Type C distal radial fractures treated with conventional AO plates: an easy and cost-saving solution in a locking plate era

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Abstract

Purpose C-type distal radial fractures remain challenging fractures. Currently locking plates are very popular because of their length preserving, stability. A considerable drawback is the high cost. Since 2003 we have been using mini AO plates (2.7 mm) as an alternative. We analysed our results and performed a cost analysis.

Methods Retrospective analysis was performed of all patients operated upon between 2003 and 2008 for C type distal radius fractures. Reduction was achieved with mini AO plates, applied in a buttress fashion, with ligamentotaxis. Rehabilitation consisted of immediate mobilisation. Pre- and postoperative X-rays, operative results and patient charts were reviewed. Furthermore, we prospectively evaluated the functional results using VAS, DASH and Mayo wrist scores. Lastly, we assessed the implant costs and compared them to locking plates.

Results Thirty-four patients were treated with a mean age of 49 years. Mean radial shortening improved 2 mm; dorsal and radial angulation improved 23 and 4°, respectively. At consolidation (eight weeks) the average radial shortening was 0.75 mm, a volar angulation of 3°, and 21° of radial angulation. Functional results were excellent, demonstrated by a mean VAS score less than 1, a DASH score of 12 and a Mayo wrist score of 87. Compared to locking plates, there was an overall reduction in material costs of 15,300 Euro.

Conclusions Our technique has excellent biomechanical stability, enabling immediate functional rehabilitation, good anatomical and functional outcome with significantly lower costs.

Introduction

With the increase of life expectancy, ageing of the population and subsequent increase in osteoporosis, there is a marked increase in fractures of the elderly. The development of well-designed implants (e.g., special intramedullary nails, locking plates and specialty plates) has led, over the last decade, to a vast expansion in the number of operations and a widening of their indications [1, 2].

With patients sustaining distal radius fractures the shift to an operative treatment is most striking [2–6]. Although literature has identified predictors for instability and malunion, it does not provide robust evidence for which patients are eligible for surgery [7, 8]. Some point out the importance to strive for an anatomical reduction and a postoperative stable situation enabling immediate active range of motion [9, 10]. Others suggest that a worse radiographic outcome in conservatively treated patients does not limit functional recovery at one year [11]. After the introduction of the volar plate in the early 1990s locking plates are currently gaining popularity because of their high stability and improved fixation in osteoporotic bone [12, 13]. In 2008, there were already more than 30 different volar plating systems [14]. However, to date there is no level 1 evidence of improved performance and there are considerable drawbacks including the high costs [15]. Furthermore, despite all new techniques, C-type (articular) distal radial fractures remain a challenging condition.

We describe an operation technique, based on the spring plate principle, whereby through a dorsal approach

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conventional mini AO plates and screws are applied to the distal radius. In order to evaluate our results we analysed our operative, anatomical and functional outcome, as well as the potential savings compared to locking plates.

Patients and methods

We retrospectively analysed all patients with a C-type (articular) distal radial fracture treated between 2003 and 2008 in the University Medical Centre Utrecht (trauma and tertiary referral hospital) using the spring plate technique. Baseline characteristics such as gender, age, hand dominance and trauma mechanism were assessed. All fractures were classified according to the AO/ASIF Comprehensive Classification based on preoperative posteroanterior (PA) and lateral radiographs.

Operation technique

All patients were operated upon by a senior staff member. After administration of one iv. dose of 2 g cefazoline and the placement of a tourniquet a dorsal approach was used, after marking the skin incision (Fig. 1a and b). This allowed opening of the second to fourth extensor compartment and exposure of the ulnar and radial column [16]. Subsequently mini AO (2.7 mm) plates were applied in a buttress fashion. Reduction was achieved with the plates and ligamentotaxis only. The result was verified by intra-operative image intensification. If possible the plate would only be fixed with one screw. Depending on the fracture pattern we would apply two to three plates: one at the ulnar dorsal column and/or one at the radial dorsal column (in some patients this required a second incision) and in very comminuted (or partially volar displaced) fractures an additional volar plate would be used (Figs. 2 and 3).

The following operation characteristics were analysed: interval between trauma and operation, operation time, approach, number of plates and screws used, reoperations. All patients were treated after prior informed consent. Rehabilitation consisted of immediate active range of motion; however, in some

patients with poor soft tissues a plaster cast was applied for the first ten days. Physiotherapy was only prescribed when indicated. Postoperative follow-up in the outpatient clinic consisted of reviewing the history, functional investigation and radiographic evaluation (until consolidation). Complications and re-interventions were registered.

Standard PA and lateral radiographs of the fractured wrist were taken and compared with the pre and postoperative views. Ulnar variance and dorsal and radial angulation were measured in our calibrated hospital digital imaging system (PACS). We did not investigate radial height because it is known that ulnar variance is a better predictor of functional outcome [17].

Prospectively we evaluated the functional outcome one year postoperatively, by an independent observer using the visual analogue scale score (VAS) (0 = no pain to 10 = the most excruciating pain), the disability arm and shoulder score (DASH) (0 = perfect function, 100 = fully impaired function) and the Mayo wrist score, combining pain, ability to work, function and grip strength (Jamar Hand Dynamometer, Clifton, New Jersey) (0 = fully impaired and 100 = normal function in every sense).

To calculate the total implant costs, the price of all used implants (mini AO plates and screws) were added and subsequently compared with the costs as though all patients were treated with a volar locking plate (bicolumn or juxta-articular) with five distal and three proximal screws.

Results

Thirty-four patients, including 11 males and 23 females with a median age of 49 years (range 16–80), were involved in the study. In 14 patients the fracture affected the dominant hand. The mechanism of trauma was sports related in 14 patients, 11 had a simple fall, six a fall from height and three patients were polytrauma patients. According to the AO/ASIF classification there were nine 23-C1 fractures, twenty-three 23-C2 and two 23-C3 distal radial fractures. At initial presentation there was an average ulnar variance of 2.75 mm, a dorsal angulation of 20° and a radial angulation of 17°. All patient characteristics

Fig. 1 Dorsal approach after preoperative skin marking (a), identification of Lister's tubercle and the tendon of the extensor pollicis longus (b) and opening of the second to fourth extensor compartment,

exposure of the ulnar and radial column after which reduction is achieved with plates and ligamentotaxis (c)

Fig. 2 Preoperative CT of intra-articular distal radius fracture (**a** and **b**) and postoperative result (**c** and **d**)

are listed in Table 1. Seven patients were lost to follow up after consolidation of the fracture (due to relocation out of the region ($n=3$), age ($n=1$), refusal to participate for no apparent reason ($n=2$) and one patient refused because a second wrist operation due to DRU instability was performed elsewhere ($n=1$)). As far as we know this patient was the only one, of the seven lost to follow up, with persisting complaints.

Average time between injury and operation was ten days. Median operation time was 63 min; six patients were operated upon for more than one injury in polytrauma cases. In 25 patients only a dorsal approach was used and in the other nine an additional radial or volar incision was made. Operation characteristics are listed in Table 2. In 27 patients only three or less screws were used and in 22 patients only one or two plates. Six patients received a plaster postoperatively for ten days because of poor soft tissues. Consolidation was achieved on average at eight weeks. Three patients developed a complication, one patient developed a GPRS-1 and two patients underwent a second intervention, after ten days and six months, respectively. These two re-interventions were due to unsatisfactory results after primary operation: one patient needed an additional radial plate to increase stability and the other underwent a correction osteotomy. In two patients osteosynthesis material was removed due to interference with soft

Fig. 3 Preoperative X-ray of intra-articular distal radius fracture (**a** and **b**) and postoperative result (**c** and **d**)

tissues ($n=1$) or reduced range of motion ($n=1$) despite adequate physiotherapy.

Postoperative ulnar variance improved 2 mm, dorsal and radial angulation improved 23 and 4°, respectively. At

Table 1 Patient characteristics of 34 patients treated for C-type distal radius fracture in the University Medical Centre Utrecht

Characteristic	Number of patients ($n=34$)
Male : female	11 : 23
Mean age (range)	49 (16–80)
Affected hand left : right	18 : 16
Dominant hand affected	14
Trauma mechanism	
Sport	14
Simple fall	11
Fall from height	6
Polytrauma	3
AO/ASIF classification	
23-C1	9
23-C2	23
23-C3	1
Ulnar variance (mm)	2.75
Dorsal angulation (degrees)	20
Radial angulation (degrees)	17

Table 2 Operation characteristics of 34 patients treated for C type distal radius fracture in the University Medical Centre Utrecht

Characteristic	Number of patients (n=34)
Time interval between trauma and operation (days)	10 (1–40)
Mean operative time	68 (24–130)
Mono-trauma	28
Approach	
Dorsal	25
Dorsal and volar	6
Dorsal and radial	1
Dorsal, volar and radial	2
Mean number of plates	2.18 (1–3)
Mean number of screws	2.64 (1–5)
Complications	
GPRS-1	1
Re-intervention	2

consolidation (eight weeks) the average ulnar variance was 0.75 mm, volar angulation was 3°, and radial angulation was 21° (Table 3).

Functional results were good, demonstrated by a mean VAS score <1 (range 0–2.75), a DASH score of 12 (range 0–80) and a Mayo wrist score of 87 (range 65–100).

Treating these 34 patients we used a total of 73 mini AO plates and 87 mini AO screws. The total cost of these stainless steel implants was 1,611 Euro. If all patients had received a volar locking plate (five distal and three proximal screws) the total implant costs would have been 18,533 Euro. Therefore the overall reduction in material costs was 16,922 Euro (almost 500 Euro per patient).

Discussion

Despite the fact there is only a weak correlation between initial radiographic displacement and final outcome, there has been a marked increase in open reduction and internal fixation of unstable distal radial fractures over the past few

Table 3 Radiological improvement of 34 patients treated for C-type distal radius fracture in the University Medical Centre Utrecht

Measurement	T = trauma	T = consolidation	Improvement
Ulnar variance (mm)	2.75	0.75	2
Dorsal angulation (degrees)	20	–3	23
Radial angulation (degrees)	17	21	4

years [8]. Unfortunately, uniform guidelines as to which fractures need fixation and how to treat these fractures are unavailable and large high quality randomized clinical trials are lacking. Even the Cochrane collaboration has not shed light on the ideal treatment, nor of one treatment being superior to another [9]. Nowadays there are many different implants from numerous manufacturers. Different authors have described good results in treating these fractures using very different modalities, e.g. Kirschner wires, external fixators, volar (locking) or dorsal (locking) plates [16, 18–20]. K-wires are still a popular method, unfortunately they may fail to maintain fracture position, are associated with a high incidence of pin site infection and require additional cast immobilisation [21]. An external fixator has the disadvantage of pin track infections and the possibility of secondary loss of reduction after removal [22]. One of the key problems in intra-articular distal radial fractures is redislocation due to a dorsal comminution zone. Therefore, biomechanically, a dorsal (buttress) plate seems logical to support this dorsal comminuted zone, especially when the double plating principle is applied [23, 24]. However, dorsal plating is supposedly associated with soft tissue problems including adherence of the overlying soft tissues, tendon irritation, and rupture [21]. Compared with dorsal and radial plates, volar plates are associated with fewer soft tissue complications and have become increasingly popular over recent years, especially since the introduction of volar locking plates [16, 25–29]. More important than whether one uses a volar or dorsal approach is the three-column concept. Column-specific fixation of the distal radius seems essential to achieve satisfactory results in complex intra-articular fractures [30]. Some advocate the use of locking plates to reach this goal [31]. We believe, however, that this column specific stabilisation can be done adequately using ligamentotaxis and simple 2.7-mm AO plates to maintain reduction.

In this retrospective study of 34 consecutive patients treated for a type-C distal radial fracture we describe good anatomical results and functional stability, enabling immediate range of motion and quick return to daily activities. One of the strengths of our study is that we only included C-type distal radius fractures. In many articles there is a large heterogeneity in fracture types. This will confound and flatter the results. The improvement in ulnar variance, an important outcome indicator [32], shows that our study results can meet up to the aforementioned series. Finally, our re-intervention rates in these complex distal intra-articular fractures is acceptable and comparable to others [31]. However we must continue to search for possible ways and techniques to further refine our results.

One of the limitations of our study is that it is a relatively small cohort, treated over a five-year period. The mean age is slightly younger than the typical radius fracture population.

Younger patients with better bone quality might benefit more from an open reduction and internal fixation than the osteoporotic elderly, where for example an external fixator might be a good alternative [20]. Unfortunately this is inevitable due to our academic and level I trauma centre situation. Obviously, our technique mandates a good pre- and intraoperative understanding of the fracture pattern and its biomechanics. In nine patients an additional radial or volar buttress plate was applied. One might argue for the use of a volar locking plate in the first instance to minimise morbidity through a single incision. However this buttress plate stabilisation facilitates the reduction and stabilisation of all three columns. Furthermore, the use of ligamentotaxis combined with the fact that the plate(s) is fixed with only one or two screws guarantees minimal additional soft tissue damage. Finally, our one-year follow-up is relative short. However most malunions will present within one year and in the other patients pain, grip strength and range of motion will continue to improve up to two to four years [33].

In treating distal radius fractures, non-operative treatment, especially in the elderly patient, should always be considered first [8]. Once a decision for surgery has been made the key challenges are to determine which fractures can be restored relatively minimally invasive by ligamentotaxis and buttressing the different columns and which fractures need opening up and performing a reconstruction of the joint as accurate as possible with the downside of more soft tissue damage and postoperative stiffness. The approach to this problem is often dictated by local expertise, availability of implants and operation room facilities, as is very nicely illustrated in the article by Hull et al. [34]. Since there is no evidence which technique is superior [9], it is of the utmost importance to use a familiar technique and perform it according to surgical principles with as little soft tissue damage as possible.

Our technique has the advantage of using cost-saving implants; in a fracture as common as the distal radius fracture and considering the ever-rising incidence of osteoporotic fractures this might become a point of importance [35]. The ever-increasing number of speciality plates [36] will lead to substantially higher implant costs in a time where national healthcare budgets and insurance premiums are already skyrocketing. Therefore, we believe we should deal wisely with this paradox and reflect carefully which implant to use in which patient. Using our technique we saved almost 500 Euro per patient. Using K-wires would probably be the only cheaper operative treatment. However K-wires come with several previously mentioned disadvantages and open reduction and internal fixation (ORIF) has the important advantages of early functional physiotherapy without casting and without obligatory second surgery and the earlier return to daily activities. Clearly many authors give preference to the latter [27, 37–39]. Although, others fail to show a clinically relevant advantage in the long term [18].

Our cost analysis was restricted to implants costs instead of looking at other variables as well, e.g. OR time, reoperations, etc. Nevertheless, the possible reduction in material costs is striking. If all patients had been treated with a volar locking plate, some of these patients, especially those with a more comminuted fracture, would have needed additional dorsal plate stabilisation as well. Therefore our calculation is an underestimation of the true implant costs.

Conclusions

We conclude that, in our hands, the spring plate technique is a valuable alternative in the treatment arsenal for distal radius fractures. A postoperative biomechanical stable situation is obtained, enabling immediate functional rehabilitation, good anatomical and functional outcome, with significantly lower costs. In a fracture as common as that of the distal radius, future work should focus on patient selection for the different treatment modalities. Furthermore, larger cohort studies are desirable and could be obtained by (inter)national collaboration.

Conflict of interest statement All authors declare that they have no conflicts of interests.

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