Stable Fixation of Osteoporotic Fractures and Nonunions in the Upper Limb – Life Before the "Locking Plate"

Stabilní fixace osteoporotických zlomenin a pakloubů horní končetiny – éra před „zamykací dlahou"

J. B. JUPITER, H. WYSS

Orthopaedic Surgery, Harvard Medical School, Massachusetts General Hospital, Boston, USA

SUMMARY

I have had a wonderful opportunity over the past 30 years to surgically reconstruct many complex fractures and nonunions in the upper limb in the elderly patient with underlying osteoporosis and prior to the development of the "locked plate".

This article will present a number of specific techniques using standard LC-DCP and screw in a variety of applications to provide stable internal fixation. These include the use of long plates; creating a "waved plate" initially described by Blatter and Weber; double plating; 3.5 mm intramedullary plate combined with a larger plate on the cortex; custom and machined blade plates as well as enhancement of screw fixation with bone cement and/ or Norian SRS cement.

INTRODUCTION

The concepts and techniques of stable fixation of the adult skeleton has witnessed continuous transformations based upon better understanding of the biological and mechanical requirements for bony union. In a relatively short time period, we have seen the well accepted principles of gaining fracture union from achieving absolute stability and "primary" bone healing to an emphasis on the creation of relative stability with a more biologic response (12, 22).

Whatever the fundamental approach taken, difficulties continue to challenge the fracture surgeon due to underlying osteoporosis. Our patients are not only living longer but healthier and leading more active lifestyles. Yet the fundamental etiology as well as prevention of osteoporosis remains elusive.

Angular stability with "locking plate" technology has added much to our ability to stabilize osteoporotic bone more securely. Yet these represent relatively new technologies. Reflections of my own experience over the past thirty years in treating fractures and nonunions in the upper limb will demonstrate that there exist a number of treatment techniques which can be effectively used to obtain satisfactory stability without angular stable "locking plates."

TECHNIQUES OF PLATE & SCREW MODIFICATIONS

The use of standard plate and screws applied in a variety of forms and functions is well illustrated in my experience in the management of diaphyseal nonunions of the osteoporotic humeral diaphysis. In a previous publication in the *Journal of Bone and Joint Surgery* (19), 22 patients (20 female and 2 male with an average age of 72 yrs) were reviewed. The average time from injury to presentation for nonunion treatment was 28 months with 15 patients having had at least one failed surgical procedure. Fourteen nonunions were in the proximal third of the diaphysis, 5 middle third, and 2 in the distal third. All the nonunions were atrophic with 15 mobile and synovial lined and 3 infected. The basic operative tactics included extensile exposures, minimal soft tissue elevations, debridement of the avascular bone and synovial membrane, and the use of autogeneous iliac crest bone graft.

The first plate technique used regardless of the location of the nonunion was the application of longer 3.5 mm or 4.5 mm LC-DC plates on average of about 85 % of the entire humeral length (Fig 1). This generally was the length of an eleven hole 4.5 mm plate (3, 7, 15, 16).

Fig. 1. A longstanding nonunion of the humeral in a 74 year old. The plate extends about 85% of the length of the bone.

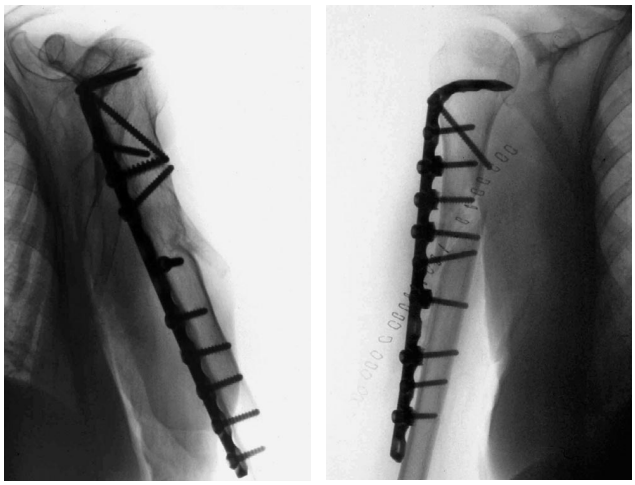


Fig. 2 a-b. Nonunions in the proximal third of the humerus can be treated with a humeral blade plate (a) or bent and machined to a tapered end (b). a | b

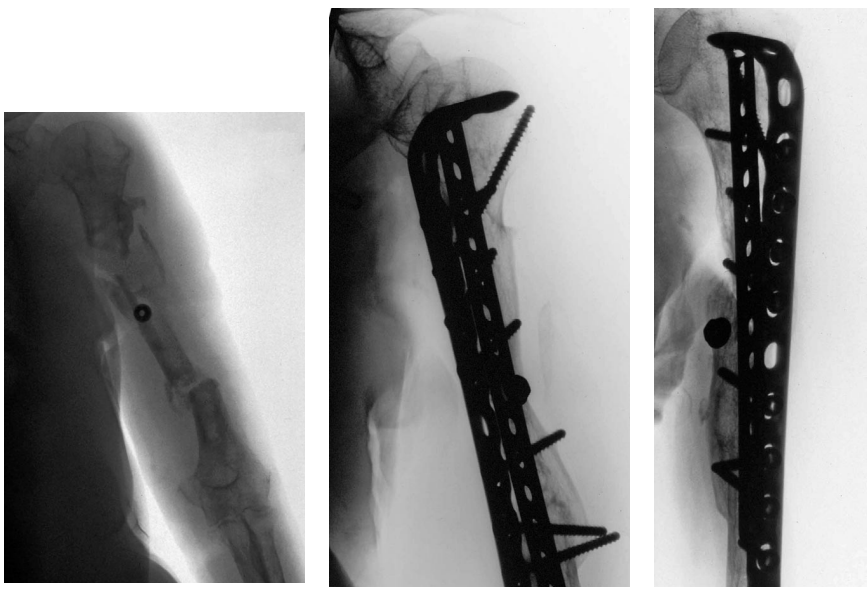
For those nonunions located in the proximal third, proximal metaphyseal fixation was enhanced through a "blade plate" fixation (6, 18) either using the humeral blade plate which I designed or preoperatively bending a standard LC-DC plate and machining the end to a thinner tapered blade, fixation was more predictable in the proximal humeral head or neck (Fig. 2).

A third modification of plate application, especially in the presence of bony defect or an incompetent cortex opposite to the applied plate, is the use of a smaller 3.5 mm LC-DC plate placed within the medullary canal in combination with a 4.5 mm LC-DC plate on the outer cortex (10). Screws placed through the longer plate in an oblique fashion entering a hole in the smaller plate can produce a mechanical "interlock" creating a more stable "opposite cortex" (Fig. 3).

An important plate modification was the creation of a "waved plate" based upon the principles defined by Blatter and Weber (1, 4, 11, 14). By contouring the standard LC-DC plate to create a space between the plate and bone extending from several centimeters proximal and distal to the fracture or nonunion, this technique incorporates a number of principles widely recognized as important in the healing of fractures as well as increased space for incorporation of autogenous bone graft. These include the importance of preserving vascular supply to the bone, the potential for mechanical advantages such as distribution of the cyclic bending forces over a greater length and the translation of a bending movement laterally so that only the lateral cortex needs to be restored to establish a tension-band function for the implant, and the ability to construct such a plate with standard implants. This concept can also be applied in the clavicle or forearm (Fig. 4), (9, 13, 20, 21).

The final plate modification involved the use of two or even three plates, each applied orthogonally to each other. This is useful in the clavicle, distal humerus (Fig. 5), or distal radius (5, 17, 23).

Standard screw fixation can be enhanced with the use of polymethylmethacrylate. The technique involves filling the screw hole after drilling and placing in the screw(s). When the cement is nearing set-up, the screw is tightened one-half turn. I also employed the Schuhli nuts to create angular stable screw fixation with stan-



a | b | c

Fig. 3. Intramedullary plate substitution with a 3.5 mm plate and 4.5 mm plate on the outer cortex is useful for bony defects.

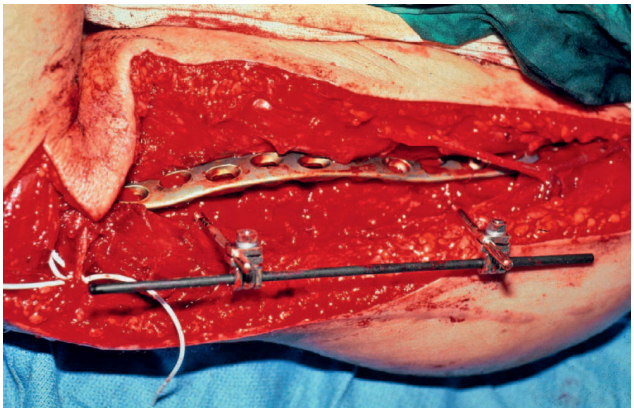


Fig. 4a-b. Waved plate application permits space for autogenous graft under the plate while distributing stresses over a wider distance than a plate applied directly to the cortex.

a | b

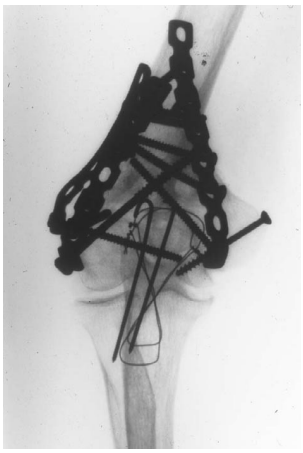


Fig. 5. Complex fractures or nonunions in the elderly are effectively treated with three strategically placed 3.5 mm reconstruction plates.

Fig. 6. A proximal third nonunion treated with a humeral blade plate and Schuhli nut screw fixation.

a | c
b

Fig. 7. A distal radius fracture in an elderly woman treated with percutaneously placed Norian SRS cement.

dard screws (8). By placing the pointed nut under the plate and a washer in the screw hole, the screw-plate bony interface is "locked" in place (Fig. 6).

Biological fixation of metaphyseal fractures was effectively done in some distal radius fractures using Norian SRS cements (2). Norian Skeletal Repair System is a biocomparable cement that has a higher compressive strength than cancellous bone. It is an injectable, fast-setting paste that cures in vivo at physiologic pH and temperature to form an osteo conductive carbonated apatite with chemical and physical properties similar to that of bone mineral. The potential for this or a similar type of material to percutaneously "cement" distal radius fractures will likely see greater application in the future (Fig. 7).

In summary, the surgeon has numerous options available to treat fractures or nonunions in osteoporotic bone using available implants and technologies with only one of these options being angular stable plate fixation.

References

1. BLATTER, G., WEBER B. G.: Reosteosynthesis in delayed fracture healing of the femoral shaft using a waved plate. Arch. Orthop. Trauma Surg., 109: 330–3, 1990.
2. CASSIDY, C., JUPITER, J. B., COHEN, M. et al.: Norian SRS cement compared with conventional fixation in distal radial fractures. J. Bone Jt Surg., 85A: 2127–37, 2003.
3. GERBER, A., MARTI, R., JUPITER, J.: Surgical management of diaphyseal humeral nonunion after intramedullary nailing. J. Shoulder Elbow Surg. 12: 309–13, 2003.
4. JUPITER, J.: Complex nonunion of the humeral diaphysis. Treatment with a medial approach, an anterior plate, and a vascularized fibular graft. J. Bone Jt Surg., 72-A: 701–7, 1990.
5. JUPITER, J. B., GOODMAN, L. J.: The management of complex distal humerus nonunion in the elderly by elbow capsulectomy, triple plating, and ulnar nerve neurolysis. J. Shoulder Elbow Surg., 1: 37–46, 1992.
6. JUPITER, J., MULLAJI, A.: Blade plate fixation of proximal humeral nonunions. Injury, 25: 301–3, 1994.
7. JUPITER, J., van DECK, M.: Ununited humeral diaphysis. J. Shoulder Elbow Surg. 7: 644–53, 1997.
8. KOLODZIEG, P., LEE, F. S., PATEL, A. et al.: Biomechanical evaluation of the Schuhli nut. Clin. Orthop., 347: 79–85, 1998.
9. LEVPIN, S., JUPITER, J. B.: LC-DC plating with bone graft in post-traumatic nonunions in the middle third of the clavicle. Swiss Surg. 4: 89–94, 1998.
10. MATELIC, T. M., MONROSE, M. T., MAST, J. W.: The use of endosteal substitution in the treatment of recalcitrant nonunions of the femur: report of seven cases. J. Orthop. Trauma, 10: 1–6, 1996.
11. McKEE, M. D., SEILER, J. G., JUPITER, J.: The application of the limited contact dynamic compression plate in the upper extremity: an analysis of 114 consecutive cases. Injury, 26: 661–6, 1995.
12. PEREN, S. M.: Fracture Healing. The Evolution of Our Understanding. Acta Chir. orthop. Traum. čech., 75: 241–246, 2008.
13. RING, D., ALLENDE, C., JUPITER, J. et al.: Ununited diaphyseal forearm fractures with segmental defects - plate fixation and autogenous/cancellous graft. J. Bone Jt Surg. 86-A: 2440–5, 2004.
14. RING, D., JUPITER, J. B.: Wave plate osteosynthesis in the upper extremity. J. Techniques in Hand and Upper Extremity, 1: 168–74, 1997.
15. RING, D., JUPITER, J. B., QUINTERO, J. et al.: Atrophic ununited diaphyseal fractures of the humerus with bony defect treated with a bridging plate and autogenous cancellous bone graft. J. Bone Jt Surg, 82-B: 867–71, 2000.
16. RING, D., JUPITER, J. B.: Ununited diaphyseal fractures of the humerus: techniques for fixation of osteoporotic bone. Techniques in Hand and Upper Extremity, 7: 2–6, 2003.
17. RING, D., JUPITER, J. B.: Treatment of osteoporotic distal radius fractures. Osteoporosis Int. 16: 80–4, 2005.
18. RING, D., McKEE, M. D., PEREY, B. H., JUPITER, J. B.: The use of a blade plate in the treatment of ununited fractures of the proximal humerus. J. Shoulder Elbow Surg. 10: 501–7, 2001.
19. RING, D., PEREY, B., JUPITER, J. B.: The functional outcome of operative treatment of ununited fractures of the humeral diaphysis in older patients. J. Bone and Jt Surg. 81-A: 177–190, 1999.
20. SIMPSON, S., JUPITER, J.: Clavicular nonunion and malunion. Evaluation and surgical management. J. Amer. Acad. Orthop. Surg., 4: 1–8, 1996.
21. Von UNGER, S., JUPITER, J. B.: The treatment of midshaft clavicle nonunion with bone graft. Techniques in Shoulder Elbow Surg., 8: 8–12, 2007.
22. WEBER, B. G., ČECH, O.: Pseudoartrosen. Bern, Hans Huber Verlag 1973.
23. WEIRICH, S., JUPITER, J.: The management of trauma about the elbow in the aging population. In: Helfet, D., Behrens R., eds. Fractures in the Elderly. New York; Raven Press 1997, 185–210.

Jesse B. Jupiter, M.D.
Orthopaedic Surgery,
Harvard Medical School,
Yawkey 2100
Massachusetts General Hospital,
Boston, MA 02114