

The use of a single volar locking plate for AO C3-type distal radius fractures

Brandon E. Earp¹ · Brian Foster¹ · Philip E. Blazar¹

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Abstract

Background A single volar locking plate (VLP) is now frequently used for open reduction and internal fixation (ORIF) of many types of distal radius fractures. Comminuted intra-articular distal radius fractures (AO C3-type) are typically the most challenging to surgically treat. No studies directly address the adequacy of a VLP alone for maintaining reduction of AO C-type fractures. We hypothesized that a single VLP provides an effective method for maintaining reduction for these fractures.

Methods We retrospectively evaluated radiographs of a series of AO C-type fractures. Seventy-seven patients with 77 AO C3-type fractures were identified from billing records and were eligible for the study. All patients were treated by fellowship-trained hand surgeons. Radiographs at the time of union were compared to those from immediately postoperatively.

Results Sixty-nine of 77 (89.6 %) fractures treated with VLP fixation alone for AO C3-type distal radius fractures united without loss of reduction. Eight of 77 (10.4 %) patients treated with VLP for AO C3 fractures lost reduction. The most common fracture fragment to lose reduction was the lunate fossa (5 of 8); loss of reduction of the scaphoid fossa die-punch fragment (2 of 8) and the radial styloid (1 of 8) were also seen.

Conclusions The majority (89.6 %) of AO C3-type fractures treated with a single volar locking plate come to union without loss of reduction.

Level of evidence: Level IV.

Keywords Distal radius fracture · Volar locking plate

Introduction

The advent of volar locking plates has changed surgical treatment of distal radius fractures [1–3, 9, 10, 16]. A single volar locking plate (VLP) is now frequently used for open reduction internal fixation (ORIF) of distal radius fractures. While VLP fixation of these fractures has become common, no studies directly address the adequacy of a VLP alone for maintaining reduction of Müller/AO-C-type fractures. Obtaining and maintaining reduction of AO C-type distal radius fractures (metaphyseal and intra-articular fractures with intra-articular comminution) to union via ORIF can be challenging [5, 11–13, 15]. Screw hole position of a single VLP may limit the ability to maintain reduction in articular fracture fragments. VLPs are successfully used to treat many intra-articular distal radius fractures but can present complications in the setting of intra-articular comminution and poor bone stock. Loss of reduction or fracture displacement of distal radius fractures treated with VLP has been reported in up to 6.7–9.8 % of cases [11, 14].

The purpose of this study was to retrospectively examine the ability of a specific fixation method (single VLP) to maintain reduction of the most complicated complex fractures (C-type) to union. We hypothesized that a single VLP would provide an effective method for maintaining reduction in of the majority of C-type distal radius fractures.

Material and Methods

The billing database of four fellowship-trained hand surgeons was retrospectively reviewed from August 2007 to April

✉ Brandon E. Earp
bearp@partners.org

¹ Department of Orthopaedics, Brigham and Women's Hospital, 75 Francis Street, Boston, MA 02115, USA

2010. The four participating surgeons performed 46, 19, 10, and 3 surgeries, respectively. The database was used to identify operative procedures with CPT codes for open reduction internal fixation of intra-articular distal radius fractures (25608 or 25609). All patients underwent a standard early motion rehabilitation protocol. Inclusion criteria were displaced AO C3-type distal radius fractures without carpal or ulnar diaphyseal fractures treated with a single VLP within 3 weeks of injury, with pre- and postoperative radiographs available for review, postoperative radiographs available within 2 weeks of surgery, and serial postoperative radiographs available until fracture union. Preoperative radiographs and available CT scans were reviewed by one of the authors (BF who was not one of the treating surgeons) to subclassify the fractures within the AO classification. However, all available radiographs of all study patients were reviewed by three fellowship-trained orthopedic surgeons from pre-op until union to evaluate for maintenance or loss of reduction. Ulnar variance, volar tilt, radial height, as well as intra-articular step off or gap were recorded. An acceptable reduction was defined as less than 2 mm of intra-articular step or gap as well as volar tilt of neutral to plus 16°.

One hundred fifty AO C-type distal radius fractures treated surgically in 150 patients were identified from the billing records. Forty-four fractures were excluded due to lack of adequate radiographs (10), non-single VLP fixation (22), ORIF greater than 3 weeks from the time of injury (6), and/or associated forearm fractures (6). This left 106 fractures in 106 patients. Patient age, AO C subclassification, loss of reduction (defined as a change in bony alignment during the postoperative period), and fracture patterns associated with loss of reduction were recorded. Of these 106 fractures, 77 AO C3-type fractures treated with a single VLP were identified, with the remaining 29 AO C1 and C2 fractures excluded. The 77 C3-type fractures were then evaluated in regard to demographics and maintenance of reduction. Follow-up averaged 120 days.

Results

Seventy-seven fractures in 77 patients were treated with a single VLP for AO C3-type distal radius fractures and otherwise met inclusion criteria. Seventy of the cases were treated with Hand Innovations plates, six were treated with Synthes plates, and one was treated with an Accumed plate. The results are summarized in Table 1. Sixty-seven females and 10 males were treated with VLP (87 and 13 %, respectively).

The distribution of AO C3 subclassification is shown in Table 2. Of the 77 C3-type fractures treated with VLP alone, subclassification revealed:

71 AO C3.2 (92.2%)

6 AO C3.3 (7.8%)

Table 1 Overall results

Category	Single VLP fixation
Patients/fractures	77
Mean age (years)	56.1
Female (%)	67 (87 %)
AO C3.2 (% of fractures)	71 (92.2 %)
CT scan obtained	18 (23.4 %)
Loss of reduction (%)	8 (10.4 %)
Time to loss of reduction (days)	38.3
Additional surgery after loss of reduction	1

Eight of 77 fractures treated with a single VLP lost reduction (10.4 %) (Figs. 1 and 2). The most common fracture fragment to lose reduction was the lunate fossa (5 out of 8 cases, 62.5 %) (Figs. 3 and 4). Loss of reduction of the scaphoid fossa was seen in two cases (25 %), loss of reduction of the radial styloid in one case (12.5 %).

All fractures that lost reduction were classified as AO C3.2. Eight out of 71 (11.3 %) AO C3.2 fractures treated with a single VLP lost reduction. Of the eight cases that lost reduction, one case required removal of hardware.

The average age of patients treated with a single VLP was 56 years old (range 18–89, SD 9.9). The average age of patients treated with a single VLP that maintained reduction was 56 years old, SD 13.26; the average age of patients who lost reduction was 60 years old, SD 19.15 ($p=0.84$). None of the fractures in our series went on to nonunion or lost reduction beyond 8 weeks from surgery.

Discussion

Sixty-nine of 77 (89.6 %) fractures treated with VLP fixation alone for AO C3-type distal radius fractures united without loss of reduction. These numbers are similar to previous reports [11, 14].

All fractures that lost reduction were AO C3.2, which are defined by metaphyseal and articular comminution. Fracture

Table 2 AO classification

Fracture type	Single VLP fixation	Other methods of fixation
AO C1.1	7	1
AO C1.2	2	0
AO C1.3	0	1
AO C2.1	14	0
AO C2.2	6	0
AO C3.2	71	19
AO C3.3	6	1
Total	106	22

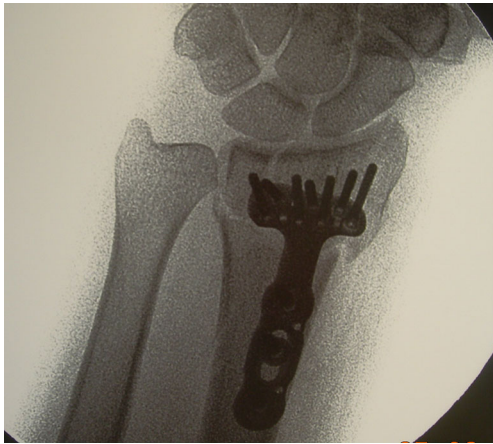


Fig. 1 Final PA intraoperative fluoroscopic image. The plate position is radial, and there is limited fixation of the lunate fossa fragment

comminution was a common characteristic in four distal radius fractures that lost reduction after VLP in a study from Rozental et al. [14]. Evaluating intraoperative radiographic reduction can be difficult in cases with articular comminution, and this may have resulted in less-than-optimal reduction. Some authors recommend routine arthroscopy or arthrotomy for managing these injuries [4, 8]. A volar locking plate construct is meant to support intra- and extra-articular fragments once they are reduced to an anatomic position. This makes maintenance of reduction with volar locking plating dependent on achieving near anatomic reduction intraoperatively.

Rogachefsky et al. reported on 12 patients with AO C3.2 or C3.3 distal radius fractures treated with open reduction with combined internal and external fixation [13]. Additionally, these patients had bone grafting with tricortico cancellous bone



Fig. 2 PA radiograph at union (5 months post-fixation) showing settling of the lunate facet fragment

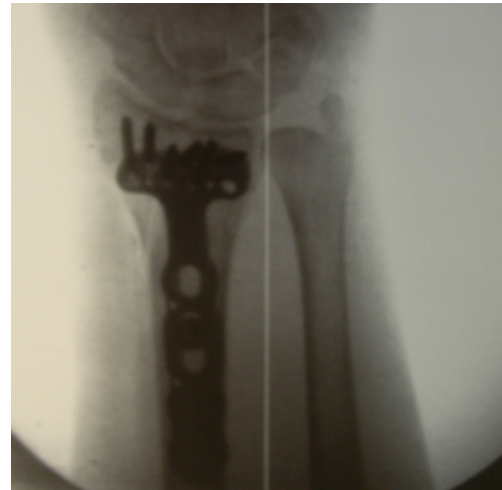


Fig. 3 Final PA intraoperative fluoroscopic image post-fixation of a patient who subsequently lost fixation

graft. No patients lost fixation, and 9 of 10 radiographic parameters were maintained at a mean of 28 months postoperatively. None of our patients underwent bone grafting. The use of bone graft might have increased our reduction maintenance, especially given the large percentage of fractures with comminution. In particular, it is possible that grafting under the lunate fossa could have provided a more robust platform to prevent subsidence of reduction; however, all the patients in our series who lost reduction had identifiable technical concerns with the implant-fracture construct.

Scheenberger et al. reported that 3 of 18 AO C3 distal radius fractures treated with plate fixation lost reduction; they believed that bone grafting would have improved reduction maintenance in two of these fractures [15]. Their fractures were treated with non-locking plates, most of them combined dorsal and volar plating.



Fig. 4 PA radiograph at union (7 months post-fixation) showing loss of fixation

The majority of the fracture fragments that seem to have lost reduction involved the lunate fossa (5 of 8 cases). Rozental et al. reported that 2 of 4 distal radius fractures treated with VLP that lost reduction involved the lunate facet [14]. Displaced lunate fossa fragments should alert the surgeon to the increased risk of failure of fixation and loss of reduction, and this should be anticipated in pre-op planning. Other authors have highlighted the role of volar marginal fragment loss of fixation; however, we did not have any of those cases in this series. This also highlights the difficulty and importance of reducing and securing this fragment, regardless of the fixation method. Surgeons must be critical of intraoperative imaging to assure that the lunate fossa is stabilized without placing fixation into the distal radioulnar joint.

In all five of the patients that lost reduction of the lunate facet, the senior authors' retrospective radiographic review demonstrated that the plate was placed too radially, which led to inadequate screw fixation in the lunate facet fragment. There were three other technical issues identified, one instance in which the plate was placed too proximal which allowed settling of a scaphoid fossa die-punch fragment due to inadequate subchondral support, one instance in which the radial styloid fragment was inadequately reduced, and one instance where a small volar lunate facet fragment was not adequately captured by fixation.

While assessing loss of reduction is one measure of outcome and of implant/fracture construct stability, further work needs to address how loss of reduction influences long-term patient clinical outcomes. This study focused solely on the mechanical capabilities of these implants to maintain a "real world" reduction. Previous studies report that articular step off and gap correlate to patient outcome [6, 18]. Of the eight cases that lost reduction, one case required removal of hardware, while seven have not required additional surgery to date and went on to bony union. Soong et al. found that in seven patients treated with VLP for distal radius fracture, five had loss of fixation that required removal of hardware and revision internal fixation [17]. Rozental et al. reported four patients that lost reduction, none of which required further surgery [14].

Limitations of this study include its retrospective nature and the lack of a set protocol when obtaining radiographs. Another limitation of this study is the subjectivity of AO sub-classifications of distal radius fractures. No studies so far in the literature have shown a very good or excellent inter- and intraobserver reproducibility rate among the different classifications of distal radius fractures [7]. This unreliability in the classification of fractures could have changed the number of patients with AO C-type fractures in our series and thus influenced our final results. Also, another limitation of this study is the use of three different volar locking plates; their different constructs might have affected the surgeons' ability to fixate some of the comminuted fractures in patients. Lastly, 22 AO

C-type fractures were treated with alternative means of fixation at the individual surgeon's discretion, and so these results may not be applicable to all C-type fractures.

This study illustrates that nearly 90 % of AO C3 distal radius fractures treated with a single VLP (including AO C3.2 in 91 % of cases) maintained reduction. All cases that lost reduction were AO C3.2 and most of these involved the lunate fossa. All of the cases that lost reduction had an identifiable technical concern with the implant-fracture construct. The use of a single VLP is effective for most C3-type fractures; however, surgeons need to pay particular attention to implant placement and anatomic reduction of fracture fragments, particularly to the lunate fossa, in these technically challenging injuries.

Conflict of Interest The Department of Orthopedics is receiving funding from Arthrex Inc. and the NIH for two studies that are unrelated to this manuscript. Philip E. Blazar has been a paid consultant for Smith and Nephew and Auxilium Pharmaceuticals. Brandon E. Earp has been paid to deliver a lecture for Biomet and holds Johnson and Johnson stock. There are no other potential conflicts to declare.

Statement of Human and Animal Rights This article was a retrospective radiographic human analysis of patients who sustained distal radius fractures. There was no direct contact with any patients or animals.

Statement of Informed Consent No identifying information has been included in this article.

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