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Original Article

Compare the clinical efficacy of internal fixation with locking plates by the henry approach and minimally invasive palmar midline approach on AO-C type distal radius fracture

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Abstract: Objective: This study aimed to compare the clinical efficacy of internal fixation with locking plates by the Henry approach and the minimally invasive palmar midline approach on AO-C type distal radius fracture. Methods: All together 105 patients with AO-C type distal radius fracture in our hospital from March 2015 to May 2018 were retrospectively analyzed and divided into the Group A (GA, Henry approach) and the Group B (GB, minimally invasive palmar midline approach). The two groups were compared for surgical indices, fracture healing time, ulnar inclination, radial inclination, radial height, active wrist joint range of motion, VAS score, Gartland-Werley score of wrist joint, and incidence of complications. Results: (1) Smaller incision, shorter fracture healing time, larger supination, pronation, palmar flexion and back extension, and lower VAS score at 3 months after the surgery were observed in the GB ($P<0.05$). (2) No significant difference was found between the two groups in terms of operation time, intraoperative blood loss, ulnar inclination, radial inclination and radial height at 3 d and 3 months after the surgery ($P>0.05$). (3) The rate of good and excellence of wrist joint function, and the incidence of complications were 86.79% and 3.85% in the GA; and 82.69% and 1.89% in the GB ($P>0.05$). Conclusion: Both surgical approaches are effective with AO-C type distal radius fracture, but the minimally invasive palmar midline approach is more advantageous based on a small incision, short fracture healing time, mitigated pain intensity and improved active wrist joint range of motion.

Keywords: Henry approach, minimally invasive palmar midline approach, internal fixation with locking plates, AO-C type, distal radius fracture

Introduction

With a high incidence, distal radius fracture often happens within 3 cm of the radial-wrist joint plane where compact bone and cancellous bone are in transition, resulting in low stress [1]. At present, operative-reduction-based external fixation technique is usually adopted according to the fracture displacement. Though ideal effects are achieved with most of the simple radius fractures, fracture end displacement is often expected as the radius-wrist articular surface is susceptible to injury, which further affects the radius-wrist articular surface [2, 3]. Therefore, surgery is usually selected for complicated distal radius fracture.

Clinically, distal radius fracture falls into diversified types, including Barton, and Smith and Colles based on the fracture displacement direction. However, this typing fails to reflect the processus styloideus ulnae injury and the relationship of facies articularis ossium, and is not suggested for surgical treatment [4, 5]. Presently, with more medical studies and upgraded digital and imaging techniques, the typing of distal radius fracture is more detailed, including digitalized, Melone, Doi, and AO/ASIF; of which, AO tying is frequently adopted [6]. According to AO typing, distal radius fracture falls into A, B and C types, and are further divided into the Group 1, Group 2, Group 2 and the Sub-group referring to the fracture severity. The

AO-C type is more common [7, 8]. Resection and reduction based palmar internal fixation with locking plates is usually employed clinically to treat AO-C type distal radius fracture, but the regular standard approach requires incising the pronator quadratus and extensively dissecting the surrounding soft tissues, resulting in a high possibility of damaging the blood supply around the fracture and disadvantages the fracture healing [9, 10]. In recent years, minimal invasion has been extensively applied in trauma orthopedics, and in the treatment of AO-C type distal radius fracture [11]. In view of this, in order to improve the therapeutic effect of AO-C type distal radius fractures, this study adopted a minimally invasive palmar midline approach in the treatment, and compared its therapeutic effect with the traditional and classical Henry approach, which has certain innovation and feasibility.

Materials and methods

Materials

A total of 105 patients with AO-C type distal radius fracture in our hospital from March 2015 to May 2018 were divided into the Group A (GA, n=52, Henry approach) and the Group B (GB, n=53, minimally invasive palmar midline approach) and retrospectively analyzed. (1) Inclusion criteria: informed consent from patients; no surgical contradictions; fresh closed fracture; AO-C type fracture; approval from the Medical Ethics Committee. (2) Exclusion criteria: complicated with several internal diseases; not tolerant to surgery; poor skin conditions at the wrist not fitting for a surgery; AO-A and B type fractures; old fracture; open fracture.

Methods

GA: patients positioned at the dorsal decubitus for brachial plexus or general anesthesia. The affected limb was outwardly opened and a 7 cm palmar Henry incision was made, during which, pneumatic tourniquets were applied. The entry approach was through the gap between the radial artery and the flexor carpi radialis muscle tendon. In such a process, radial artery was effectively protected. The pronator quadratus was vertically incised to sufficiently expose the fracture end, where incarcerated soft tissues and extravasated blood were thoroughly cleaned. After reduction at euthyphoria, the fracture end was internally fixed with palmar locking plates, and after repairing the pronator quadratus, the incision was sutured.

GB: patients were positioned at the dorsal decubitus for brachial plexus or general anesthesia. The affected limb was outwardly unfolded and a vertical incision of 2 cm was respectively formed at the proximal end of waist palmar side close to rasceta, and the distal end, between which a distance of 2-3 cm remained. The entry approach was the gap between the cubitalis gracilis tendon and the flexor carpi radialis muscle tendon. The method of tunneling stripping by periosteum detacher was used under the pronator quadratus to fully expose the fracture end, which was temporarily fixed with steel needles (1.5 mm) after removal of incarcerated soft tissues and extravasated blood, and reduction; locking plates were inserted beneath the pronator quadratus and to the palmar side at the distal end of radius. The distance between the distal end of the steel plate and the articular surface was controlled between 2 and 3 mm, while the proximal end of the steel plate was located in the middle of the radius. A common nail was inserted into the movable hole at the proximal end. The position of locking plate and the reduction effects were identified on a C-arm X-ray machine. Afterward, other nails were screwed in at the specific sequence; in case of larger bones, the adjunctive therapy of intradermic fixation with steel needles extracorporally were adopted; in case of obvious bone defect, artificial bone or autogenous iliac bone grafting was adopted; the steps in the next were hematischesis, rinsing, incision suturing, and placement of drainage strips as a general practice after the surgery.

Observation Indices

Surgical indices were compared between the two groups.

Fracture healing time was compared between the two groups according to the following healing criteria [12]: With the external fixation removed, the upper extremities could lift an object of 1 kg to the shoulder and maintain for several minutes; no abnormal local movement or tenderness and pain upon vertical percussion exist; the fracture line is blurred in the

Table 1. Intergroup comparison of general materials [n (%)]/($\bar{x}\pm s$)

Materials		GA (n=52)	GB (n=53)	t/X^2	*P*
Gender (n)	Male	33 (63.46)	35 (66.04)	0.076	0.782
	Female	19 (36.54)	18 (33.96)		
Age (y)		61.25±2.52	61.28±2.49	0.061	0.951
Fracture AO type					
C1		22 (42.31)	20 (37.74)	0.128	0.967
C2		18 (34.62)	21 (39.62)		
C3		12 (23.08)	12 (22.64)		
Cause					
Traffic accident		19 (36.54)	21 (39.62)	0.158	0.998
Fall from heights		20 (38.46)	22 (41.51)		
Other		13 (25.00)	10 (18.87)		

X-ray examination, and passed by continuous poroma; the fracture is not deformed after 2 weeks of observation. When those conditions are satisfied, on the first day is defined as the clinical fracture healing date.

The waist joint was frontally photographed with an X-ray machine at 3 d and 3 months after the surgery to measure the ulnar inclination, radial inclination and radial height.

Active wrist joint range of motion: the subjective motion of waist joint at 3 months after the surgery was compared between the two groups, including supination, pronation, palmar flexion and back extension.

VAS [13]: at 3 months after the surgery, all patients evaluated their pain intensity with the VAS. The total score ranges between 0 and 10. Zero indicates no pain and 10 the worst possible pain.

Gartland-Werley score of wrist joint [14, 15]: at 3 months after the surgery, the Gartland-Werley point system was used to evaluate the waist joint function of all patients from perspectives of complications, residual deformity, objective and subjective evaluation. The waist joint function was rated as excellent (0-2), good (3-8), moderate (9-20) and poor (>20).

The incidence of complications was compared between the two groups.

Statistical analysis

Statistical analysis was performed with SPSS 22.0. In case of numerical data expressed as Mean ± Standard Deviation, comparison studies were carried out through *t* test for data which were normally distributed, and Mann-Whitney U test for data which were not normally distributed. In case of nominal data expressed as [n (%)], comparison studies were carried out through chi-squared test for intergroup comparison. For all statistical comparisons, significance was defined as $P<0.05$.

Results

Intergroup comparison of general data

Statistical difference was not found between the two groups in terms of gender, age, number of patients with AO-C1, AO-C2 and AO-C3 fractures, as well as causes of fracture (traffic accident, fall from heights, other) ($P>0.05$) (**Table 1**).

Intergroup comparison of surgical indices

The length of incision was (3.02±0.25) cm in the GB, which was shorter than that of (7.58±0.65) cm in the GA, showing significant difference ($P<0.05$). The operation time and intraoperative blood loss were (72.15±1.25) min and (28.15±0.25) ml in the GA, and (68.98±1.32) min and 27.16±0.28) ml in the GB, showing no significant difference ($P>0.05$) (**Figure 1**).

Intergroup comparison of fracture healing time

Patients in the GB required (10.02±0.28) weeks for fracture healing, which was shorter than that of (15.63±2.15) weeks in the GA, showing a significant difference ($P<0.05$) (**Table 2**).

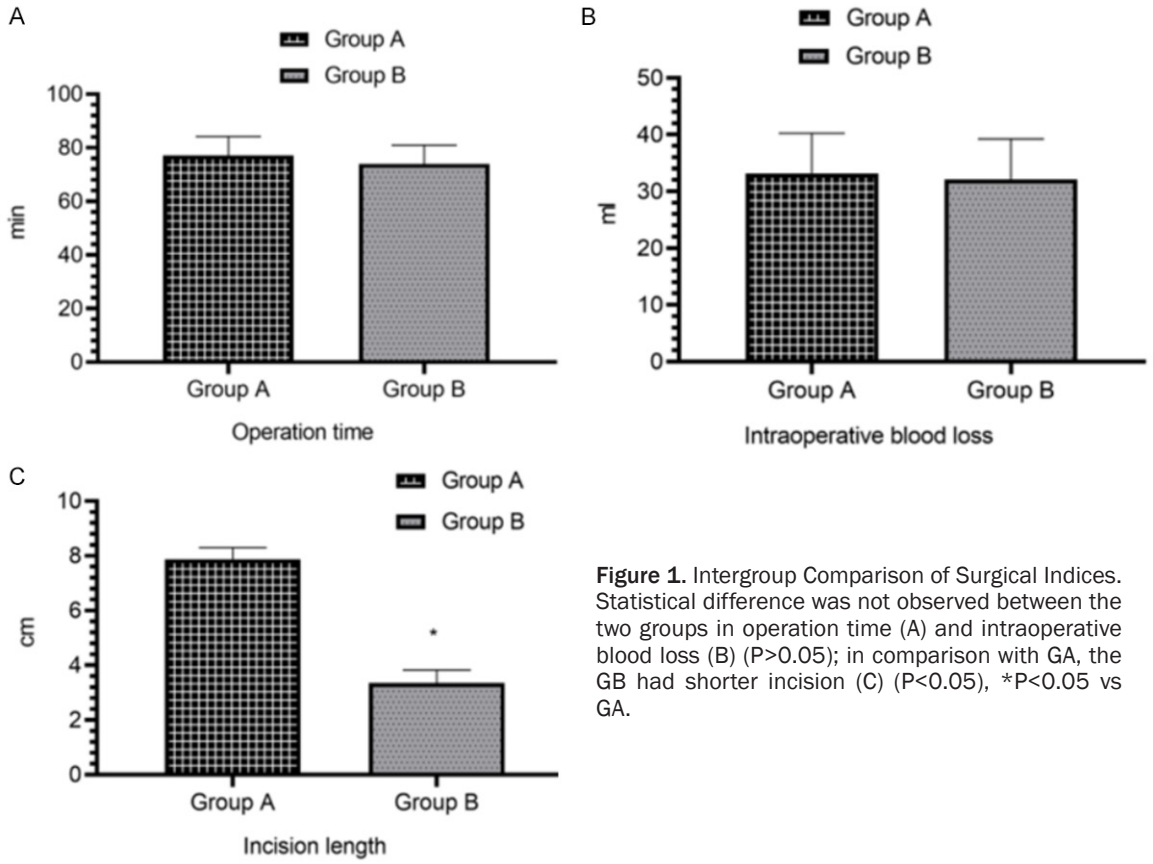

Figure 1. Intergroup Comparison of Surgical Indices. Statistical difference was not observed between the two groups in operation time (A) and intraoperative blood loss (B) (P>0.05); in comparison with GA, the GB had shorter incision (C) (P<0.05), *P<0.05 vs GA.

Table 2. Intergroup comparison of fracture healing time ($\bar{x}$±s, week)

Group	Fracture healing time
GA (n=52)	15.63±2.15
GB (n=53)	10.02±0.28*
T	18.836
P	0.000

Note: *P<0.0 vs GA.

Intergroup comparison of ulnar inclination, radial inclination and radial height

No intragroup or intergroup significant difference in ulnar inclination, radial inclination, and radial height was observed in or between the two groups at 3 d and 3 months after the surgery (P>0.05) (**Table 3**).

Intergroup comparison of active wrist joint range of motion

At 3 months after the surgery, the wrist joint range of motion was better in the GB, including supination, pronation, palmar flexion and back extension (P<0.05) (**Figure 2**).

Intergroup comparison of VAS score

The VAS score of the GB at 3 months after the surgery was lower as compared with the GA's (P<0.05) (**Figure 3**).

Intergroup comparison of wrist joint function

At 3 months after the surgery, the number of patients with excellent, good, moderate and poor wrist joint function was 31, 15, 3 and 4 in the GB; and 29, 14, 5 and 4 in the GA (P>0.05). The excellent and good rate was 86.79% in the GB, and 82.69% in the GA (P>0.05) (**Table 4**).

Intergroup comparison of complications

The number of patients reporting median nerve irritation, thenar eminence numbness and flexor carpi radialis muscle tendon inflammation was 0, 1, 1 in the GA (3.85%); and 1, 0 and 0 in the GB (1.89%) (P>0.05) (**Table 5**).

Table 3. Intergroup comparison of ulnar inclination, radial inclination and radial height ($\bar{x}\pm s$)

Group	3 d after the surgery			3 months after the surgery		
	Ulnar inclination (°)	Radial inclination (°)	Radial height (mm)	Ulnar inclination (°)	Radial inclination (°)	Radial height (mm)
GA	21.62±3.12	12.25±2.18	11.65±2.15	21.12±2.15	12.16±1.28	11.23±1.28
GB	21.65±3.09	12.28±2.12	11.69±2.12	21.15±2.09	12.13±1.22	11.28±1.22
t	0.050	0.071	0.096	0.073	0.123	0.205
P	0.961	0.943	0.924	0.942	0.902	0.834

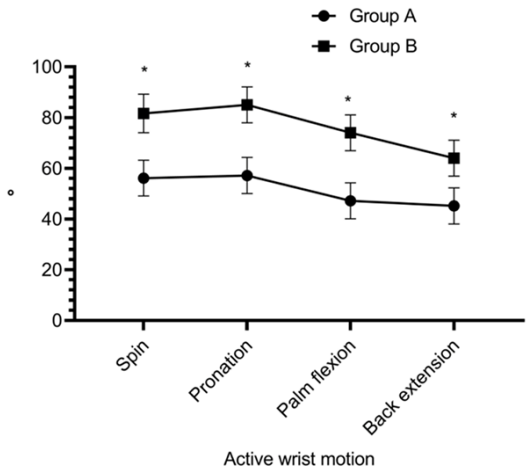

Figure 2. Intergroup Comparison of Active Wrist Joint Range of Motion. At 3 months after the surgery, the supination, pronation, palmar flexion and back extension were larger in the GB (P<0.05). *P<0.05 vs GA.

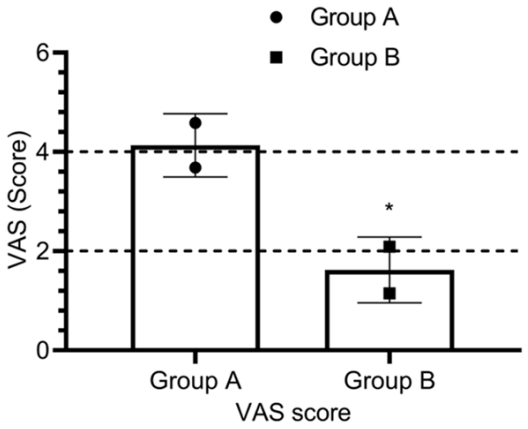

Figure 3. Intergroup comparison of VAS score. At 3 months after the surgery, the VAS score was lower in the GB (P<0.05). *P<0.05 vs GA.

Discussion

The aged are more susceptible to distal radius fracture, including the most serious AO-C type defined as complete intra-articular fracture [16]. According to previous clinical practice, distal radius fracture was usually treated by plantlets, gypsum, and manipulative reduction. However, the effects of reduction and fixation are hardly maintained, and wrist joint dysfunction may be observed in some patients [17, 18]. Resection and reduction based palmar internal fixation with locking plates is a commonly adopted fixation mode to obtain firm fixation, anatomical reduction, low postoperative incidence of complications and early recovery of functional exercise [19, 20]. Although the application effect of this fixation is ideal, the effect of different fixation methods on fracture healing varies [21]. In the past, the conventional Henry approach was usually used, but it was necessary to cut the pronator quadratus open and remove the local soft tissue extensively, which caused damage to the local blood supply, and then affected the fracture healing effect [22, 23]. To this end, this study attempted to adopt minimally invasive palmar midline approach, and compared its effect with that of conventional Henry approach.

According to the study results, the two groups had no significant difference in operation time, intraoperative blood loss, ulnar inclination, radial inclination, radial height at 3 d and 3 months after the surgery, excellent and good rate of wrist joint, as well as incidence of complications (P>0.05), indicating that both approaches could effectively reduce the AO-C type distal radius fracture by providing firm fixation, maintain fracture reduction effects, improve wrist joint function, reduce the incidence of complications and elevate the surgical safety. However, the results of this study also revealed that compared with GA, GB required a shorter fracture healing time (P<0.05), which means the minimally invasive palmar midline approach, when compared with

Table 4. Intergroup comparison of wrist joint function

Group	Case	Excellent	Good	Moderate	Poor	Excellent + good
GA	52	29 (55.77)	14 (26.92)	5 (9.62)	4 (7.69)	43 (82.69)
GB	53	31 (58.49)	15 (28.31)	3 (5.66)	4 (7.55)	46 (86.79)
X^2						0.342
P						0.559

Table 5. Intergroup comparison of incidence of complications [n (%)]

Group	N	Median nerve irritation	Thenar eminence numbness	Flexor carpi radialis muscle tendon inflammation	Total incidence
GA	52	0 (0.00)	1 (1.92)	1 (1.92)	2 (3.85)
GB	53	1 (1.89)	0 (0.00)	0 (0.00)	1 (1.89)
X^2					0.363
P					0.547

the Henry approach, could shorten the postoperative fracture healing time. The possible mechanism may be that this approach selects the gap between the cubitalis gracilis tendon and flexor carpi radialis muscle tendon, where the tissue layers are distinct and highly identifiable. The incision is located close to the center of the palmar side, in order to easily expose the broken ends of fractured bone. In contrast, the conventional Henry approach requires traction of the flexor carpi radialis muscle tendon from the radialis side to the ulnar side [24]. From another perspective, in the minimally invasive palmar midline approach, the location of the incision facilitates the placement of steel plates in the middle so as to support the distal middle column of forearm and radial column, while in the Henry approach, the steel plate has a high possibility of deflecting to radialis source and demands repeated adjustment [25]; other advantages of the first approach are reservation of the whole pronator quadratus, and protection of the fracture end blood flow. For those reasons, the postoperative fracture healing time was shortened in this approach. Some scholars believed that the retention of pronator quadratus in the surgery could promote the postoperative recovery, reduce the postoperative VAS score and improve the dysfunction of upper limbs, whereas others insisted on its removal since the pronation function was dominated by the pronator teres. Referring to the results of this study, at 3 months after the surgery, the supination, pronation, palmar flexion and back extension were larger and the VAS score was lower in the GB ($P<0.05$). The significant differences are evidence that the minimally invasive palmar midline approach is beneficial to the improvement of wrist joint range of motion and mitigation of pain intensity. Henceforth, it is necessary to remain the pronator quadratus. An exploration of its underlying mechanism found that during the internal fixation with locking plates by minimally invasive palmar midline approach, blunt dissection was performed along the fibers so that the integrity of pronator quadratus was ensured and the fracture was anatomically reduced [26]. Secondly, a flat articular surface is good for the early movement of distal radioulnar joint, reduction of blood clots and local tissue edema, and maximal recovery of the wrist joint function. Though the minimally invasive palmar midline approach is ideal in AO-C type distal radius fracture, attention needs to be paid to the surgical indications and contradictions. Before the surgery, wrist joints shall be examined by CT 3D reconstruction and X-ray imaging, and after the surgery, the affected limb shall be shortly fixed with plaster slabs and elevated to reduce pains and mitigate edema.

In conclusion, both the Henry approach and the minimally invasive palmar midline approach are effective with AO-C type distal radius fracture, but the latter is more advantageous with small incision, short fracture healing time, mitigated pain intensity and improved active wrist joint range of motion.

However, the number of samples was limited and the results were not representative enough

in this study. Future studies shall be based on more aspects, large sample size and longer duration.

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Disclosure of conflict of interest

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