Intramedullary Fixation of Midshaft Clavicle Fractures

Erik M. Fritz, MD, Olivier A. van der Meijden, MD, PhD,* Zaamin B. Hussain, BA,* Jonas Pogorzelski, MD, MHBA,* and Peter J. Millett, MD, MSc*†*

Summary: Clavicle fractures are among the most common fractures occurring in the general population, and the vast majority are localized in the midshaft portion of the bone. Management of midshaft clavicle fractures remains controversial. Although many can be managed nonoperatively, certain patient populations and fracture patterns, such as completely displaced and shortened fractures, are at risk of less optimal outcomes with nonoperative management; surgical intervention should be considered in such cases. The purpose of this article is to demonstrate our technique of midshaft clavicle fixation using minimally invasive intramedullary fixation.

Key Words: clavicle, clavicle fracture, midshaft, intramedullary fixation

Video available at: http://links.lww.com/JOT/A18.

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BACKGROUND

Fractures of the clavicle frequently occur, accounting for 2%–5% of all adult fractures; over two-thirds of clavicle fractures occur within the middle third.[1,2] Allman described the first widely used classification system of clavicular fractures in 1967 based on the location of the fracture site.[3] In 1998, this classification was modified by Robinson emphasizing the presence of fracture dislocation and comminution, which has proven to have the greatest prognostic value for outcome of midshaft fractures.[4,5] Medial third (Robinson type I), middle third (Robinson type 2), and lateral third (Robinson type 3) fractures are further subclassified based on degree of displacement (group A $<$ 100% displacement, group B $>$ 100%) and finally, categorized based on articular involvement or degree of comminution.[4] Using this system, Robinson reported high risks of delayed union or nonunion associated with displaced and comminuted fractures.

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From the *The Steadman Clinic, Vail, CO; and †Steadman Philippon Research Institute, Vail, CO.

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Research performed at the Steadman Philippon Research Institute, Vail, CO.

Reprints: Peter J. Millett, MD, MSc, The Steadman Clinic, 181 W. Meadow Drive, Suite 400, Vail, CO 81657 (e-mail: drmillett@thesteadmanclinic.com).

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Controversy still surrounds the indications for surgical fixation of midshaft clavicle fractures. Although most cases of nondisplaced or minimally displaced fractures may be treated nonoperatively, recent studies demonstrate that certain subsets of patients may be at higher risk of nonunion, shoulder dysfunction, or residual pain following nonsurgical management.[4,6–10] This is particularly true of fractures involving displacement of over 1 shaft width. A relative indication for surgical intervention may include fracture shortening of $\geq$1.5 cm shortening, which has been associated with less optimal outcomes.[7,11–17] Ultimately, treatment must be individualized to each patient's particular case along with his or her goals and expectations.

Once the decision for operative intervention has been made, the surgeon has several options for clavicle fixation. The purpose of this article is to demonstrate our technique of intramedullary (IM) fixation of a midshaft clavicle fracture. Advantages of IM pinning may include minimally invasive surgery, and thus improved cosmesis, and providing relative stability resulting in enhanced callus formation. Compared with plate fixation, IM pinning involves smaller incisions, decreased soft-tissue dissection, decreased stripping of the periosteum, and decreased rates of infection and refracture after hardware removal.[15,16,18,19] However, IM pins do require routine removal after clinical and radiographic evidence of bony union is apparent.

TECHNIQUE

This case presentation demonstrates the surgical technique of IM fixation with a specially designed clavicle pin (see **video**, **Supplemental Digital Content 1**, http://links.lww.com/JOT/A18). This is a minimally invasive technique for the fixation of midshaft clavicle fractures. The technique is demonstrated on a 70-year-old highly active gentleman who fractured his right clavicle while skiing and had a clear preference for surgical fixation and early return to activity. The preoperative radiographs showed a completely displaced wedge comminuted fracture of the right clavicle (Robinson type 2B1).[4]

The operation is performed in the beach-chair position with the C-arm draped into the field for intraoperative fluoroscopic assessment of the fracture. The fracture site is prepared, draped, and marked in routine sterile fashion. Before incision, the appropriate size is determined by holding up the variously sized pins and viewing them under fluoroscopy. A 3.0-mm diameter pin is used in most cases. A skin incision is then made over the fracture and subcutaneous flaps are developed while protecting the

supraclavicular nerves, if they are encountered. Next, the trapezius and subclavius muscles are split in line with their fibers and the medial fracture segment is debrided.

In acute cases, the medial clavicle segment is tapped with a medium-sized blunt tap that is slightly larger in diameter than the IM pin. In this case, a 3.2-mm tap is used for the 3.0-mm pin. In chronic cases when callus has begun to form or in acute cases if cortical fragments overly the medullary canal, a drill should be used before tapping, but care must be taken to avoid penetrating the anterior cortex of the medial fragment, as it is a straight drill in a curved bone. Tap placement is checked under fluoroscopy. All the threads of the tap need to engage the proximal fragment to ensure that the IM pin will be able to cross the fracture to get compression, without threads in the fracture site. Next, after debriding the lateral fragment, the IM canal is prepared using a 3.2-mm drill bit. Before perforating and drilling out of the lateral posterior cortex, correct placement is confirmed with fluoroscopy. The drill should exit laterally and inferiorly, although it cannot go too low or it can exit into the spine of the scapula. It is critically important to tap the lateral fragment at this point to ensure that the pin can be appropriately recessed into the fragment, before reducing the fracture and retrograding the pin into the proximal fragment.

The pin is then prepared for final insertion. The medial end is placed into the power drill so that the sharp lateral end of the pin can exit out the previously drilled lateral posterior cortex of the lateral fragment. The pin should exit out the previously drilled hole or it will engage and bind and be difficult to insert. After antegrade insertion into the lateral fragment, the skin is incised just above where the pin exits the posterolateral cortex, and the pin is driven out. The power drill is then switched to the lateral end of the pin. The pin is backed further into the previously tapped medial aspect of the lateral fragment, the fracture is then reduced, and the pin is driven into the medial fragment. The pin should be inserted far enough medially so that all the threads are in the medial fragment. The pin can be left incompletely seated to provide fracture reduction while leaving enough space laterally to assemble the locking nut mechanism.

A pearl for this procedure is to estimate how far the pin needs to travel into the medial fragment to reduce the fracture and then cold weld the nuts relative to this estimate outside the skin. This makes it easier to cut the pin as the pin is not under the skin. Alternatively, the pin can be positioned and the locking mechanism can be engaged with the 2 nuts that are cold welded together. The pin can then be backed out and cut flush with a pin cutter. After the pin is cut flush, sharp edges are removed with a rasp before burying it under the skin. The wrench for the lateral nut (the 2 nuts are cold welded together) is then used to drive the pin completely into the medial fragment, thus reducing the fracture and obtaining compression.

The butterfly fragment can then be secured with cerclage sutures. Polyethylene sutures are then passed around the clavicle to shuttle #2 absorbable sutures, which aim to cerclage the butterfly fragment into place. As many sutures as needed are passed around in the same fashion. The sutures are then tied with a racking half hitch knot, thus completing the reduction. The construct is then backed up with a number of half hitches. The reduction is checked once more with fluoroscopy and the pin is driven in with a lateral wrench until the nuts come to rest at the posterolateral cortex of the clavicle. Fluoroscopy from different angles is used to confirm reduction and the position of the hardware; this completes the fixation. On postoperative bilateral radiographs, the length of the fixed bone can be compared with the contralateral side.

Postoperative Rehabilitation

In general, rehabilitation includes full active and passive range of motion from day 1 after the operation, strengthening from week 6, and return to full activities at week 6–8 when the fracture is clinically and radiographically stable. The progression is somewhat dependent on the fracture pattern and the stability of the fixation. For example, a transverse fracture without any comminution that is anatomically reduced can be progressed through rehab very rapidly.

For those with more comminuted fractures, rehab will be at a slower pace with passive range of motion in a supine position for the first 2 weeks. In such cases, active range of motion can be delayed to week 2 or 3. Strengthening is started at week 6 and full activities can be resumed after clinical and radiographic evidence of stability after 12 weeks.

Hardware Removal

The pin is routinely removed after 3–4 months when healing has been confirmed clinically and radiographically. The patient is placed in the beach-chair position and mild sedation along with local subcutaneous anesthetic can be used. An incision is made over the posterolateral tip of the clavicle where the nut was previously buried. The soft tissue is dissected to expose the lateral end of the clavicle pin, and a wrench that fits the medial nut is then used to remove the pin. Intraoperative fluoroscopy is used to confirm complete hardware removal and clavicle stability, and the wound is closed in standard fashion.

Rehabilitation consists of immediate full passive and active range of motion while avoiding loading of the shoulder for 2–4 weeks. The patient may return to full activities at 4 weeks when clinically and radiographically stable.

CONCLUSION

The technique of IM fixation offers a minimally invasive option in the surgical management of midshaft clavicle fractures. In general, full activities can be resumed after clinical and radiographic evidence of healing after approximately 6 weeks.

REFERENCES

1. Nordqvist A, Petersson C. The incidence of fractures of the clavicle. *Clin Orthop Relat Res.* 1994:127–132.
2. Postacchini F, Gumina S, De Santis P, et al. Epidemiology of clavicle fractures. *J Shoulder Elbow Surg.* 2002;11:452–456.
3. Allman FL, Jr. Fractures and ligamentous injuries of the clavicle and its articulation. *J Bone Joint Surg Am.* 1967;49:774–784.
4. Robinson CM. Fractures of the clavicle in the adult. Epidemiology and classification. *J Bone Joint Surg Br.* 1998;80:476–484.

5. O'Neill BJ, Hirpara KM, O'Briain D, et al. Clavicle fractures: a comparison of five classification systems and their relationship to treatment outcomes. *Int Orthop.* 2011;35:909–914.
6. Lazarides S, Zafiropoulos G. Conservative treatment of fractures at the middle third of the clavicle: the relevance of shortening and clinical outcome. *J Shoulder Elbow Surg.* 2006;15:191–194.
7. Nordqvist A, Redlund-Johnell I, von Scheele A, et al. Shortening of clavicle after fracture. Incidence and clinical significance, a 5-year follow-up of 85 patients. *Acta Orthop Scand.* 1997;68:349–351.
8. Zlowodzki M, Zelle BA, Cole PA, et al. Treatment of acute midshaft clavicle fractures: systematic review of 2144 fractures: on behalf of the Evidence-Based Orthopaedic Trauma Working Group. *J Orthop Trauma.* 2005;19:504–507.
9. COTS. Nonoperative treatment compared with plate fixation of displaced midshaft clavicular fractures. A multicenter, randomized clinical trial. *J Bone Joint Surg Am.* 2007;89:1–10.
10. Robinson CM, Goudie EB, Murray IR, et al. Open reduction and plate fixation versus nonoperative treatment for displaced midshaft clavicular fractures: a multicenter, randomized, controlled trial. *J Bone Joint Surg Am.* 2013;95:1576–1584.
11. Nowak J, Holgersson M, Larsson S. Sequelae from clavicular fractures are common: a prospective study of 222 patients. *Acta Orthop.* 2005;76:496–502.
12. Robinson CM, Court-Brown CM, McQueen MM, et al. Estimating the risk of nonunion following nonoperative treatment of a clavicular fracture. *J Bone Joint Surg Am.* 2004;86-a:1359–1365.
13. Millett PJ, Hurst JM, Horan MP, et al. Complications of clavicle fractures treated with intramedullary fixation. *J Shoulder Elbow Surg.* 2011;20:86–91.
14. van der Meijden OA, Gaskill TR, Millett PJ. Treatment of clavicle fractures: current concepts review. *J Shoulder Elbow Surg.* 2012;21:423–429.
15. Wijdicks FJ, Houwert RM, Millett PJ, et al. Systematic review of complications after intramedullary fixation for displaced midshaft clavicle fractures. *Can J Surg.* 2013;56:58–64.
16. Smith SD, Wijdicks CA, Jansson KS, et al. Stability of mid-shaft clavicle fractures after plate fixation versus intramedullary repair and after hardware removal. *Knee Surg Sports Traumatol Arthrosc.* 2014;22:448–455.
17. Martetschlager F, Gaskill TR, Millett PJ. Management of clavicle nonunion and malunion. *J Shoulder Elbow Surg.* 2013;22:862–868.
18. van der Meijden OA, Houwert RM, Hulsmans M, et al. Operative treatment of dislocated midshaft clavicular fractures: plate or intramedullary nail fixation? A randomized controlled trial. *J Bone Joint Surg Am.* 2015;97:613–619.
19. Wijdicks FJ, Van der Meijden OA, Millett PJ, et al. Systematic review of the complications of plate fixation of clavicle fractures. *Arch Orthop Trauma Surg.* 2012;132:617–625.