

Original Article

Efficacy of anterior dynamic pried reduction technique combined with crane frame external fixation for the treatment of femoral neck fracture in adolescent

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Abstract: This study aims to explore the reduction efficacy and postoperative complications of anterior dynamic pryed reduction technique combined with Crane Frame External fixation on the femoral neck fracture in adolescent. 21 young people with femoral neck fracture that were single closed fracture without other injury were enrolled into this study during December, 2009 to December, 2012. There were 14 males and 7 females, with the average age of 15.3 years (ranged from 14 to 18 years). They were performed by anterior dynamic pried reduction technique combined with Crane Frame External fixation. The results were assessed by the Ratliff criterion after the mean follow-up of 19.2 months (range 12 to 24 months). Type I had one patient with fair, mediate, poor respectively, and type II had good in 8 patients, fair in 2 patients and mediate in one patient; type III had good in 3 patients and fair in one patient and type IV had 3 patients with good. All fractures were healed and the average time was 13.5 weeks (range 11 to 24 weeks). After operation, there were one case with coxa vara, one case with femoral head necrosis, one case with premature physeal closure and 2 cases with infection of acus tube. This treatment had some advantages with respect to good clinical efficacy, convenient operation, fast functional recovery and few complications to treat the femoral neck fracture in adolescent.

Keywords: Pried reduction, femoral neck fracture, crane frame, external fixation, adolescent

Introduction

With the fast development of modern society, femoral neck fracture presents an ascending trend yearly [1], mostly seen in elderly patients but rarely in adolescent [2]. Falls from a height, traffic accidents, swift sport and natural disaster were the main causative factors. Because of particular anatomy and blood-supply of femoral head, some complications easily occurs after operation, like fracture hard to heal and femoral head necrosis [3-5], which becomes a difficult issue for clinical orthopedists [6]. The treatment principle of femoral neck fracture in adolescent complies with the principle of anatomic reduction and internal fixation [7]. Anatomic reduction could rebuild the blood supply in the neck of femoral head, which plays an important role in healing of femoral neck fracture [8, 9]. Closed reduction and cannulated screws fixation is the common method to

treat femoral neck fracture. However, it was not always successful [10]. Moreover, repeated reduction further destroys the blood supply in the part of fracture and causes soft tissue injury. Some patients who failed to get reduction and had to choose surgical therapy. Compared with closed reduction, surgery causes worse blood supply injury in the area of fracture parts and increases the incidence of postoperative femoral head necrosis and non-healing [11]. Therefore, adequate reduction method is eager to need for orthopedists. This method must spend short time and few frequency of reduction in finishing the anatomic reduction of teenager femoral neck fracture. Here, we designed anterior dynamic pried reduction technique combined with Crane Frame External fixation for the treatment of teenager femoral neck fracture, which effectively reduce the operative trauma and got good efficacy compared with traditional closed reduction internal fixation.

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Data and methods

General data

This study enrolled 21 patients with single closed fracture, including 14 males and 7 females, with an average age of 15.3 years old (range from 14 to 18) and 9 left hip fractures and 12 right hip fractures. This study was conducted in accordance with the declaration of Helsinki. This study was conducted with approval from the Ethics Committee of Orthopaedic Hospital of Henan Province. Written informed consent was obtained from all participants. There were 8 patients caused by high fall, 5 patients caused by traffic accidents, 3 patients caused by swift sports and 3 patients caused by tumble injuries. According to the classification of Delbet-Colonna [12], 3 cases were classified as type I (transepiphyseal fractures), 11 were type II (transcervical fractures), 4 were type III (basal fractures) and 3 were IV (intertrochanteric fractures). All patients were performed skin traction of injured leg and operation within 24 h.

Operative method

After combined spinal and epidural anesthesia, patients placed at dorsal position. Normal legs were expanded and fixed at the G arm, followed by blocked up butt. Hand reduction was firstly conducted under the guidance of G arm after routine surgical operation. If it was difficult, a kirschner wire with 2.0 mm diameter would be inserted into the femoral bone to fix the near end of fracture about 2 cm at the outside of femoral artery in the inguinal area. Meanwhile, assistant pulled, expanded and intorted the injured leg, operator used kirschner wires to finish reduction through adjustment angles. When it was confirmed that fracture reduction was satisfied under G-arm X-ray medical equipment, 4 Steinmann's pins with 2.5 mm diameter were pierced from femoral neck that one pin was implanted from calcar femorale, one pin from bone trabecula and two pins made across at the femoral position of which angle was about 15 degree. After confirmed good reduction by G arm X-ray again, 1 Steinmann's pin with 3.0 mm diameter was vertically placed about 3 cm upside of the condyle of femur and penetrate into double sides of cortical bone. Near end of 4 pins were locked by near lock device of crane frame (Henan Luozheng Me-

dical Appliance Company, Luoyang, China) and 1 pin was locked by remote end lock device, and the device left away about 1.5 cm from skin. After that, stirrup was used to fix all pins and crane frame through regulated connecting pole. All pins outside of skin were cut off and the pinholes were packed by sterilized dressing.

Postoperative treatment

After operation, patients need take isometric exercise for quadriceps femoris, and the ends of pins were sterilized by iodine every one or two days. On the third day, patients trained sitting down but the injured leg was inhibited overload, crossed and laid on side. After postoperative 6-8 weeks, injured leg could have activities with walking stick. If radiography implied union of fracture after postoperative recheck, patients would walk with a heavy load.

Follow-up observation

All patients should be followed up after operation and were performed hip orthoaxis DR examination, which evaluated the postoperative healing condition of fractures, meanwhile, union time of fractures was recorded and complications were observed, such as non-union fracture, avascular necrosis, premature physeal closure and varus malunion.

All patients were removed crane frame in clinic. According to the Ratliff's evaluation criterion, good presented that hip joint recovered normal activity without pain and normal movement, fair presented that hip joint recovered generally normal activity and was occasional pain but not affected walking or squatting down, moderate presented that the activity of hip joint was lightly limited and patients had rest without symptoms, and walked with pain, additionally, they could have semi squat down and they generally did something by themselves, then poor presented that the activity of hip joint was obviously limited and patients walked with stick and felt pain, and they could not take care of themselves.

Statistically analysis

Statistical analysis was performed by SPSS 20.0 software and chi-square test was used for counting data and rank-sum test was used to compare the rank data, *P* value <0.05 denoted a significant statistical difference.

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Table 1. Comparisons of clinical efficacy in all fracture types (%)

Delbet-Colonna classification	n	Good	Fair	Moderate	Poor
Type I	3	0/0	1/33.3	1/33.3	1/33.3
Type II	11	8/72.7	2/18.2	1/9.1	0/0
Type III	4	3/75.0	1/25.0	0/0	0/0
Type IV	3	3/100.0	0/0	0/0	0/0

Table 2. Comparisons of efficacy among all types of fractures

Delbet-Colonna classification	n	Femoral necrosis	Coxa vara	Premature physeal closure	Infection of acus tube
Type I	3	1/33.3	0/0	1/33.3	1/33.3
Type II	11	0/0	1/9.1	0/0	0/0
Type III	4	0/0	0/0	0/0	1/25.0
Type IV	3	0/0	0/0	0/0	0/0

Results

General data

This study enrolled 21 young patients with femoral neck fracture. They received surgical treatment and were followed up after operation. The average time of follow-up was 19.2 months, ranging from 12 to 24 months.

Therapeutic evaluation

According to Ratliff criteria, 21 patients were assessed, including 14 patients as a good result, 4 as fair, 2 as moderate and 1 as poor. All fractures were full healing, varying from 11 to 24 weeks, with a mean of 13.5 weeks. Overall, the efficacy was much perfect, and the total acceptance rate was 85.7% (**Table 1**). Meanwhile, according to fracture classification, the efficacy of different fracture types was compared, and the results showed that type I had a significant difference with other fracture types (type I vs. type II: $Z=2.852$, $P=0.022<0.05$; type I vs. Type III: $Z=2.036$, $P=0.027<0.05$ and type I vs. type IV: $Z=2.760$, $P=0.033<0.05$). Furthermore, there was no significant difference among other three fracture types ($P>0.05$). According to analysis of acceptance rate comparison among all fracture types, the acceptance rate was obviously lower in type I than that in other fracture types. Therefore, we primary concluded that type I of fracture got the poorest efficacy after operation (**Table 1**).

Postoperative complications

Our results found that 1 patient with coxa vara, 1 with femoral necrosis, 1 with premature physeal closure and 2 cases with infection of acus tube. Fracture Type of patient with coxa vara was type II, and moderate efficacy, it did not treat any measures except regular follow-up. It was performed intertrochanteric of femur to adjust limb alignment and recover hip joint function. One patient had femoral necrosis, of which fracture type was type I, and got poor effect that indicated they need walk with stick and got pain to affect the normal life and received oral yu capsules of femoral necrosis (He Nan Luo Zheng Pharmaceutical factory, China), following by one year of follow-up. 1 case underwent premature physeal closure and the fracture was type I. After operation, the efficacy was evaluated as moderate; the length of injured leg was shorter than healthy leg, and patient had light limp and need regular follow-up. Further treatment was done when the height stopped growth. 2 patients with pinhole infection suffered from local inflammation and leakage liquid, which should use iodine to clean wound, and pins were taken away after union of fracture. The complications were significant differences between type I fracture and other three fractures (type I vs. type II: $X^2=6.023$, $P=0.019<0.05$; type I vs. type III: $X^2=6.831$, $P=0.009<0.05$ and type I vs. type IV: $X^2=6.350$, $P=0.021<0.05$). There was no significant difference among other three fractures (**Table 2**).

Typical case

Male patient with the age of 16 years old, who caused left hip injury when he rode electric motor vehicle, was diagnosed as left femoral neck fracture (Garden type III). He positively performed perfect preparation 48 h before operation and was conducted the anterior dynamic pried reduction technique combined with crane frame external fixation after combined spinal epidural anesthesia. He got good union after 4 months of follow-up and the hip joint function recovered well (**Figure 1**).

Discussion

Nowadays, more and more teenagers suffer from femoral neck fracture caused by high-energy injury. Teenagers usually undergo frac-

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Figure 1. A Typical case was shown. A: outside view of crane frame; B: DR X-ray before operation; C: pried reduction at surgery; D: instant DR X-ray after operation; E: DR X-ray 1 month after operation; F: DR X-ray two months after operation; G: DR X-ray with the removal of crane frame at four months after surgery, which showed good union of fracture.

ture needed by fierce power due to their tough bones [13, 14]. Fracture characteristics present obvious shift, local worse blood supply and poor prognosis. Clinically, it results in some complications of non-union, delayed union and avascular necrosis. Presently, how to treat femoral neck fracture is not definite in the world. The selection of treatment is generally determined by age, type of fracture and migration condition of patients [15-17]. According to the characteristic of femoral neck fracture in adolescent, the primary principle should be exact reduction and firmly internal fixation, for example, closed fracture reduction with cannulated screws internal fixation [18] that has short operative time, small trauma and postoperative fast recovery. Meanwhile, open reduction is used for patients with difficult reduction. Some studies indicated that open reduction could decompress capsule of hip and effectively reduce the incidence rate of postoperative femoral avascular necrosis [19]. But some studies thought there was no certain correlation between decompression of capsule of hip and femoral avascular necrosis [20].

Here, we subtly used pried reduction method of traditional Pingle reduction techniques, which put a kirschner wire into the near end of frac-

ture, and performed longitudinal traction of injured leg. **Figure 1C** showed the process of reduction through anterior dynamic pried reduction technique combined with crane frame external fixation to reach the exact reduction of teenager femoral neck fracture. Crane frame was produced by our hospital and applied to internal fixation treatment of femoral neck fracture of young patients and elderly intertrochanteric fracture. The crane frame was made up of 5 Steinmann's pins of which diameter was 2.5 mm and an adjustable connecting pole (**Figure 1A**). During the operation, 1 Steinmann's pin was implanted nearly calcar femorale at the side of bone trabecula and another pin was implanted at the upward of femoral neck. Then other 2 pins were implanted to make a cross of the angle of 15°. Connecting pole fixed four pins by near screws and connected 1 pin at the end side of thigh-bone, which was adjusted by linkage pole to generate power to move up or down. This crane frame further maintained the pressure of fracture and recovery of collodiaphyseal angle, which effectively prevented from shift of fracture fragments and decreased the incidence rate of postoperative coxa vara. Additionally, 2.5 mm diameter and 19.6 mm² the total cross-sectional area of four Steinmann's pins used

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by crane frame is smaller than the total cross-sectional area of cannulated screw with 7.3 mm diameter. This design could reduce the bone injury caused by femoral neck and blood supply. Furthermore, the smaller the cross-sectional area, the lower the incidence rate of femoral avascular necrosis, premature physal closure and nonunion of fracture [21].

This study showed that anterior dynamic pried reduction technique combined with crane frame external fixation got a satisfied efficacy to treat femoral neck fracture in adolescent and the total effective rate was 85.7%. Moreover, it had great advantages, such as simple operation, small trauma and easy to learn. But the postoperative effect and incidence rate of complications was poorer in patients with Delbet-Colonna type I fracture than other types of fractures.

Disclosure of conflict of interest

None.

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