

Original Article

Efficacy and acceptability of lateral and medial approach vs. posterolateral and anteromedial approach in treating terrible triad of the elbow

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Received July 4, 2017; Accepted March 13, 2018; Epub June 15, 2018; Published June 30, 2018

Abstract: Difficulty in treating terrible triad of the elbow (TTE) is closely associated with the lack of appropriate surgical techniques. Therefore, it is important to study the efficacy of the surgical treatment methods. This study was conducted to compare the efficacy and acceptability of the combined lateral and medial approach (CLM) and the combined posterolateral and anteromedial approach (CPA) in treating TTE. The 32 TTE patients were recruited, with sixteen TTE patients receiving CLM and sixteen TTE patients receiving CPA. Follow-up lasted fifteen months. The Mayo Elbow Performance Score (MEPS) was performed to assess the elbow joint stability and activity, and the visual analogue scale (VAS) was used to assess the pain of patients. The forearm rotation and elbow joint flexion-extension were used to assess the postoperative elbow functioning. Meanwhile, the healing time and complication rates were also compared. After surgery, compared to the CLM group, the CPA group had a non-significant higher final MEPS and non-significant better postoperative elbow functioning after surgery, but had a significantly shorter healing time. Meanwhile, the CPA group had a significantly lower VAS score. The two methods had similar complication rates. These results showed that the CPA had better efficacy and acceptability, and should be explored further. Our findings could be useful for clinicians to make an optimal treatment choice for TTE patients.

Keywords: Terrible triad of the elbow, TTE, lateral and medial approach, posterolateral and anteromedial approach

Introduction

Terrible triad of the elbow (TTE), coined by Hotchkiss in 1966 [1], is mainly characterized by the dislocation of the elbow combined with fractures of both the ulnar coronoid and radial head. The posterior dislocation of the elbow is the main cause of this injury [2]. Bohn et al. reported that the TTE accounted for 31% of elbow dislocations and 4% of adult radial head fractures [3]. Inappropriate treatment or care for TTE will seriously affect the quality of life of patients. However, due to the great potential for joint instability, unfavorable complications and relatively poor prognosis [4], treatment of the TTE is still very difficult.

Currently, the main treatment method of TTE is the conservative or surgical treatment meth-

ods, such as anteromedial or Kocher/lateral approaches [5]. But, due to the long-term fixation-induced stiffness and recurrent instability, the conservative methods often yield poor results. Therefore, using surgical treatment methods to restore the concentric structure and stability of the elbow is recommended by more and more researchers [6-8]. Our previous systematic review also showed that the functional outcomes after surgery for TTIE were generally satisfactory [9]. Nowadays, the mainstays of surgical treatment of TTE include radial head fixation and arthroplasty, lateral collateral ligament repair and coronoid process fixation [10].

Although the advantage of surgical management of TTE has been described in numerous reports, there is still no universally accepted surgical treatment method [8]. Our previous

study reported that the combined lateral and medial approach (CLM) could yield better overall outcomes compared with conservative treatment [11]. Meanwhile, we found that the combined posterolateral and anteromedial approach (CPA) could promote the reduction and fixation of TTE [12], and CPA had significant benefits in regards to complication rate and healing time over conservative treatment [13]. Rodriguez-Martin et al. also reported that the combined posterolateral and anteromedial approach (CPA) was effective for most patients [14]. Historically, difficulty in dealing with TTE was closely associated with the lack of appropriate surgical techniques [15]. Therefore, it is important to study the efficacy and safety of the surgical treatment methods. Here, in order to compare the efficacy and acceptability of CLM and CPA, we recruited TTE patients to conduct this study.

Materials and methods

Recruited patients

This study was reviewed and approved by the Ethical Committee of Wenzhou Medical University. The TTE patients were recruited from Department of Orthopedics, Yiwu Hospital of Wenzhou Medical University from January 2010 to January 2016. Patients met the following criteria were included: i) patients had completed medical records and were diagnosed with TTE; ii) patients were over 18 years old and could tolerate the surgery; iii) patients had no prior fractures; and iv) the functioning of the elbow was normal. Meanwhile, patients were excluded if they: i) had endocrine, autoimmune or metabolic fractures; ii) suffered from mental diseases or severe primary diseases in brain, heart, kidney, liver or hematopoietic system; iii) had fractures not caused by high energy trauma; and iv) had distal humerus fracture, fracture of shaft of radius and ulna or olecranon fracture. All patients signed the written informed consents.

Research design

Before surgery, all patients received the manual reduction, and their elbow joints were fixed externally. After the swelling disappeared and general conditions of TTE patients were stable, the operation was performed. Patients received general anesthesia or brachial plexus nerve

block, and then the injured elbows of patients were placed on a visible operation table. A tourniquet was used for the proximal end of upper arm. Totally, sixteen patients received the CLM, and the procedure of this approach was performed according to our previous study [11]. Meanwhile, sixteen patients received the CPA, and the procedure of this approach was performed according to our previous study [13].

Lateral and medial approach

The procedure for CLM was performed according to our previous study [11]. Lateral approach: it was conducted along with the lateral epicondyle of the humerus between brachioradialis and triceps. Then, the collateral ligament and lateral elbow were exposed after the anconeus was separated from the extensor carpi ulnaris. Medial approach: To protect the ulnar nerve, an incision was performed on deep fascia in the lateral epicondyle of the humerus. Then, to explore the deep medial collateral ligament, the beginning part of the flexor was cut and dragged.

Posterolateral and anteromedial approach

The procedure for CPA was performed according to our previous study [12]. Posterolateral approach: the posterolateral elbow Kocher incision was performed by starting from the lateral epicondyle of the humerus and enter via the gap between extensor carpi ulnaris and anconeus. This kind of injury was always along with injury in the part between deep fascia and lateral soft tissue. The most common type was the laceration of ligament at the posterolateral surface of lateral epicondyle of the humerus and lateral joint capsule. In result, the lateral epicondyle of the humerus was featured by bareness. The gap of injury could be served as the passage to joint, and the annular ligament could be incised vertically and horizontally on the radial head. During the exposure procedure, to avoid injuring the deep branch of the radial nerve, the forearm should be pronated. Anteromedial approach: it started from the place 1-3 cm away from the medial epicondyle of the humerus, when the distal end extended to the middle wrist joint and then stretched to the place 5 cm away from the ulnar coronoid process. The incision was 6-8 cm long. The skin and subcutaneous tissues were incised bluntly to identify and protect the medial cutaneous

CLM vs. CPA for treating TTE

Table 1. Baseline characteristics of TTE patients in two groups

Variables	CLM group	CPA group	t/x ²	p-value
Age (years)	37.8±5.2	37.2±5.6	0.457	0.517
Gender (F/M)	9/7	6/10	1.129	0.288
BMI (kg/m ²)	22.0±1.9	21.8±2.2	0.857	0.426
Alcohol consumption (yes/no)	5/11	7/9	0.533	0.465
Smoking (yes/no)	8/8	9/7	0.125	0.733
Cause of fracture (traffic accident/fall)	5/11	6/10	0.139	0.710
Unilateral fracture (left/right)	6/10	7/9	0.130	0.719
Mean duration of injury (days)	5.3±1.4	5.5±1.3	0.807	0.570
Length of stay (months)	2.7±1.0	2.8±1.5	0.922	0.358
O'Driscoll classification (type I/II/III)	5/8/3	4/9/3	0.170	0.919

F, female; M, male; BMI, body mass index; CLM, combined lateral and medial approach; CPA, combined posterolateral and anteromedial approach.

nerve of the forearm and ligate the veins obstructing the exposure. The medial intermuscular septum must be found to be released towards the proximal end. After defining the position of the crest of the medial epicondyle, the anterior structure at the distal end of humerus was lifted under periosteum to separate the pronator teres and flexors of the forearm longitudinally along the muscle fiber and incise the joint capsule in front of elbow joint. The coronoid process appeared and articular surface of the coronoid process tended to appear obviously when the elbow joint was completely extended. Anatomical reduction of fracture was conducted in an open manner. Kirschner wires were used for temporary fixation. The distal end of the humerus should be completely located at the trochlear notch of olecranon before reduction and fixation of the coronoid process. Metacarpal support mini-plate fixation was used for all patients.

Postoperative treatment

After surgery, a plaster cast was used to fix the elbow position of patients with a bend at 90°. During the perioperative period, the routine antibiotics were used to prevent the infection. Clinicians gave extra attention to the acral blood circulation and wound care of patients in this period. Meanwhile, patients were recommended to do appropriate exercises for the joint movement. After two weeks, the appropriate pressure and stitches could be removed. Two or three weeks later, patients were recommended to do passive exercises, such as rotation of the forearm and elbow joint flexion-extension. After four weeks, the plaster cast

was removed, and patients were recommended to do active exercises, such as rotation of the forearm and elbow joint flexion-extension, but avoiding an >150° elbow flexion within the first six weeks.

Efficacy evaluation

One clinician who was blinded to the treatment methods conducted the efficacy evaluation. The Mayo Elbow Performance

Score (MEPS) was performed to assess the elbow joint stability and activity of TTE patients. The final MEPS of 90-100 was defined as excellent, 75-89 as good, 60-74 as acceptable and <60 as poor. The forearm rotation and elbow joint flexion-extension were recorded. Follow-up lasted fifteen months. The healing time was calculated from the first day after surgery to no visible fracture line. The visual analogue scale (VAS) was used to assess the pain of patients. The VAS score ranged from 0 to 10, and the higher score indicated the more severe pain. Additionally, the complication rates in two groups were also analyzed.

Data analysis

The data analysis was conducted using SPSS 19.0. Chi-square and student's t-test were applied for categorical and continuous variables, respectively. The mean and standard deviation (SD) were used to describe the continuous data, and the number and percentage were used to describe the dichotomous data. All tests were two-sided, and the *p*-value <0.05 indicated that the difference was statistically significant.

Results

Baseline characteristics

Totally, 32 TTE patients were recruited in this study. The sixteen patients with average age of 37.8±5.2 received the CLM, and the sixteen patients with average age of 37.2±5.6 received the CPA. The main cause of fractures in two groups was fall. According to the O'Driscoll clas-

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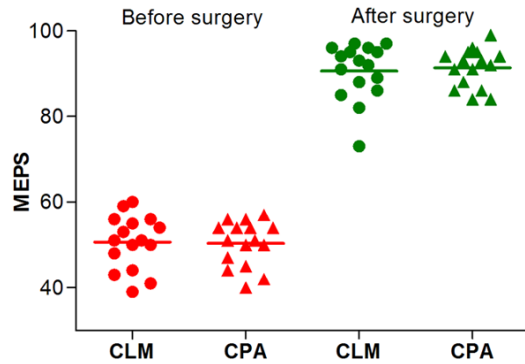


Figure 1. MEPS in two groups before and after surgery.

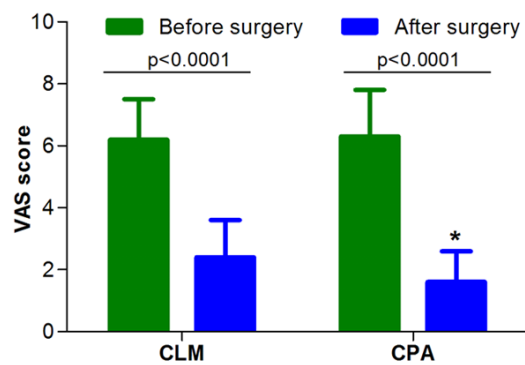


Figure 2. VAS score in two groups before and after surgery.

sification standard [16], there were 9 cases of type I, 17 cases of type II and 6 cases of type III fractures among the recruited patients. No significantly differences in the baseline data between the two groups. The detailed information was described in **Table 1**.

MEPS evaluation

Before surgery, the average MEPS were 50.6 ± 6.3 in the CLM group and 50.3 ± 5.3 in the CPA group. The difference of average MEPS between the two groups was non-significant. After surgery, both the final average MEPS in the CLM group (90.6 ± 6.6) and the CPA group (91.3 ± 4.5) were significantly increased (both $p < 0.0001$), but the difference of average MEPS between the two groups was still non-significant (**Figure 1**). In the CLM group, there were 10 cases, 5 cases and 1 case considering excellent, good and acceptable, respectively. In the CPA group, there were 11 cases and 5 cases considering excellent and good, respectively.

VAS score evaluation

Before surgery, the average VAS score were 6.2 ± 1.3 in the CLM group and 6.3 ± 1.5 in the CPA group. The difference of average VAS score between the two groups was non-significant. After surgery, the final average VAS score in the CLM group was significantly decreased to 2.4 ± 1.2 ($p < 0.0001$), and the final average VAS score in the CPA group was significantly decreased to 1.6 ± 1.0 ($p < 0.0001$). The CPA group had more reduction, and the difference of final average VAS score between the two groups was significant ($p = 0.04$, **Figure 2**).

Postoperative elbow functioning

Before surgery, the two groups had similar elbow functioning. After surgery, both the forearm rotation and elbow joint flexion-extension were significantly improved in the two groups (both $p < 0.0001$). In the CLM group, the average forearm rotation was significantly improved from 72.3 ± 31.7 to 120.5 ± 25.3 ($p < 0.0001$) and the average elbow joint flexion-extension was significantly improved from 62.4 ± 22.5 to 110.9 ± 23.1 ($p < 0.0001$). In the CPA group, the average forearm rotation was significantly improved from 71.9 ± 25.6 to 127.4 ± 31.1 ($p < 0.0001$) and the average elbow joint flexion-extension was significantly improved from 60.8 ± 18.7 to 118.9 ± 28.6 ($p < 0.0001$) (**Figure 3**). Although the patients receiving CPA had a greater increase in both the forearm rotation and elbow joint flexion-extension after surgery, the differences between two groups were still non-significant.

Healing time and complication rates

The healing time was 14.3 ± 2.6 weeks in the CLM group and 12.1 ± 2.1 weeks in the CPA group (**Figure 4**). The difference of healing time between the two groups was significant ($p = 0.01$), which indicated that the patients receiving CPA had a significantly shorter healing time. Meanwhile, in the CLM group, one patient had superficial infection, one patient had discomfort and one patient had elbow pain. In the CPA group, two patients had discomfort. The complication rates in the two groups were not significantly different. No patient was lost during follow-up.

Discussion

Early surgical intervention is the optimal choice for TTE treatment due to its better performance

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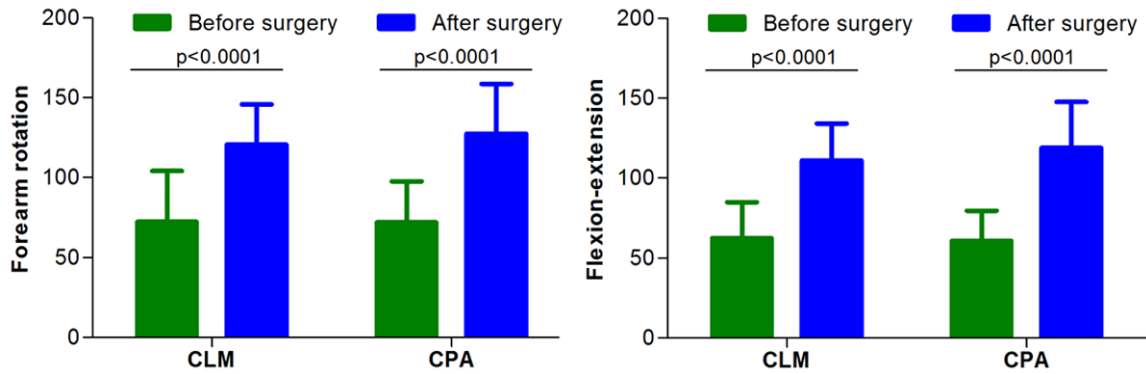


Figure 3. Postoperative elbow functioning in two groups before and after surgery.

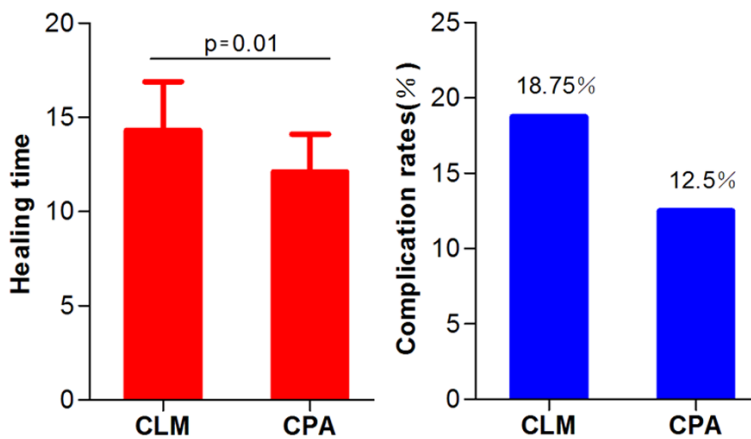


Figure 4. Healing time and complication rates in two groups.

than conservative treatments on joint stability and early mobility. It is very important to find an effective surgical and reasonable treatment for TTE. Here, the efficacy and acceptability of two surgical treatment methods was compared. The results showed that compared to the CLM group, the CPA group had a non-significant higher final MEPS and non-significant better postoperative elbow functioning after surgery, but had a significantly shorter healing time. Meanwhile, the CPA group had a significantly lower VAS score, which indicated that the patients receiving CPA had lower elbow pain. The two methods had similar complication rates. Therefore, these results showed that the CPA had better efficacy and acceptability, and should be explored further.

Our previous systematic review reported the satisfactory functional outcomes for TTE patients after surgery, but did not find that which

surgical treatment method could optimize the functional outcomes [9]. Actually, up to now, there still exists certain controversy about the selection of surgical technique should for TTE. Some researchers recommended the posterior longitudinal approach [17, 18]. One advantage is that this method has lower risk of injury to cutaneous nerves compared with the combined CLM. Another advantage is that this method could be used for the elbow arthroplasty if patients required in the

future. Meanwhile, Reichel et al. reported an anterior approach to treat coronoid process fractures, without complications in blood vessel nerve, anterior heterotopic ossification, internal fixation failure, or recurrent unstable elbow joint [6]. However, some researchers thought that the CLM could make exploration and repair simultaneously more easily, and the results of treatment could be improved by treating each injured structure [7]. Here, we firstly conducted work to directly compared the efficacy and acceptability of CLM and CPA, and found that the CPA had some advantages over CLM in treating TTE.

There were several imitations in this study. Firstly, the number of TTE patients included was relatively small. Then, our results were needed future large-scale studies to confirm. Secondly, all TTE patients were from the same place. Thus, we cannot rule out the ethno- and

site-specific biases, and it might also limit the applicability of these results [19]. Thirdly, there was no negative control group, but most of the previous studies reported that both CLM and CPA could yield better outcomes than conservative treatment methods.

In conclusion, our study was conducted to compare the efficacy and acceptability of CLM and CPA in TTE treatment. The results showed that both the CLM and CPA could effectively treat TTE, but the CPA might be the better approach. The patients receiving CPA had a significantly shorter healing time and significantly lower VAS score. Our findings could be useful for clinicians to make an optimal treatment choice for TTE patients. However, limited by the relatively small samples, our conclusions were needed future large-scale studies to support.

Acknowledgements

This work was supported by Zhejiang Science and Technology Department Project (2013C-33216), Zhejiang Province Health Department project (2014KYB296) and Yiwu Science and Technology Project (2013-G3-02).

Disclosure of conflict of interest

None.

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