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HANDSURGERY

Complications following palmar plate fixation of distal radius fractures: a review of 665 cases

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Abstract

Introduction Palmar plate fixation of unstable distal radial fractures is quickly becoming the standard treatment for this common injury. The literature reporting complications consists mainly of isolated case reports or small case series.

Method Between February 2004 and December 2009 palmar plate fixation was performed in 665 cases. The overall complication rate was 11.3 % (75 complications). Revision surgery was necessary in 10 % (65 procedures).

Results The reasons for revision surgery were: postoperative median nerve compression (22 patients) and secondary dislocation (9 patients). An ulna shortening osteotomy for ulnar impingement syndrome was necessary in eight cases. Intraarticular screw placement occurred in three patients. There were two flexor pollicis longus, one finger flexor and three extensor pollicis longus tendon ruptures. Posttraumatic compartment syndrome of the forearm requiring fasciotomy occurred in four cases. There were three cases of infection. Nonoperative treatment was necessary in nine patients, who developed a complex regional pain syndrome. Hardware failure occurred in three cases. Hardware removal was performed in 232 (34 %) cases.

Conclusion Palmar plate fixation of distal radius fractures is a safe and effective procedure. Nevertheless, complications necessitating a second intervention are relatively common. A proportion of these complications is iatrogenic and can be avoided by improving the surgical technique.

Keywords Distal radius fracture · Complications · Palmar plate fixation · Revision surgery

Introduction

Fractures of the distal radius are the most common fractures in the upper extremity and treatment options have been controversially discussed throughout the literature over the last decades [1–10]. The development of angle-stable palmar plating systems has had a considerable impact by emerging as the currently perceived gold standard. As shown in biomechanical studies, palmar angle-stable plates allow rigid fixation of cancellous, fragmented bone. Palmar plates have long been established in the treatment of extraarticular fractures; however, their role in severe fractures is not undisputed. A short-term follow-up study of our work group has also shown striking advantages in severe radius fractures of palmar over dorsal plates with the rapid return of function with palmar plates [5, 6]. An advantage of palmar plate fixation is better soft tissue coverage compared to dorsal plating. Furthermore, the fixed angle concept allows stable fixation and early mobilisation, even in unstable fracture patterns. This has generated a shift towards palmar plates. Angle-stable palmar plates are now considered to be safe, effective and more physiological even in severe fractures. While the palmar approach may be less troublesome than the dorsal approach, it is by no means more forgiving as an increasing number of reports

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of complications with this technique have been shown [2, 8–13]. The concept of angle stability has been very appealing to most surgeons and thus indications have been expanded. While it can be expected that by treating more fractures surgically complication numbers will increase, it is unclear which complications will occur more frequently and in which fracture types. Some surgeons have reported the method of treatment to be of minor importance in the long term, as the fracture pattern seems to predetermine the long-term outcome. In an attempt to determine possible downsides of palmar implants, a large group of patients was evaluated. The aim of this study is to analyse the number and type of complications following palmar fixed-angle plate fixation of distal radius fractures in a large patient population.

Materials and methods

A retrospective analysis of relevant data was performed. Data were extracted in December 2010 from the electronic medical charts of all patients who underwent unilateral palmar plate fixation of the distal radius between January 2004 and December 2009. All patients were treated at our institution. Patients who had received palmar plate fixation elsewhere and were referred for further treatment were excluded. Patients initially treated with dorsal plate fixation or Kirschner wire pinning were excluded as well. Patients undergoing palmar plate fixation for corrective osteotomy of the distal radius were also excluded. Fracture type, age or additional injuries as well as open fractures were not defined as exclusion criteria. Informed consent was obtained from all patients prior to surgery. In this study, all procedures were performed with several generations of the same implant (Aptus® Radius 2.5 mm by Medartis®) to minimise any impact from using several implant types and systems. Surgical steps followed the established technique unless differently dictated by the fracture pattern. The operations were performed in the Department of Hand-, Plastic- and Reconstructive Surgery of our hospital. Several different surgeons were involved in this study. In each operation at least one surgeon with specialisation in orthopaedic, hand- or plastic- surgery was involved.

An incision over the flexor carpi radialis was made and extended distally in a radially angulated manner to access the radial styloid. The incision was deepened beneath the flexor carpi radialis sheath, the flexor pollicis longus tendon was retracted ulnarly. The pronator quadratus muscle was incised radially and elevated off the radius. Fragments were then identified and repositioned after reduction of the fracture. Temporary K-wires were only used when it was impossible to maintain reduction. The palmar plate was fixed in the proximal gliding hole. After verification of reduction under fluoroscopy, the distal screws were placed and checked under fluoroscopy. The proximal screws were inserted last. During the final fluoroscopy the intercarpal ligaments were assessed. The pronator quadratus muscle was readapted. A drain was placed in all patients. Postoperatively, a standard rehabilitation protocol was applied. The wrist was immobilised in a palmar splint for 2 weeks, followed by a protective removable splint for an additional 4 weeks. Early mobilisation of the wrist was encouraged at 2 weeks after surgery under the supervision of a therapist. Weight bearing was initiated 6 weeks postoperatively. All patients with radius fractures were followed up after 6 weeks, 3, 6 and 12 months postoperatively. Final follow-up was recommended between 1.5 and 2 years postoperatively. Patients who did not complete at least 12 months of follow-up were not included in this study.

Complications were extracted after a review of charts and the radiographs of all patients. All types of revision surgery were recorded. Medical conditions not related to the trauma were not further investigated and not regarded as complications. Hardware removal was also extracted from the charts and recorded although hardware removal was not defined as a complication in itself.

Results

In the period of the study more than 750 patients were treated operatively. In this study, 665 patients with a mean age of 58 years and a range between 13 and 96 years were included. Mean follow-up was 13 months (range 12–24 months); 61 % were female, 39 % were male. Distribution of fracture types did show 70 % of treated fractures were C1–C3 fractures. 75 complications occurred in 65 patients, resulting in a total complication rate of 11.3 %, or 10 % of all patients. Average age of patients with complications was 58 years, with 33 % males and 66 % females. Furthermore, 71 % of complications occurred in C1–C3 fractures. While C1 fractures were found in 34.5 % of cases and represented 21 % of all complications, C3 fractures were found in 14 % but represented almost 30 % of all complications. In C1 fractures, complications occurred in 6 %, while in C3 fractures, complications were found in 20 % of all cases (Fig 1). A summary of type, number and percentage of complications is shown in Table 1. The most frequent complication was development of carpal tunnel syndrome, which was seen in 22 cases. Acute median nerve compression requiring immediate carpal tunnel release was seen in five patients, three in AO type C2 fractures, one in a Gustillo grade three open fracture and another one in a patient with thrombophilia. In 17 cases a gradual development of median nerve compression was observed and treated with carpal tunnel release and hardware removal at

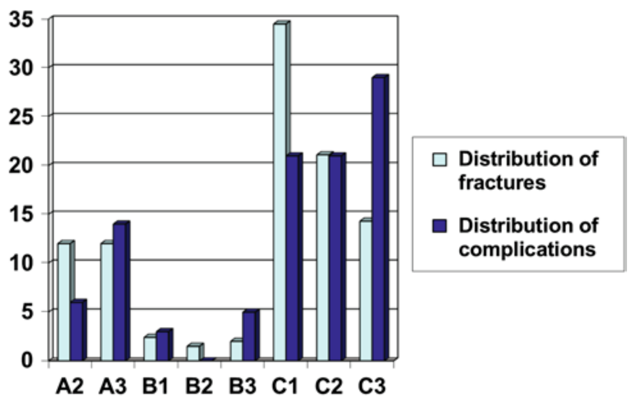

Fig. 1 Distribution of complications with regard to fracture types (% to total)

Table 1 Type, number (*n*) and percentage of complications

Complication type	*n*	Percentage of all patients
Median nerve compression	22	3
Secondary dislocation	9	1.4
CRPS	9	1.4
Ulnar impingement	8	1.2
Hematoma	5	0.7
Compartment syndrome	4	0.6
Osteoarthritis	3	0.5
Intraarticular screw placement	3	0.5
Flexor tendon ruptures	3	0.5
Extensor tendon ruptures	3	0.5
Infection	3	0.5
Hardware failure	3	0.5
Total	75	11.3

an average of 5.1 months postoperatively. Secondary fracture dislocation was observed in nine cases. Six occurred in C2 and C3 fractures with patients' age in a range between 25 and 88 years. Three secondary dislocations were observed in A3 fractures in older patients (range 75–88 years). Secondary dislocations were treated with revision of palmar plate in three cases, double plate osteosynthesis in three cases and shift to external fixation in three cases. Intraarticular screw placement was seen in three cases requiring revision. Ulnar impingement treated with ulnar shortening osteotomy was observed in eight cases. In three patients intraarticular steps of more than 2 mm were seen and treated with corrective osteotomy. In three patients radiocarpal arthritis developed and was treated with styloidectomy in one patient, one had a wrist fusion and one responded to denervation alone. Tendon irritations were seen in three patients and treated with hardware removal and tenolysis. These cases became symptomatic with tenderness and palpable crepitation. Rupture of the EPL tendon occurred in three cases, while one rupture of a finger flexor tendon was observed in two cases as a FPL rupture. Three postoperative infections were observed and treated with debridement and irrigation. In five patients development of a hematoma required surgical exploration and evacuation of the hematoma. Development of a compartment syndrome was observed in four young patients with C3 fractures and treated with immediate fasciotomy and secondary closure, in one case even requiring a free flap. Nine patients developed CRPS and were treated conservatively. The three cases of hardware failure were solved by reosteosynthesis.

Hardware removal was performed in 232 cases (34 %). In asymptomatic patients requesting hardware removal, hardware was removed 6 months postoperatively routinely.

Discussion

In recent years palmar plate fixation with fixed-angle implants has become the preferred treatment for unstable distal radius fractures. This technique represents an important improvement in the treatment of these injuries as operative treatment has been made technically easier than before. While dorsal plating systems have never gained huge popularity and have been confined to more experienced surgeons, palmar plates are used by many. The shift to palmar plates is largely unexamined by randomised research [14–16]. As a reaction, some authors have demanded evidence that justifies the change in the management of radius fractures [7]. While previous reports on some of our patients have shown better functional results and considerably less complications in the short term, which in itself justifies the use of palmar plates, few larger series of scientific reports with longer term follow-up exist [5]. Numerous reports on complications have been published in recent years (Table 2). The overall complication rate discussed in the literature ranges from 8 to 39 %. The complication rate in this study was 11.3 %. This may reflect familiarity with these implants and the surgical technique required (on average 150 operations per year in our department). Furthermore, there is definitely some referral bias as rather severe fractures were predominantly treated; therefore, it is not known whether these results can be generalised. The use of only one implant may significantly contribute to the lower complication rate [10]. Complications can be categorised into surgeon-related and surgeon-independent complications as well as major complications and minor complications. We focussed our investigation particularly on surgeon-related complications. Surgeon-related complications include intraarticular screw placement, malunions, secondary

Table 2 Number of cases (n) and complication rates in recent publications

Authors	Years	n	Complication rate (%)
Soong et al. [10]	2011	594	8
Rozental et al. [9]	2006	41	22
Zettl et al. [37]	2009	60	12
Arora et al. [2]	2007	114	27
Rampoldi et al. [8]	2007	90	8
Zettl et al. [13]	2001	49	39

fracture dislocations, flexor tendon ruptures secondary to prominent plate edges, and extensor tendon ruptures secondary to penetration of screw tips.

The rate of intraarticular screw placement during surgery is low and shows the importance of meticulous knowledge and handling of a specialised implant. Screws beneath the lunate facet are more likely to be placed intra-articularly and thus the angle of placement must be calculated carefully. Arora et al. [2] found intraarticular screws in 1 of 114 cases (0.9 %). Other authors did not report on this complication at all [9, 13]. In our study we found intraarticular screw placement in 3 of 665 cases, which was lesser than that reported by Soong et al. [10] (8 out of 594 patients). It has also to be noted that postoperative CT scans are not routinely requested in our institution and thus some close screw placements may have remained undetected (Fig. 2). Intraarticular screws can also occur as a result of secondary fracture dislocations and thus have to be regarded as an independent entity since such intraarticular screws are the result of poor bone quality. Fixed-angle implants do not completely protect from secondary dislocations as evidenced in nine cases of our study (Fig. 3). This finding is similar to recently published results of Soong et al. [10] who report 1.2 % loss of fixation (7 of 594 cases). Six out of nine cases in our study were C2 and 3 fractures in a wide range of ages, whereas dislocations in three AO type A fractures occurred only in elderly patients. Loss of reduction was treated with revision surgery in six patients receiving additional fixation, while three were sufficiently treated with plate revision and insertion of a new plate to allow secure screw locking.

Osteoarthritis may develop regardless of the postoperative course. This was seen in three patients within 12 months. Osteoarthritis is believed to be due to inadequate articular surface reduction with a residual articular step of >2 mm. Symptoms of arthritis were not controlled by denervation in two patients and one went on to require a total wrist fusion. Our reported rate of osteoarthritis may not represent the true rate [17]. The greatest weakness of this study may be the average follow-up period, which was

Fig. 2 Intraarticular screw shown in a CT scan

little more than 1 year. Still, it has been shown, that 1-year follow-up is sufficient in radius fractures as "little change in terms of function occurred after that period and thus 2- to 5-year follow-ups are not indicated in this population" [18]. Nevertheless, our follow-up is insufficient to allow conclusions about true long-term problems such as post-traumatic osteoarthritis which may arise after more than a decade.

Tendon ruptures can occur regardless of the fracture pattern. Extensor tendon ruptures, such as an EPL rupture can be directly related to the fracture itself and therefore occur in conservatively treated fractures in up to 5 % [19–21]. The close proximity of the extensors especially of the EPL to the radius puts them at risk when palmar screws are placed [12]. The incidence seems to be as high as 8.6 % [11]. To avoid this complication, Kumar et al. [22] proposed an intraoperative tangential radiograph. This, however, is difficult to obtain from a practical point of view. A good knowledge of the three-dimensional anatomy of the distal radius remains an important prerequisite in avoiding this complication. Well positioned oblique and lateral views under image intensifier are sufficient to judge the right screw length.

The incidence of flexor tendon ruptures in our study is <2 %. Casaletto et al. [23] found ruptures of the long flexor of the thumb in 7 out of 353 cases. Due to large

Fig. 3 A case of secondary dislocation. **a, b** The trauma situation. The first intraoperative X-rays show a promising result (**c, d**). Fourteen days after surgery the fixation was lost (**e, f**). Fourteen days after revision surgery dislocation happened again (**g, h**). Final solution with an dorsal and palmar approach (**i, j**)

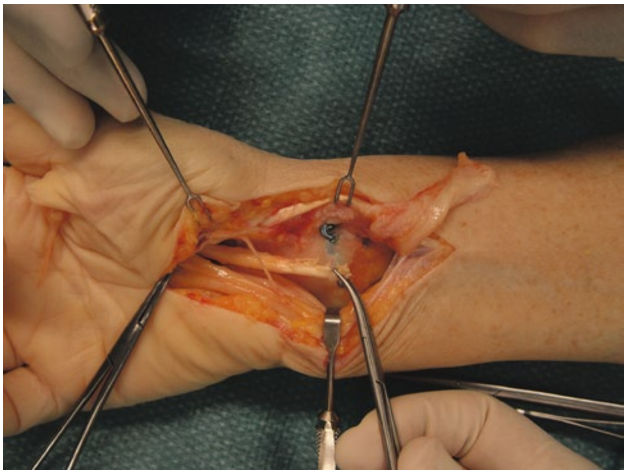

Fig. 4 Rupture of the long flexor tendon of the thumb due to an over standing distal border of the plate

defect zones they often require tendon grafting followed by lengthy rehabilitation period [24]. They occur almost always at the distal edge of the implant as it remains uncovered by the refixed pronator quadratus muscle and serves as a hypomochlion for flexor tendons (Fig. 4). Flexor tendon ruptures are often a result of plates that are placed too distally not respecting the Watershed line or unlocked screws, which may lead to attrition and subsequent rupture the flexor tendons.

Surgeon-independent complications include median nerve compression, infection, compartment syndrome, complex regional pain syndrome, haematoma and implant failure. These are influenced by the severity of the trauma, patients' medical condition and the swelling following trauma.

Cases of carpal tunnel syndrome, which needed operative decompression of the median nerve were investigated. 22 patients presented with typical symptoms which allowed the diagnosis of a carpal tunnel syndrome [25]. Mild cases can often be missed in the acute hospital setting and are subsequently treated non-operatively by the general practitioners. On average, gradual onset of typical symptoms led to an operative median nerve decompression 163 days after osteosynthesis in 17 patients. Thus, it can be debated if such late occurrences of carpal tunnel syndrome can be regarded as a complication or rather a sequela of implant material close to the carpal canal. Patients with initial signs of median nerve compression gained decompression during the osteosynthesis procedure. Only five patients developed acute carpal tunnel syndrome which required urgent release, in four of the patients a concomitant compartment syndrome had to be treated as well. The critical pressure for the median nerve in the carpal tunnel is estimated to be 30–60 mmHg [26]. Kongsholm and Olerud [27] demonstrated a relationship between the dorsal angulation of the fracture and the pressure in the carpal tunnel. Stewart et al. [28] also reported on rising pressures in the carpal tunnel with highly dislocated distal radius fractures. Expedient fracture reduction is an important factor in reducing the risk of developing carpal tunnel syndrome. Fuller et al. [29] demonstrated that 24 h after open reduction and palmar plate fixation the intracarpal pressures dropped to 31 mmHg, though still above the critical value. Steward et al. [28] found the incidence of a postoperative carpal tunnel syndrome of 17 % after 3 months, and 12 % after 6 months, respectively.

The incidence of compartment syndrome following distal radius fractures reported in the literature is between 0.25 and 2 % [30, 31]. In Cooney [32] study, however, all dorsally dislocated distal radius fractures were included, regardless of the treatment method. In our study we saw four cases of compartment syndrome as mentioned above (0.6 %). Two patients suffered high-energy motor vehicle accidents. One fell from a cherry tree, another one had a bicycle accident. Initial operative time was >90 min. All compartment syndromes were treated by forearm-fasciotomy and subsequent secondary wound closure. Young men, approximately 25 years of age are at most risk of developing compartment syndrome, as their injuries are most frequently the result of high-energy trauma [30]. Fasciotomy of all compartments is crucial to avoid late complications.

Infection is a rare complication. There were three infections (0.5 %) in our study. It is greatly influenced by the preoperative contamination and the severity of the trauma with open fractures. Rozental and Blazar [9] found an infection rate of 44 % after the treatment of open distal radius fractures. In this study the fractures were treated with internal and external fixation devices. Infections can best be avoided with meticulous debridement and irrigation in combination with the use of perioperative antibiotics. Complete elimination of infection risk is however not possible.

Complex regional pain syndrome (CRPS) remains a clinical diagnosis. As part of our postoperative regiment we treat CRPS if there are clinical signs such as increased sweating, swelling, different hair pattern, etc. Additional analysis is not performed. In our study we observed nine cases (1.4 %). This is consistent with a report by Dijkstra et al. [33] who describes an incidence of 1 %. Gradl et al. [34] found that 16 weeks after trauma 18 out of 158 patients (11 %) fulfilled the criteria for CRPS. This finding was independent of the treatment modality. The pathophysiology for the development of a CRPS, however, is still not fully understood. Uçeyler et al. [35] suggests that the development of a CRPS is related to an over expression of cytokines in the corresponding extremity. There is likely a genetic predisposition [35]. It has to be stated clearly that

CRPS is a complication that cannot be influenced by the surgeon.

The three cases of hardware failure were caused by non-compliant patients. Fixed-angle screws lead to higher bending forces on the palmar plate than conventional screws. This can lead to fatigue and breakage of the plate at the site of the screw holes. Filling all screw holes may avoid this problem.

The follow-up period is short in this study. Therefore, late complications may not be adequately represented at the time of data collection. This corresponds to the findings of Soong et al. [10]. But despite this considerable drawback obvious conclusions can be drawn. The shift from dorsal to palmar plates has been fuelled by higher complication rates in dorsal plates or external fixation [36–38].

Conclusion

Palmar fixed-angle plate fixation of distal radius fractures allows, in the majority of cases, recovery without complication. Therefore, this technique can be considered a safe procedure. Nevertheless, the complication rate cannot be neglected and not all complications can be avoided. It can be mentioned, that despite the improvements seen in modern implants, there are still risks and difficulties related to the procedure that the surgeon must be aware of. The complication rate can be lowered when the surgical technique is applied correctly. Especially, the correct placement of the plate and screws is crucial to minimise secondary dislocations and tendon attritions. These steps may possibly reduce complication rates furthermore.

Conflict of interest All named authors hereby declare that they have no conflicts of interest to disclose.

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