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ORIGINAL ARTICLE

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Do angle stable implants provide advantages? Treatment of distal radius fractures with the locking compression plate (LCP)

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Abstract Can distal radius fractures be held in place with palmar locking compression plates (LCPs) and heal completely without an additional bone transplant? From 1 March 2001 to 1 September 2002, 40 patients with distal radius fractures (CCF: 2× A2, 13× A3, 2× C1, 22× C2 and 1× C3 fractures) were treated with locking compression small fragment titanium plates. In 37 cases, the plates were inserted in a palmar direction without an additional corticocancellous bone graft. All patients received a follow-up check-up after an average of 12.1 months. On this occasion, the range of motion, grip strength and radiological result were measured and rated according to the Gartland and DASH score. All fractures healed completely. In one case, a re-osteosynthesis was carried out after the plate had bent because full load was placed on it prematurely. An average of 5.1 points was achieved in the Gartland and 12.6 points in the DASH score. An extremely good result was achieved in 19 cases, a good result in 15 and a satisfactory result in 6. At the follow-up examination, the average range of motion was 52°-0°-50° for stretching and bending in the wrist, 20°-0°-27° for radial and ulnar deviation and 82°-0°-78° for pronation and supination. On the radiographs, the average radiocarpal angle in the anteroposterior projection was 22° with a palmar tilt of an average of 5°. Radius fractures with metaphyseal, one-sided comminuted zones can be treated with locking compression plates with good results using a palmar approach without a cancellous bone graft.

Keywords Locking compression plate (LCP) · Distal radius fracture · Plating · Internal fixation

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Traitement des fractures distales du radius par plaques LCP

Résumé Les fractures distales du radius peuvent-elles être stabilisées par des plaques palmaires à compression et à vis verrouillées et peuvent-elles consolider sans aucun apport de greffons osseux ? Du 01–03–2001 au 01–09–2002, 40 patients ayant des fractures distales du radius (voir les types dans le summary anglais) ont été traités avec des plaques à compression en titane pour petits fragments. Dans 37 cas les plaques ont été placées en palmaire sans aucune adjonction d'os spongieux. Tous les patients ont été contrôlés avec un recul moyen de 12,1 mois. Lors de ce contrôle, l'amplitude de mobilité, la force de serrage et le résultat radiologique ont été évalués selon le score de Gartland et DASH. Toutes les fractures ont complètement consolidé. Dans un cas, une réostéosynthèse fut réalisée après que la plaque se soit incurvée par suite d'une mise en charge trop précoce. Le score de Gartland a été amélioré de 5 points et celui de DASH de 12,6 points. Un résultat très satisfaisant a été noté dans 19 cas, un bon résultat dans 15 cas et un assez-bon dans 6 cas. Au contrôle, l'amplitude de mobilité était de 52°-0°50° pour la flexion-extension du poignet , de 20°-0°-27° pour l'inclinaison radiale et ulnaire et de 82°-0°-78° pour la pronation et la supination. Sur les radiographies l'angle radio-carpien moyen était de 22° avec une inclinaison palmaire moyenne de 5°. Les fractures du radius avec une comminution métaphysaire unilatérale peuvent être traitées par ostéosynthèse avec des plaques à compression et à vis verrouillées avec un bon résultat grâce à un abord palmaire et sans apport de greffons d'os spongieux.

Mots clés Plaques à compression verrouillées · Fracture du radius distal · Fixation interne

Introduction

The distal radius fracture is the most common fracture. Its incidence is 0.2–0.4%. It makes up about one sixth of

all fractures in emergency surgical admissions [14, 18]. With the ageing population, a further increase in frequency can be expected [3, 17]. Fractures that cannot be reduced or cannot be maintained in reduction are treated surgically. Here, depending on the type of fracture, K wires (transosseous or according to Kapandji), fixators (joint bridging or purely radial) and plate and screw osteosyntheses are used [7, 11, 13, 14, 22].

Fractures with extra-articular comminuted zones without or with only a low level of joint participation can be successfully supported with a plate. Here, both dorsal and palmar plate positions are possible. In the case of a dorsal position, there is a risk of scar adhesions on the extensor tendon that runs directly above the bone, or of the tendon tearing [21]. However, in the case of large comminuted zones, the dorsal approach provides the possibility of carrying out a cancellous bone graft or filling with bone substitutes. The palmar plate position is less damaging to the soft tissue and allows a good orientation of the achieved reduction because, in the case of Colles fractures, the palmar corticalis is typically only torn and does not have any comminuted zones. However, direct cancellous bone grafts cannot be carried out via the palmar approach. A small additional dorsal approach would be possible if required [10]. All additional detachment of soft tissue is, however, detrimental to bone healing [2, 16].

With the introduction of new locking compression plates, it has now become possible to hold the reduced distal fragment in place with screws that cannot tilt in the plate [15]. Based on the experiences gained with the PC-Fix locking compression plate system [9] and the LISS for the distal femur and the proximal tibia [19], AO ASIF devised the further developed system of the locking compression plate (LCP) (Synthes-Mathys; Bochum) and launched it onto the market in 2001 [5].

With the introduction of what is known as a combination hole, it has become possible to select whether to use locking-head screws or conventional cortex or cancellous bone screws or a combination of both. The locking-head screws are either self-drilling, or self-cutting and self-drilling. The plate systems have been on the market since 1 July 2001. As a test clinic, we have been able to use the implants in clinical operations since 1 March 2001. The aim is to carry out a prospective investigation into whether distal radius fractures with comminuted zones can be fixed in a sufficiently stable manner with the new locking compression small fragment titanium plates using a palmar approach without an additional cancellous bone graft.

Materials and methods

From 1 March 2001 to 15 Septemner 2002, 40 patients were treated with plate osteosyntheses for distal radius fractures as part of a prospective study. In all cases, reduction and the fitting of a plaster cast were carried out first. Inclusion criteria for the operation were dislocations despite reduction of more than 15° on the anteroposterior or lateral radiograph, shortening of the radius by more than 2 mm and joint discrepancies of more than 2 mm. All patients received open reduction and stabilization with a locking compression, small-fragment titanium plate. After at least 6 months, the patients attended a follow-up examination, which included radiographs in two planes. Wrist range of motion was determined using the neutral-zero method. Fist-clenching strength was measured using a vigorimeter and compared to the intact contralateral limb.

The DASH score (disability of arm-shoulder-hand) was used to measure arm function. Here, functions of everyday life, symptoms and special activities such as sport and music are assessed according to 30 criteria. A DASH score of 0 points corresponded to a result with an ideal function without disability and a score of 100 to the maximum bad result [12]. Remaining deformities of the wrist, subjective patient complaints and the achieved range of motion, as well as any possible complications, were assessed with points according to the Gartland and Werley scores. A maximum of 37 points could be achieved as the worst result: 0–2 points corresponded to an excellent result, 3–8 points to a good result and 9–20 points to a satisfactory result, while more than 20 points represented a poor result [6]. The study was supported by subsidies from the Maria Pesch Foundation in Cologne.

Results

Forty patients —22 men and 18 women with an average age of 49.2 (17–81) years—were included in the study. According to the AO classification (CCF), there were two A2 fractures, two C1 fractures, 22 C2 fractures and one C3 fracture. All fractures were initially reduced and, in the case of insufficient retention, a secondary operation was performed; 161 of 251 screws were inserted as locking head screws (on average four of six screws per plate).

In 37 cases, the plates were inserted in a palmar direction with no additional support through a corticocancellous bone graft. In the case of one C1 fracture, dorsal plate insertion was selected for a considerably dislocated dorsal fragment. In two further cases with C2 fractures, the plates were combined with a cancellous bone graft via a dorsal approach. In one case, the fracture was already 3 weeks old and had to be dismantled. In another case, a non-locking compression plate had been inserted in another clinic and had come loose. All patients received functional aftercare with decompression over 6 weeks. Wound healing disturbances or infections were not observed. In one case, second-degree reflex dystrophy developed, which healed following pain therapy and physiotherapy.

In one case, 3 weeks after the operation, plate bending occurred in a polytraumatised patient after he placed full load on the arm. The plate was removed and re-osteosynthesis with a locking compression palmar humerus plate was carried out. This led to complete bony healing of the fracture in the correct position. In two cases, there were post-operative sensitivity disturbances in the fingers supplied by the median nerve, which regressed spontaneously and completely within 6 weeks. Post-operatively, after 6 weeks and for the follow-up check-up, radiographs in two planes were carried out. No implant loosening was observed. The post-operatively achieved position was maintained until the follow-up. All the patients underwent a follow-up

examination after at least 6 months, on average after 12.1 (6.1–24.1) months. An average of 5.1 points was achieved in the Gartland score. An extremely good result was achieved in 19 cases, a good result in 15 and a satisfactory result in 6.

At the follow-up examination, the average range of motion was 52°-0°-50° for stretching and bending in the wrist, 20°-0°-27° for radial and ulnar deviation and 82°-0°-78° for pronation and supination. In the fist-clenching test, 80.3% of the strength of the intact contralateral limb was achieved. The average DASH score was 12.6 points (see Table 1). On the radiographs, the average radiocarpal angle in the anteroposterior projection was 22° with a palmar tilt of an average of 5° on the lateral radiograph. Radius shortening 0.1 mm.

Fractures with extra-articular dorsal comminuted zones were treated in particular (13× A3 fractures and 22× C2 fractures). Thus, in the case of A3 fractures, an average of 4.4 points in the Gartland score and 9.7 points in the DASH score was achieved. The average range of motion for the A3 fractures was 51°-0°-56° for stretching and bending in the wrist, 21°-0°-30° for radial and ulnar deviation and 81°-0°-81° for pronation and supination. In the fist-clenching test, 84% of the strength of the contralateral limb was achieved. On the radiographs, the average radiocarpal angle for the A3 fractures in the anteroposterior projection was 27° with a palmar tilt of an average of 7°. Radius shortening was 0.1 mm. For the C2 fractures, an average of 4.5 points were achieved in the Gartland score and 11.8 points in the DASH score. The average range of motion for the C2 fractures was 56°-0°-49° for stretching and bending in the wrist, 20°-0°-24° for radial and ulnar deviation and 83°-0°-77° for pronation and supination. In the fist-clenching test, 81% of the strength of the contralateral limb was achieved. On the radiographs, the average radiocarpal angle for the C2 fractures was 20° with a palmar tilt of an average of 5°.

Plates were removed again in six cases. In one case, a wrist ganglion that occurred post-operatively was resected at the same time. In one case, 3 days after implant removal, a hitherto unnoticed iatrogenic false aneurysm ruptured. Emergency treatment was performed on the aneurysm whilst retaining the radial artery.

Discussion

Two thirds of radius fractures can be fully treated with very good results in a non-operative manner using reduction and immobilisation in a lower-arm plaster cast [21]. Treatment of the remaining one third is discussed controversially in the literature. Because of the variety of possible therapies for different types of fractures, a precise classification of fractures should occur pre-operatively [4]. In this process, the AO classification takes into account the degree to which the joint and shaft section is affected, but not the extent of the dislocation and the concomitant injuries to the ulnar styloid process.

It nonetheless allows a stage-adapted procedure. The A3 fractures are thus extra-articular fractures with a comminuted zone that is usually situated dorsally. In the case of an extensive defective zone, there may be a secondary dislocation after reduction. With the C2 fractures, there is a simple joint fracture in addition to the multi-fragmentary diaphyseal fracture. If the congruent stabilisation of the joint fracture is successful, the break can be treated in the same way as an A3 fracture.

Today, intolerable malalignments include joint discrepancies over 2 mm and the flattening or tilting of the radiocarpal angle by more than 15° [11, 15]. In younger patients, the limits for an operation are seen in more generous terms. Joint discrepancies are not accepted and axis deviations are only accepted up to 10° [18]. Thus, unstable A3 and C2 fractures can be treated by open reduction and plate osteosyntheses.

Further indications also arise more rarely for A2 fractures, frequently for B1–3 fractures and in part for C1 and C3 fractures in competition with the external fixator, K wires and screw osteosyntheses [1, 8, 10, 21, 22, 23]. Disturbances of the extensor tendon that runs directly above the plates are described in 11% of cases with dorsal plate positions [10]. Lister's tubercle as a hypomochlion for the long thumb-extensor tendon needs to be resected for T plates [15]. Felderhoff thus reports on 213 patients who were treated with non-locking compression plate osteosyntheses between 1988 and 1998. In 158 cases, the plates were inserted dorsally, and bone defects were filled with pelvic bone graft. In a follow-up examination, after an average of 3.4 years, 61°-0°-52° was achieved for bending and stretching and 81°-0°-77° for pronation and supination. Radial and ulnar deviation was 32°-0°-37°. The average angle of the radiocarpal joint surface was 20° on the anteroposterior radiograph and 2° in a palmar direction on the lateral radiograph. Grip strength in the fist-clenching test was 80.6% of the intact contralateral limb. The average DASH score was 23.7 points. In 8.8% of cases, arthrosis occurred, and in one case, there was a post-traumatic rupture of the long thumb extensor tendon [3]. Kamano treated 33 patients with a total of six A2, two A3, five C1, 18 C2 and three C3 fractures with non-locking compression plates situated in a palmar position. Corticocancellous bone graft was used in the case of defects. Follow-up examinations were carried out after an average of 14 months. The fractures had healed completely in all cases. There were no tendon problems. The range of motion achieved was 63°-0°-60° for bending and stretching and 73°-0°-83° for pronation and supination. The average radiocarpal joint surface angle was 24° on the anteroposterior radiograph and 1° in a palmar direction on the lateral radiograph. According to the Gartland score, 12 excellent results, 20 good results and one satisfactory result were achieved [10]. These two investigations lead to the conclusion that radius fractures can also be treated from the palmar aspect with similarly good results without tendon problems ensuing. However,

Table 1 Results of follow-up checks on patients

name	m/f	age	side	CCF	angle stable screws	follow up [mo.]	Gartland	Dash	plate position	Extension [°]	Flexion [°]	Pronation [°]	Supination [°]	Radial (°)	Ulnar (°)	Radiocarpal AP (°)	Radiocarpal lateral (°)	Shortening (mm)	Grip (%)
WM	f	72	r	23A2	3/6	19,3	14	35,00	palmar	42	35	85	75	10	32	18	3	1	60
JW	m	54	l	23A2	6/7	6,4	1	7,50	palmar	50	60	90	90	25	30	20	−10	0	80
JH	f	65	l	23A3	3/6	11,9	2	2,50	palmar	75	58	90	90	22	27	32	−10	0	95
ZE	m	32	r	23A3	3/7	9,6	5	2,50	palmar	70	60	90	90	25	30	30	−8	0	90
HK	f	47	l	23A3	5/5	22,3	2	5.00	palmar	50	50	80	80	15	15	29	−12	0	90
SJ	m	56	l	23A3	5/6	20,9	7	12,50	palmar	55	55	20	35	20	25	31	−5	0	80
SI	f	60	r	23A3	6/6	13,9	13	37,50	palmar	30	45	90	75	15	25	25	0	0	65
WE	f	53	r	23A3	4/6	13,7	1	0,83	palmar	62	82	90	90	25	35	31	−10	0	90
TW	m	46	l	23A3	4/8	10,8	9	16,66	palmar	40	30	60	60	10	15	20	0	1	65
FJ	m	36	r	23A3	5/6	10,4	0	0,16	palmar	40	65	90	90	25	45	25	−10	0	90
WJ	m	17	r	23A3	4/5	9,9	2	13,33	palmar	45	50	90	90	32	35	25	−10	0	95
KK	f	62	r	23A3	5/7	7,9	8	16,60	palmar	25	60	90	90	15	40	22	−5	0	85
SR	f	61	r	23A3	3/8	7,7	4	13,33	palmar	55	60	90	90	25	42	25	−5	0	75
HJ	m	55	l	23A3	3/6	6,9	2	2,50	palmar	60	60	85	85	25	25	30	−10	0	90
SC	m	22	r	23A3	3/6	14,3	2	2,50	palmar	60	60	90	90	25	35	30	−10	0	90
PM	f	56	r	23C1	3/6	8,6	17	25,83	palmar	12	15	90	75	12	30	15	0	1	60
DJ	m	30	l	23C1	3/7	6,4	8	15,83	palmar	45	45	70	70	15	15	17	0	0	70
ST	m	46	l	23C2	5/6	8,2	7	15,83	palmar	55	40	85	75	10	15	22	−5	0	80
OH	f	67	l	23C2	5/6	6,1	4	5,00	palmar	60	40	85	85	15	20	20	−4	0	80
HJ	m	51	l	23C2	3/6	8,1	5	25,00	palmar	60	62	80	70	20	25	20	−5	0	85
OU	m	37	l	23C2	3/6	11,6	2	7,50	palmar	75	65	90	90	25	30	25	−8	0	90
KK	f	81	l	23C2	3/6	7,7	1	2,50	palmar	55	55	80	80	30	35	20	−8	0	90
BP	m	63	r	23C2	3/7	13,9	2	10,83	palmar	55	55	85	90	25	25	20	−8	0	85
AK	m	31	r	23C2	4/8	24,1	2	7,50	palmar	50	35	80	80	20	25	20	0	0	80
BK	m	52	r	23C2	5/6	16,1	4	16,60	palmar	45	45	85	85	20	20	22	−5	0	80
AK	m	52	l	23C2	3/6	8,4	8	10,83	palmar	65	80	90	90	20	35	20	−8	0	75
AU	f	42	r	23C2	5/6	24,0	5	15,83	dorsal + bone	70	50	85	30	22	40	20	−12	0	80
SK	f	61	r	23C2	4/6	22,2	2	5,83	palmar	60	40	90	90	18	22	25	0	0	85
ZW	m	50	r	23C2	5/6	20,0	2	6,66	palmar	55	40	85	85	20	25	22	−3	0	80
WU	m	60	r	23C2	7/7	19,7	1	0,83	palmar	60	50	85	85	25	20	25	0	0	85
GA	f	74	l	23C2	3/6	18,9	2	6,66	palmar	55	65	80	80	25	28	20	−8	0	90
PT	m	29	l	23C2	4/6	16,9	8	15,83	palmar	60	60	60	50	12	25	20	0	0	80
RG	f	60	l	23C2	2/5	10,5	18	46,66	dorsal + bone	40	20	85	25	30	18	10	0	0	50
AK	m	45	l	23C2	2/6	6,5	7	12,50	palmar	55	50	85	85	20	25	15	3	0	80
FD	f	44	r	23C2	5/6	6,3	8	16,60	palmar	45	45	80	80	15	15	20	−5	0	75
VS	f	45	r	23C2	3/6	6,3	2	7,50	palmar	65	45	85	90	20	25	25	−8	0	90
NJ	f	34	r	23C2	3/6	6,1	2	6,66	palmar	55	65	90	90	25	28	20	−10	0	90
SI	m	34	l	23C2	5/6	7,5	2	5,83	palmar	60	40	85	90	18	22	25	−10	0	85
GK	f	52	r	23C2	6/8	7,0	5	10,00	palmar	45	45	75	80	15	20	18	−11	0	75
BG	m	35	l	23C3	5/6	6,3	11	33,33	palmar	40	20	60	50	10	20	15	0	1	50
									mean	**52,5**	**50,1**	**82,0**	**78,0**	20.0	26.6	22.4	−5.4	0.1	80.3
									stand.-dev.	**12,9**	**14,6**	**13,0**	**17,3**	5.9	7.8	5.0	4.5	0.3	11.3

both investigators still used corticocancellous bone grafts in the case of defects because non-locking compression implants alone are not sufficient to maintain reduction results.

By using locking compression plates, Widman was successful without using a bone graft. Forty-five patients with dislocated radius fractures of the A2 + 3 and C1–3 type were included in a prospective, randomised study. Twenty-two patients were treated by closed reduction and a fixed-angle external fixator was applied. A corticocancellous bone graft was inserted via a small dorsal incision to fill defects. Twenty-three patients were treated with a fixator only without a bone transplant. After 1 year, there was no significant difference between the two groups. Even without the graft, no significant shortening of the radius or tilting of the radio-carpal joint surface had developed [20].

In 2002, Orbay was the first to report on a larger collective of radius fractures treated from a palmar direction with locking compression plates (DVR plate, distal 2.0 mm, proximal 3.5 mm, Hand-Innovations, Miami, FL, USA). Thirty-one patients (5× A2, 12× A3, 4× C1, 7× C2 and 3× C3 fractures) were operated on. In only three cases of combined dorsal and ventral comminuted zones was a corticocancellous bone graft also inserted. Follow-up examinations were carried out on the patients after an average of 12.5 months. Solid bone healing was observed for all fractures. The average angle of the radiocarpal joint surface was 21° on the anteroposterior radiograph and showed a 5° tilt in the palmar direction on the lateral image without significant reduction losses being observed during treatment. A range of motion of 59°-0°-57° was determined during stretching and bending, of 80°-0°-78° for pronation and supination and of 17°-0°-27° during radial and ulnar deviation. Grip strength during fist clenching was 79% compared to the intact contralateral limb. According to the Gartland score, 19 excellent and 12 good results were achieved. In one case, the extensor tendons were irritated by a screw that was too long and that was removed prematurely [15]. The results correspond to our own investigations and show that when using locked compression implants in the case of a one-sided cortical defect, an additional cancellous bone graft is not necessary.

Locked compression implants are, however, linked to high costs. Thus, the locking compression small-fragment titanium plate (Synthes-Mathys, Bochum, Germany) currently costs €66.50. The costs of the plates alone are about twice those of non-locking compression plates. A combination hole in the LC plate allows a choice of using either locking compression screws that are fixed into the plate using a head thread or conventional small fragment screws. Locking compression screws are available in two different versions. The self-drilling and self-cutting screws (cost per screw €32.00) can be drilled directly into the bone, whilst the self-cutting screws (cost per screw €24.70) require pre-drilling. A normal small fragment screw, on the other hand, costs just €6.10. A complete instrument set with six self-drilling screws would thus cost €260.50 on the radius and €216.70 with self-cutting screws. Our experience has shown that it is sufficient only to use locking compression screws in the distal fragment. Normal small fragment screws can be used proximally. The costs of the instrument set can thus be reduced to €160.90. Implant removal is not routinely necessary with titanium implants. In one case, we observed an iatrogenic false aneurysm after implant removal.

Conclusion

Locking compression implants provide advantages in the treatment of distal radius fractures with metaphyseal comminuted zones (A3 and C2 fractures). Palmar-plate positioning protects the extensor tendons. In the case of mainly dorsal comminuted zones, the palmar aspect provides a good orientation for reduction. Through the angular stability of the distal screws, reduction results can be maintained until the fracture has healed. Additional bone grafts are not required in the case of a one-sided comminuted zone.

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