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Comparison study of the clinical effect and biomechanics between locking compression plate and interlocking intramedullary nail for humerus shaft fracture.

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Abstract

Objective: To compare and discuss the clinical effect and biomechanics between locking compression plate and interlocking intramedullary nail for treatment of humerus shaft fracture.

Methods: 112 cases of patients with humerus shaft fracture were selected and divided into the locking compression plate group (LCP group) with 58 patients and the interlocking intramedullary nail group (IIN group) with 54 patients. The different operation time, bleeding volume, the length of stay after operation, healing time, difference of complication and shoulder joint dysfunction were made a comparison between the LCP group and IIN group.

Results: The operation time of patients in IIN group was (77.17 ± 15.46) min, which was shorter than that of LCP group (97.20 ± 30.06) min, $p<0.05$; the bleeding volume of patients in IIN group was (110.59 ± 50.34) ml, which was significantly less than that in LCP group, $p<0.01$. Besides, in IIN group there were 4 patients (7.41%) with the acromion injury, which was not seen in LCP group ($p<0.05$). However, in IIN group there were 6 patients (11.11%) with the radial nerve palsy, which was not seen in IIN group ($p<0.05$). Compared with patients in IIN group, the recovery of shoulder joint function was due to the plate ($p<0.05$).

Conclusion: The operation time, intraoperative blood loss, and the rate of radial nerve palsy of patients in IIN group are superior to these in LCP group, which is more aligned with modern orthopaedic advocated by the "Biological Osteosynthesis" principle.

Keywords: Humerus shaft fracture, Locking compression plate, Interlocking intramedullary nail, Biological osteosynthesis principle, Clinical effect.

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Introduction

Humerus shaft fracture refers to that located between 2 cm to humerus surgical neck and 2 cm to humerus epicondyle in general, which mainly happens in 20-40 y old males, as well as elderly population (>60 y old) [1,2]. For patients with open fracture, pathological fracture, and fractures with radial nerve injury, operation should be the first choice including open reduction and internal fixation, closed reduction and external fixation, plate fixation, and intramedullary nail fixation etc., among which humerus locking compression plate can better control the rotation, separation, and angulation of humerus [3-6]. However, locking compression plate needs a long operation time and large exposed area and causes heavier periosteum injury, even neurovascular injury [7]. Compared with it, interlocking intramedullary nail, which belongs to axis fixation with small size of incision, pills and damages a little soft tissue and has a lower risk of deep neurovascular injury, but patients, will have joint movement limitation accompanied by pain and foreign body sensation after surgery [8].

Both of these two treatments have their own advantages and disadvantages. But which one is more aligned with the widely accepted theory of "Biological Osteosynthesis" in the recent years? This study retrospectively analyses 112 cases with humerus shaft fracture, and contrastively analyses their clinical effect and biomechanics, aiming to give reliable suggestions in the selection of therapeutic scheme for humerus shaft fracture.

Materials and Methods

Clinical data of patients

112 cases with humerus shaft fracture diagnosed and preformed operations in our hospital from Jan 2015 to Oct 2016 were randomly selected in this study, male 78, female 34,

age ranged from 18 to 44, 30.3 ± 3.7 years in average. 60 cases suffered from left humerus shaft fracture, and 52 had right humerus shaft fracture. Among them, 58 cases underwent locking compression plate (LCP group), 54 received interlocking intramedullary nail (IIN group). All cases were closed fracture verified by imaging. Compared the data of two groups, there was no difference, which was comparable (Table 1).

Table 1. *Comparison on the data of two groups.*

General data	LCP group	IIN group	Statistic (t/X^2)	P
Number of patients (case)	58	54	0.4413	0.1881
Age (year)	18-44	20-41	0.732	0.4361
Mean age (year)	30.5 ± 5.4	30.9 ± 3.7	0.2872	0.0776
Sex				
Male (case)	38 (65.52%)	40 (74.07%)	0.1974	0.0671
Female (case)	20 (34.48%)	14 (25.93%)		
AO types				
Type A	30 (51.72%)	28 (51.85%)	0.3992	0.1263
Type B	20 (34.48%)	18 (33.33%)		
Type C	8 (13.79%)	8 (14.81%)		
Reasons of injury				
Traffic accident	22 (37.93%)	20 (37.04%)	0.1977	0.055
Failing	18 (31.03%)	14 (25.93%)		
Heavy body impact	18 (31.03%)	20 (37.04%)		

The inclusion criteria

The fracture was diagnosed as humerus shaft fracture by imaging, and the patients hadn't other diseases needed to be treated and had no surgical contraindication. All participants gave written informed consent voluntarily and received follow-up.

The exclusion criteria

Patients were not eligible for the study if they were not in accord with the criteria mentioned above and they suffered from severe primary baseline diseases including diabetes, hypertension, coronary heart disease, kidney disorder, liver disease, and lung disorder, and if their fractures were pathological ones or old closed fracture or open fracture or multisegmental fracture, and they were not appropriate for receiving surgery.

Indication for surgery

Conservative nonsurgical therapies were unable to get ideal reduction and linear as well as positional alignment. The fracture was accompanied with neurovascular injury. The fracture was multisegmental open fracture or old fracture or pathological fracture or patients had floating elbow.

Indication

The fracture area and condition could be showed entirely by the whole humerus (includes shoulder) X-ray. The length of the compression plate was at least 8 times than the length of fracture and there were at least 3 screws to fix the plate for the patients received the locking compression plate. The diameter of the intramedullary nail was at least smaller 1-2 mm than that of the narrowest marrow cavity, and that of the overlong interlocking intramedullary was at least smaller 3-4 cm than the length from the acromion to the olecranon at the healthy humerus.

Humerus locking compression plate

The patient's shoulder was abducted 90 degrees after general anaesthesia. The superficial fascia was cut open through an incision divided between the triangular muscle and pectoralis major, and the force should be proper avoiding to impact radial nerves. The broken end of humerus shaft was exposed by bluntly dissected brachialis muscle along the space between the biceps and triceps, and then the plate bended previously was placed at the poster lateral side to get anatomic reduction of fracture segments. Try to avoid damage to periosteum. If the bone slices were divided, it could be strapped by steel wire or lag screws. 3~4 locking nails were installed to fix the plate, so that the anatomic location can be reached as far as possible. The incision could be seamed after fixation. The patient needed a triangular arm sling to fasten his shoulder after operation, and in the 2nd day after surgery, he could move his wrist joint and finger joints, and in the 3rd day, he could do some non-gravity exercise of shoulder joint and elbow joint. Pre and post-operative venous transfusion of antibiotics for patients, so as to avoid infection.

Interlocking intramedullary nail

It includes antegrade nail and retrograde nail. Before surgery, venous transfusion of antibiotics for patients to avoid infection. The patient received antegrade nail was exposed his shoulder part as large as possible after general anaesthesia and his elbow joint was flexed to 90 degrees. Manipulation was performed before the following. Bone awl was put into the marrow cavity along the bone foramen located at 1 cm to the medial of humerus greater tuberosity and the lateral of cartilage after dissected the deltoid fascia through a longitudinal incision performed over the acromion, and then the guide pin was inserted into 2 cm upper olecranon, and the reaming was 1 mm bigger than the nail, to lock the proximal and distal screws. The incision could be seamed after fixation. For the patient underwent retrograde nail, a longitudinal incision was made from olecranon to the triceps at posterior of elbow. A hole was drilled at 2.5 mm upper olecranon fossa by bone awl. All patients received interlocking intramedullary nail were locked with static force. The patient needed a triangular arm sling to fasten his shoulder after operation, and in the 2nd day after

surgery, he could move his wrist joint and finger joints, and in the 3rd day, he could do some non-gravity exercise of shoulder joint and elbow joint.

Observation index

Operation time, intraoperative blood loss, fracture healing time (the time costed after operation to clinical healing), and complications of the patient should be observed. The patient was followed up from the day of surgery continued 6-24 months, and during when his conditions were recorded carefully, and he was guided to do excises for recovery. His shoulder joint movement function was evaluated with Neerat the last time of follow-up.

The clinical healing criteria included that the patient had no local tenderness and longitudinal percussion pain with normal local movement, and X-ray showed the callus located at fracture was continues with blurry fracture line, and his upper arm could lift 1kg object forward over 1 min, and the fracture was not deformation after observed for two week.

Statistical analysis

The data was processed with statistical analysis software SPSS17.0. All quantitative data were expressed with $\bar{x} \pm s$ and t-test was used to compare the data of two groups. The enumeration data was summarized with percentages and analysed by$\chi 2$ test, and ANOVA's was used for >2 means comparison. The statistical difference was defined as $P<0.05$.

Results

Comparison on the intraoperative conditions of patients in both groups

Surgeries for 58 cases underwent locking compression plate were all successful. The operation time of this group was (97.20 ± 30.06) min, longer than that of IIN group, the difference was significant, $P<0.05$. The intraoperative blood loss was (201.61 ± 71.03) ml, much more than that of the IIN group, the difference had much significance, $P<0.05$. That indicated that the surgical trauma of locking compression plate was large, making the patient loss more blood. The hospital stay and fracture healing time after surgery of both groups were similar with no statistic difference, $P>0.05$ (Table 2).

Table 2. *Comparison on the conditions of both groups.*

Group	Operation time (min)	Intraoperative blood loss (ml)	Hospital stay (d)	Healing time (m)
LCP	97.20 ± 30.06	201.61 ± 71.03	14.18 ± 2.17	3.70 ± 0.32
IIN	77.17 ± 15.46*	110.59 ± 50.34*	13.96 ± 3.25	3.38 ± 0.53

Note: Compared with the LCP group, p<0.05.

Comparison on the complications of two groups

The patients of both groups suffered from complications after surgery. 6 cases (10.34%) had radial nerve injury in the LCP group, but none in the IIN group, the difference was significant, $P<0.05$. And 4 (7.41%) cased had acromion injury in the IIN group, but none in the LCP group, the difference was significant, $P<0.05$. Moreover, in the LCP group, there was 2 case with incision infection, 2 joint pain, and 2 broken plate; in the IIN group, there was 2 case with disunion, and 2 joint pain; the difference was not significant, $P>0.05$ (Table 3).

Evaluation on joint function of patients in both groups

All patients were followed up for 6 to 24 months, (14.71 ± 4.55) months in average. In the last time of follow-up, all patients were evaluated for Neer score of shoulder joint function, including degrees of shoulder joint pain, power, range touched by the arm, stability, movement range, and anatomy. Total scores ≥ 90 was excellent, 80-89 was great, 71-79 was good, and ≤ 70 was bad. The result showed that the recovery rate of shoulder joint function patients was 74.14% in the LCP group and 8 patient (13.79%) had worse shoulder joint function, and it was 81.48% in the IIN group and 3 patients (5.56%) had worse shoulder joint function, compared the data of efficacy assessment on shoulder joint function of patients in two groups, the difference was significant, $P<0.05$ (Table 4).

Table 3. *Comparison on the complications of two groups (n,%).*

Group	Disunion	Radial nerve injury	Incision infection	Joint pain	Acromion injury	Broken nail and plate
LCP	0	6 (10.34%)*	2 (3.45%)	2 (3.45%)	0	2 (3.45%)
IIN	2 (3.70%)	0	0	2 (3.70%)	4 (7.41%)*	0

Note: *Comparison of the two groups, p<0.05;

Table 4. *Comparison on the long-term efficacy after surgery of patients in two groups.*

Group	Number (case)	Efficacy assessment			
		Excellent	Great	Good	Bad
LCP	58	23 (39.66%)	20 (34.48%)	7 (12.07%)	8 (13.79%)
IIN group	54	27 (50.0%)*	17 (31.48%)	7 (12.96%)	3 (5.56%)*

Note: * Comparison of the two groups, p<0.05;

Discussion

Up to now, the clinically frequent used surgical treatment for humeral shaft fracture includes humerus locking compression plate and interlocking intramedullary nail [9]. In the recent years, the theory of biomechanics is gradually replacing the theory of mechanics, and has become the main principle for fracture treatment [10]. Restoration is done at the location far away from the fracture, to ensure blood supply as much as possible at soft tissue attachment and fracture, to shorten surgical exposure time and contact areas between fixation and bone, to reduce periosteum injury, to achieve optimal treatment with as minimal trauma as possible.

The method of humerus locking compression plate (LCP) belongs to eccentric fixation. It can effectively control the rotation, separation, and angulation of humerus [11]. However, humerus locking compression plate needs a long operation time and large exposed area and causes heavier periosteum injury, even neurovascular injury. Moreover, humerus locking compression plate can cause bone ischemia more easily, and will influence the fracture healing; secondly, it will more easily cause iatrogenic injury to radial nerve and deep infection [12]. The results of this study also demonstrate that, the operation time of patients in LCP group was (97.20 ± 30.06) minutes, longer than that of IIN group, $p<0.05$. The bleeding volume of patients in LCP group was significantly more than that in IIN group ($p<0.01$), which indicates larger operative wound in LCP causes more bleeding of patients. Additionally, 6 (10.34%) patients have radial nerve injury in LCP group, while 0 case in IIN group, $p<0.05$.

The method of interlocking intramedullary nail (IIN) belongs to intramedullary fixation, and can obtain maximum stability with locking nails passing through the bone. Its surgical operation is easier than that of humerus locking compression plate, with smaller incision, less periosteum injury and maximum blood supply, so that the healing speed is faster [10]. IIN includes antegrade nail and retrograde nail. The fixation of retrograde nail is clinically prevailed, because it can reduce injury to shoulder joint and elbow joint, and the anatomical structure near olecranon fossa of elbow joint and vascular nerve tissue are relatively simple, not easily causing iatrogenic injury during surgery. But the requirements of operation technique are higher, with relatively more difficulties [13]. In this trial, the operation time of patients in IIN group was (77.17 ± 15.46) min, with statistic difference to that of LCP group, $p<0.05$. The bleeding volume of patients in IIN group was significantly less than that in LCP group, $p<0.01$. Besides, in IIN group there were 4 patients (7.41%) with the acromion injury, which was not seen in LCP group ($p<0.05$).

In the recent years, with the deepening research of Biomechanics, it is theoretically considered that stress stimulation can promote local blood supply of soft tissue, and accelerate the healing of fracture. The axial fixation of interlocking intramedullary nail can appropriately have pressure to speed up the blood stream at the location of fracture and soft tissue, stimulate the healing of fracture. Furthermore, this study also proves that IIN group has shorter operation time and lower intraoperative blood loss. As such, the setting of broken bone can be successfully finished with minimal trauma to patient, complying with the principle of "Biological Osteosynthesis" [14]. Whereas, due to the lack of stimulation of LCP group to the location of fracture, the bone healing is negatively influenced, resulting in osteoporosis or articular dyskinesia, etc., with longer operation time and higher intraoperative blood loss, causing higher pressure to physical traumas and psychological stress of patients. Therefore, from the aspect of "Biological Osteosynthesis" theory, IIN has more advantages over LCP [15]. The results of this study shows that, after evaluation of Neer score, the recovery rate of shoulder joint function patients was 74.14% in the LCP group and 81.48%; additionally, in the IIN group 8 patient (13.79%) had worse shoulder joint function, compared the data in two groups, the difference was significant, $P<0.05$.

In conclusion, the IIN group is superior to the LCP group in operation time, intraoperative blood loss and radial nerve injury, and is more aligned with the "Biological Osteosynthesis" principle. LCP patients have better effects in lower rate of acromion injury and improved shoulder joint function recovery. Both of the two operations have their own disadvantages and advantages. This study can provide some theoretical supports for clinical treatment.

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