:1217–1220.