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Original Article

Locking Plate for AO Type C Intra-articular Distal Radius Fracture: Volar or Dorsal Approach?

以鎖定鋼板治療AO- C型橈骨遠端關節內骨折 —— 應使用掌側抑或背側入路?

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ABSTRACT

Purpose: There is controversy over the outcomes and complications of volar and dorsal plating for the treatment of intra-articular fracture distal radius.
Methods: From 2008 to 2010, 81 patients with intra-articular fracture distal radius of AO type C1–C3 treated with distal radius locking plates via volar or dorsal approaches were reviewed in our institute. The clinical, radiological, and functional outcomes were evaluated at 6 months after operation.
Results: The volar approach group showed a significantly better flexion range, flexion-extension arc as well as Green and O'Brien functional score than dorsal approach group. Volar tilting of the distal radius was significantly better in the dorsal group, but that did not contribute to better palmar–flexion range or grip strength. Overall complication rate was similar in both groups.
Conclusion: The volar approach group demonstrated better range of motion and functional score. The complication rates were similar between the two groups. The volar surgical approach should be adopted in most operative cases of AO type C intra-articular fracture distal radius while the dorsal approach should be reserved for intra-articular fracture with dorsal comminuted fragments.

中 文 摘 要

目的： 關於以鋼板內固定手術去治療橈骨遠端關節內骨折，使用掌側抑或背側入路，效果和拼發症都存有爭論。
方法： 從2008年到2010年，我們回顧研究本院的81例患者，以鎖定鋼板手術治療AO–C1到C3型橈骨遠端關節內骨折，通過掌側或背側的方法入路。在術後6個月，評估其臨床，影像學和功能結果。
結果： 對比背側入路組，掌側入路組有更好的屈曲範圍，屈伸弧度以及格林和奧布萊恩的功能評分。背側入路組雖然有較好的橈骨遠端掌側斜角，但對屈伸弧度或握力卻沒有幫助。兩組的總體併發症發生率相似。
結論： 掌側入路組有更好的活動範圍和功能評分而兩組的併發症發生率相似，所以我們認為以鎖定鋼板內固定手術治療AO–C型橈骨遠端關節內骨折的大多數病例中，應採用掌側入路，而背側入路應只用於有背側粉碎性關節內骨折的情況。

Introduction

Fracture distal radius is one of the commonest injuries in orthopaedic practice. Anatomical reduction is closely related to the functional outcomes.[1,2] Open reduction and internal fixation are gaining popularity in treating displaced intra-articular fracture of the distal radius. It is favoured over external fixation for an unstable distal radius fractures suggested by two recent meta-analyses.[3,4] Two surgical approaches have been commonly used in clinical practice. The volar approach is more frequently adopted in view of a lower chance of extensor tendon attrition. Theoretically, the volar hardware can also be covered by pronator quadratus, which in turn protects the flexor tendons. However, sporadic cases of flexor pollicis tendon rupture are still reported.[5] By contrast, the dorsal approach can provide good exposure to the articular surface, easier reduction, and fixation of dorsal comminuted fragments. Biomechanically, dorsal plating was found to be stiffer and stronger than volar plating,[6] which could be an advantage in osteoporotic bone.

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There is to date no conclusion as to which approach yields better functional outcome. Rein et al[7] and Chou et al[8] found that both volar and dorsal approaches showed comparable functional and radiological outcomes, while Ruch et al[9] and Jakubietz et al[10] found that volar plating offered better functional outcomes than dorsal plating. These studies showed that complications were more common in the dorsal plating group.

In view of the controversial results, we aim at throwing more light on this by evaluating the clinical and radiological outcomes on our patients with AO type C intra-articular fracture of the distal radius treated operatively via either volar or dorsal approaches.

Methods

From 2008 to 2010, all patients with AO type C intra-articular distal radius fractures in our trauma centre treated with dorsal or volar plating were reviewed. Data were retrieved from electronic patient records, outpatient clinic records, and physiotherapy and occupational therapy progress records. Classification of fracture pattern was defined according to the Müller AO Classification of fracture distal radius.[11] Only types C1–C3 complete intra-articular fractures were included in this study. Patients with incomplete data, premature dropout from follow-up assessment prior to maximal medical improvement, combined volar and dorsal approaches, open fracture, and concomitant ipsilateral upper limb fracture or dislocation were excluded.

The patients had first been treated by closed reduction and temporary immobilization with a cast or slab. They were then scheduled for operations later. During operation, the fractures were screened under general or regional anaesthesia for alignment and their characteristics. The decision of surgical approach was subject to: (1) preoperative radiography and/or computed tomography CT scan assessment; (2) fracture alignment after closed reduction; (3) irreducible dorsal comminution; and (4) surgeon preference (Figure 1).

A total of 81 patients were recruited with a mean age of 49.2 years. Fifty patients were male and 31 patients were female. The average length of follow-up was 6.34 months. There were 60 cases of AO type C1 fractures, 17 C2 fractures, and four C3 fractures. Among them, 39 patients were treated via volar the approach by applying either a 2.4-mm or 3.5-mm fixed angle locking compression plate (Synthes, Switzerland) depending on the size of fragments and feasibility. Forty-two patients were treated via the dorsal approach using a 2.4-mm two-column fixed angle locking compression plate.

The preoperative radiographs were reviewed for fracture classification and associated injuries were recorded. The postoperative radiographs at the time of maximal medical improvement were reviewed for articular congruity, palmer–dorsal tilting, and ulnar variance.

The clinical outcomes were assessed at the time of maximal medical improvement. Objective assessment includes the range of wrist motion and grip strength with the comparison of contralateral noninjured side. The functional outcomes were evaluated using the modified Green and O'Brien score.[12] Scores were graded as follows: 90–100 was excellent, 80–89 was good, 65–79 was fair, and < 65 was poor. Complications were identified and graded according to the complication checklist proposed by McKay et al.[13]

Surgical techniques

In the volar plating group (Figure 2), a conventional Henry approach was adopted. A longitudinal volar incision was made just radial for flexor carpi radialis. A surgical plane was then developed between the radial artery and flexor carpi radialis with the artery

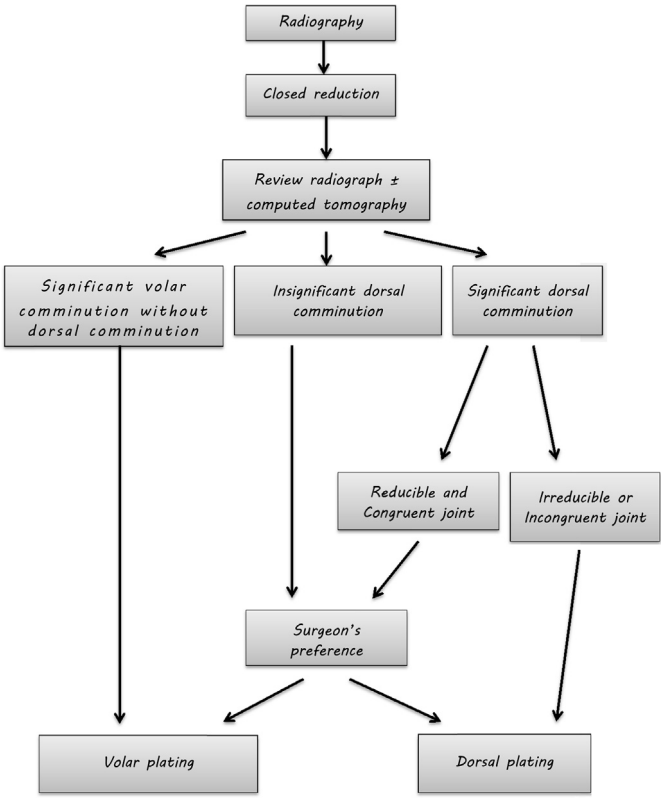

Figure 1. Algorithm for surgical approach selection.

well protected. The pronator quadratus was then exposed and incised along the radial border, thereby reflecting the muscle ulnarly and exposing the fracture site. Reduction was performed under X-ray control. Temporary fixation with K-wires by intra- or extrafocal technique might be required particularly for the dorsal or radial fragment. A 2.4-mm or 3.5-mm T-shaped fixed angle volar locking plate was then applied volarly depending on the size of bone fragments and fracture configuration.

In the dorsal plating group (Figure 3), a longitudinal dorsal incision was made just ulnar to Lister's tubercle. The third extensor compartment was opened to expose the extensor pollicis longus tendon by fashioning an incision over the extensor retinaculum to facilitate subsequent pulley reconstruction. Adjacent extensor compartments were elevated from the fracture site without exposing other extensor tendons. An optional window between the first and second compartments was opened to facilitate radial column plate insertion. Reduction was performed under X-ray control. Temporary fixation with K-wires might be used. A 2.4-mm dorsal column locking plate and a radial column plate were then applied as buttress or for fragment stabilization at 90–90° orientation to each other. Half of extensor retinaculum was then repaired and placed between the plate and the extensor tendons to avoid plate attrition to extensor tendons. And the remaining half was repaired for the tendon pulley.

In both groups after the plate was applied, radiographs were obtained to confirm the appropriate position of the plate, screw length, adequacy of fracture reduction, and joint congruity. A tilted lateral view at 22° was obtained to confirm absence of intra-articular screw penetration.[14]

Postoperatively, the patients were allowed to have free active mobilization of their fingers and wrist. Stitches were taken off on postoperative Days 10–14. The patients then started to have physiotherapy and/or occupational therapy until they reached maximal medical improvement.

Figure 2. Radiographs of volar plating group.

Results

The variables were evaluated using Chi-square test and Mann–Whitney *U* test, and the rate of complications was evaluated using Fisher's exact test. Variables were recorded as mean ± standard deviation. Statistical significance was taken as $p < 0.05$.

Concerning the demographic data (Table 1), there was no statistically significant difference between volar and dorsal groups in terms of age, sex, dominance, injury on duty, duration before surgery, length of stay, and fracture type (Table 2). The operation time was statistically significantly shorter in the volar group (86.05 ± 24.57 minutes) than in the dorsal group (121.02 ± 38.74 minutes). The radiological outcome is shown in Table 3. There was a statistically significant difference in the volar tilting angle between the volar group (1.13 ± 8.65°) and the dorsal group (5.96 ± 7.80°). No significant difference was obtained in ulnar variance between the volar group (1.03 ± 1.74 mm) and dorsal group (1.18 ± 1.76 mm). Frequency of intra-articular stepping was similar in both groups.

The clinical results are shown in Table 4. The volar group demonstrated a statistically significant better flexion (65.85 ± 20.86° versus 57.38 ± 19.36°, $p = 0.028$) and flexion–extension arc (132.38 ± 38.00° versus 116.79 ± 31.91°, $p = 0.030$) compared with the dorsal group. There was no statistically significant difference in extension, supination, pronation, or grip strength between the two groups.

Figure 3. Radiographs of dorsal plating group.

The functional results are shown in Table 5 and Figure 4. Modified Green and O'Brien score was used to classify the final outcome. This consists of four components including pain, function regarding ability of return to work, flexion–extension motion, and

Table 1
The demographic data of the study population

		Volar group ($n = 39$)	Dorsal group ($n = 42$)	p
Age		50.62	47.88	0.49
Sex	Female	17	14	0.34
	Male	22	28	
Dominance	Yes	22	16	0.10
	No	17	26	
Injury on duty	Yes	10	15	0.41
	No	29	27	
Days before surgery		7.59 ± 5.28	8.21 ± 3.44	0.11
Operation duration (min)		86.05 ± 24.57	121.02 ± 38.74	< ***0.0001***
Admission duration (d)		3.15 ± 2.07	2.67 ± 1.37	0.39

Statistically significant p values are indicated in bold and italics ($p < 0.05$).

Table 2
The distribution of fracture types (Müller AO classification)

	Volar group	Dorsal group	p
C1	27	33	0.46
C2	9	8	
C3	3	1	

Table 3
Radiological results

	Volar group	Dorsal group	p
Volar tilting (°)	1.13 ± 8.65	5.96 ± 7.80	***0.013***
Ulnar variance (mm)	1.03 ± 1.74	1.18 ± 1.76	0.467
Intra-articular stepping > 1 mm	7	6	0.201

Statistically significant p values are indicated in bold and italics ($p < 0.05$).

Table 4
Clinical outcomes

	Volar group	Dorsal group	*p*
Flexion (°)	65.85 ± 20.86	57.38 ± 19.36	***0.028***
Extension (°)	66.54 ± 19.47	59.40 ± 18.52	0.073
Flexion-extension arc (°)	132.38 ± 38.00	116.79 ± 31.91	***0.030***
Pronation (°)	83.33 ± 13.83	82.02 ± 10.88	0.274
Supination (°)	85.90 ± 7.853	80.64 ± 19.14	0.209
Grip strength (%)*	68.71 ± 13.50	59.00 ± 30.40	0.265

Statistically significant *p* values are indicated in bold and italics ($p < 0.05$).
* Compared with contralateral normal side.

Table 5
The modified Green and O'Brien scores of both groups

	Volar group	Dorsal group	*p*
Pain	21.67 ± 4.64	20.36 ± 4.47	0.069
Work	20.13 ± 5.68	21.31 ± 5.53	0.260
Motion	21.41 ± 6.17	18.45 ± 6.20	***0.021***
Grip	11.67 ± 3.31	10.00 ± 4.80	0.062
Total	74.62 ± 10.28	69.38 ± 11.33	***0.038***

Statistically significant *p* values are indicated in bold and italics ($p < 0.05$).

grip strength. Pain score, work score, and grip score were similar in both groups. The range score was significantly better in the volar group (21.41 ± 6.17) than the dorsal group (18.45 ± 6.20). The total score was 74.62 ± 10.28 in the volar group and 69.38 ± 11.33 in the dorsal group, with the volar group showing overall significant better score.

The complications are shown in Table 6. Ten of 39 patients in the volar group and eight of 42 patients in the dorsal group were reported to have complications.

In the volar group: four patients were reported to have hypertrophic scar; three patients were noted to have median neuropathy and they were treated successfully with conservative management; one patient was found to have numbness along the dorsal cutaneous branch of the ulna nerve confirmed by nerve conduction test; one patient was noted to have intra-articular screw penetration requiring removal of the implant; one case with dorsal comminuted fragment was noted to have early loss of reduction 2 months postoperatively; and one patient had ulna impaction with positive ulna variance of 4.3 mm. Ulna shortening osteotomy was done after the fracture had healed with good improvement of ulna wrist pain and range of movement.

In the dorsal group: one patient was reported to have hypertrophic scar and two median neuropathy; two patients were noted to have reflex sympathetic dystrophy; two patients were found to have delayed extensor pollicis longus rupture (extensor indicis tendon transfer was done in 1 patient and the other patient was

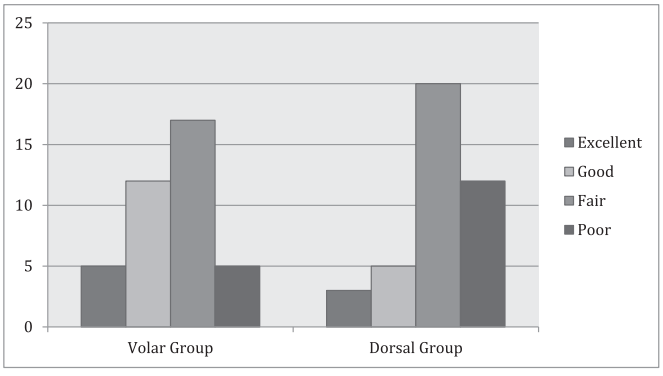

Figure 4. The outcome measured by modified Green and O'Brien scores of both groups.

Table 6
The complications of both groups

	Volar group	Dorsal group
Scar hypertrophy	4	1
Median neuropathy	3	2
Reflex sympathetic dystrophy	0	2
Dorsal cutaneous branch of ulna nerve	1	0
Intra-articular screw	1	0
EPL rupture	0	2
Ulna impaction	1	0
Rotational stiffness	0	1

EPL = extensor pollicis longus.

treated conservatively); and rotational stiffness was noted in one patient who had Sauve Kapandji procedure done later.

Wound complication and reflex sympathetic dystrophy are thought to be independent of surgical approaches. Median neuropathy in the dorsal group was probably a sequela of the fracture itself rather than the dorsal approach. The rate of complications in both groups was similar.

According to McKay classification,[13] the score was 0.38 ± 0.78 in the volar group and 0.31 ± 0.81 in the dorsal group. There was no statistically difference in the complication scores between both groups.

Discussion

The results of this study showed that the volar group demonstrated better outcomes than the dorsal group, while complications were comparable in both groups. The volar approach was advocated because of satisfactory reduction, good functional outcomes, and less risk of extensor tendon complication.[15,16] Our results support the use of volar plating with the advantages of good soft tissue coverage over the metal implants, no risk of extensor tendon complication, shorter operation time, and satisfactory clinical and radiological outcomes. In addition, it demonstrated a similar complication rate compared with the dorsal group. Three patients in the volar group (7.7%) were found to have postoperative median neuropathy. Ho et al[17] found that the local incidence of median neuropathy after volar plating was 5.3%, and that of carpal tunnel syndrome was 3.2%.

Median nerve neuropathy has been postulated to be the result of scarring in the forearm surgical wound or retractor injury during surgery. Different causes of carpal tunnel syndrome have been postulated such as local oedema, fracture hematoma, closed reduction, and manipulation. There has been controversy over prophylactic carpal tunnel release at the time of volar plating. Fuller et al[18] demonstrated pressure within the carpal tunnel after volar plating was below the threshold pressure level for median nerve injury and therefore routine carpal tunnel release was not suggested. On the contrary, Gwathmey et al[19] advocated routine carpal tunnel release because it is a safe procedure and reported to have low incidence of delayed median nerve dysfunction in their series (2.9%). We did not routinely release the carpal tunnel but would perform carpal tunnel release and median nerve neurolysis if significant median neuropathy arises. One patient of the volar group was found to have dysfunction in the dorsal cutaneous branch of the ulna nerve, which is actually more common in the dorsal approach. Possible hypotheses included impingement by cast before surgery, nerve injury during closed reduction, or damage from the percutaneous K wire during temporary fixation during surgery.

In the dorsal group, there were two cases of median neuropathy. We believe that the cases were the sequela of fracture displacement or pressure from haematoma rather than the result of dorsal surgical approach. There were two cases of extensor pollicis longus tendon (EPL) rupture. EPL rupture is a well-known complication of

fracture distal radius even without the operation. The incidence ranged from 0.2% to 5%,[20] an average of 6.6 weeks after the fracture. Multiple series have found the rate of extensor tendon irritation or rupture after dorsal plating to be 0–14.3%.[7–10,21,22] Our rate of EPL rupture was 4.7%, which was comparable with nonoperative incidence. Closure of extensor retinaculum over the dorsal plate to prevent attrition of the plate to the extensor tendons may be useful.

The dorsal approach enables surgeons to visualize directly the articular surface for reduction,[21] easily fix and approach the dorsally displaced comminuted fragment, which may otherwise be irreducible by the volar approach.[8] Biomechanically,[6] dorsal plating was found to offer greater stability and higher load to failure than volar plating, especially in elderly patients with osteoporosis.

In this study, the volar group demonstrated a shorter operative time, and better range of motion and functional outcomes compared with the dorsal group. The complications were comparable between the two groups. We would suggest adopting the volar approach in treating AO type C intra-articular fracture of the distal radius without dorsally comminuted and displaced fragments. However, fear of extensor tendon complication should not prohibit one from using the dorsal approach, which is valuable in reducing the dorsal comminuted fragment. We believe that extensor tendon complications can be prevented with dedicated extensor retinaculum coverage.

There were limitations in this study because it was a retrospective study with data collected from patient's records only. Some patients were excluded due to inadequate data. A prospective randomised study with detailed data collection would provide a thorough assessment and evaluation of outcomes. Another weakness was lack of long-term follow-up evaluation, although maximal medical improvement as determined by physiotherapist and occupational therapist have been achieved. Long-term functional results and subsequent post-traumatic osteoarthritic evaluation were not available. Finally, the operations were done by different surgeons, so interpersonal variation could not be excluded.

Conflicts of interest

The authors declare that they have no financial or non-financial conflicts of interest related to the subject matter or materials discussed in the manuscript.

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