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Original Article

Treatment effect of elastic intramedullary nail reduction and fixation on children with femoral neck fractures

Qian Xu[1*], Hongyong Zhu[2*], Guangqiang Zhen[3], Jin Xu[4], Longzu Li[5]

[1]Outpatient Office, Zhengzhou Hospital of Traditional Chinese Medicine, Zhengzhou 450007, He'nan Province, China; [2]Department of Orthopedics, Penglai Traditional Chinese Medicine Hospital, Yantai 265600, Shandong Province, China; [3]Department of Orthopedics, Linqing People's Hospital, Liaocheng 252600, Shandong Province, China; [4]Department of Orthopedics and Traumatology, Chun'an Xinfu Traditional Chinese Medicine Orthopedic Hospital, Hangzhou 311700, Zhejiang Province, China; [5]Department of Pediatric Surgery, Jinxiang County People's Hospital, Jining 272200, Shandong Province, China. [*]Equal contributors and co-first authors.

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Abstract: Objective: To investigate the treatment effect of elastic intramedullary nail reduction and fixation on children with femoral neck fractures. Methods: Sixty-two children with femoral neck fractures in our hospital were equally divided into the open reduction and Kirschner wire internal fixation group (group O) and elastic intramedullary nail reduction and fixation group (group E). We investigated the differences in fracture healing time, intraoperative situation, clinical efficacy, Harris scores, secondary effects and bone healing time between group O and group E. Results: The intraoperative indexes such as operation time and blood loss of group E were significantly lower than those of group O ($P<0.05$). After the operation, the treatment effect of group E was slightly higher than that of group O, but there was no significant difference ($P>0.05$). The Harris score of group E was significantly higher than that of group O ($P<0.05$). The fracture healing time and bone healing time after the surgery in group E were significantly shorter than those in group O ($P<0.05$). The incidence of secondary effects in group E was lower than that in group O, but without significant difference ($P>0.05$). Conclusion: Elastic intramedullary nail reduction and fixation has a better effect in the treatment of children with femoral neck fractures, which can accelerate fracture healing time and improve children's hip function after the operation.

Keywords: Femoral neck fractures, elastic intramedullary nail reduction and fixation, treatment effect, children

Introduction

The femoral neck fracture is relatively rare in children, with an incidence of about 1%. It is mostly caused by falling, trauma or the decrease of children's weight. It is usually accompanied by high-energy injury, osteonecrosis of the femoral head, hip varus, premature closure of epiphysis, greater trochanter fracture, dislocation, hemorrhagic shock or traumatic shock caused by vascular injury, severely endangering the health and life of children [1]. According to the Delbet classification, it is divided into four subtypes, of which type II (40%-50%) and type III (25%-35%) account for about 3/4 of femoral neck fractures. At present, internal fixation is an effective way to treat femoral neck fracture in children. Surgical treatment is an effective method to treat femoral neck fractures [2] and its basic principle is to provide strong internal fixation, which mainly includes bone round needles, hollow threaded needles, Kirschner wires and plate internal fixation. However, such treatment has some limitations: fixation of trochanteric and intertrochanteric fractures are unstable; bending and even cracks of Kirschner wires may occur; the common plate fixation of trochanteric and intertrochanteric bone requires multiple pre-bending, which increases the risk of plate strength loss and cracks. In addition, screw fixation through the epiphyseal plate may lead to potential epiphyseal injury. The above results may lead to long-term osteonecrosis of the femoral head, so a good fixation method is of great significance to the prognosis of children [3].

Studies have confirmed that elastic intramedullary nail reduction and internal fixation play an

Table 1. Comparison of general information between the two groups (n, $\bar{x}\pm sd$)

Index	Group O (n=31)	Group E (n=31)	χ^2/t	P
Gender			0.089	0.956
Male	16	14		
Female	15	17		
Delbet type			0.076	0.962
Type I	9	7		
Type II	8	9		
Type III	8	8		
Type IV	6	7		
Cause of injury			0.605	0.739
Car accident	5	8		
High-altitude falling	6	6		
Craniocerebral trauma	4	3		
Thoracic and abdominal trauma	7	7		
Concomitant injuries	9	7		
Injured position			0.135	0.826
Left	14	16		
Right	17	15		
Age (years)	6.5±2.2	6.3±2.1	0.141	0.849

important role in treating femoral shaft fractures, femoral neck fractures and other multiple fractures in children. It not only has a good effect of internal fixation but also has the advantages of simple operation and fewer complications [4-7]. However, the influence of this treatment method on children's intraoperative situation, fracture healing time and other indicators has not been clarified completely. Therefore, this study analyzed the effect of different internal fixation methods on children femoral neck fractures, hoping to provide more evidence-based basis for the selection of clinical internal fixation methods.

Materials and methods

General information

Sixty-two children with femoral neck fractures from January 2018 to January 2020 were enrolled in this retrospective study. According to the surgical method, they were divided into the open reduction and Kirschner wire internal fixation group (group O) and elastic intramedullary nail reduction and fixation group (group E), with 31 cases in each group.

Inclusion criteria: children with femoral neck fractures diagnosed by X-ray or CT scan; children who were 4-15 years old; children with complete data; children who had a closed fracture and with poor alignment and instability after manual reduction. Exclusion criteria: children with open or pathological fractures; children with coagulation dysfunction or hematopoietic system diseases; children with vital vascular and nerve injury; children with hepatic and renal insufficiency.

The guardians of the children were aware of and agreed to this trial. This study was approved by the Ethics Committee of our hospital. There was no significant difference in general information between group O and group E (P>0.05). See **Table 1**.

Therapeutic methods

Group O received open reduction and Kirschner wire internal fixation. The children lay in supine position on the operating table and were anesthetized with conventional methods. Under the guidance of a C-arm X-ray machine (model: PLX7200, Pulang medical instrument company, Nanjing), the injured limb received traction reduction in an abduction and internal rotation position, and then the internal fixation was carried out. The intra-articular hematocele was extracted to reduce the internal pressure of the joint.

Group E received elastic intramedullary nail reduction and internal fixation. A small incision was made on the femur's fracture side, and an elastic intramedullary nail with a diameter of 2.0 mm or 2.5 mm (Chuanghui medical instruments Jiangsu Co., Ltd., China) was inserted, slowly rotated and pushed into the fracture end. With the help of a C-arm X-ray machine (model: PLX7200, Pulang medical instrument company, Nanjing), the nail tip was fluoroscopically observed, and the lateral displacement was corrected. The periosteum's integrity and the blood supply of the femoral head were paid particular attention during the operation. The

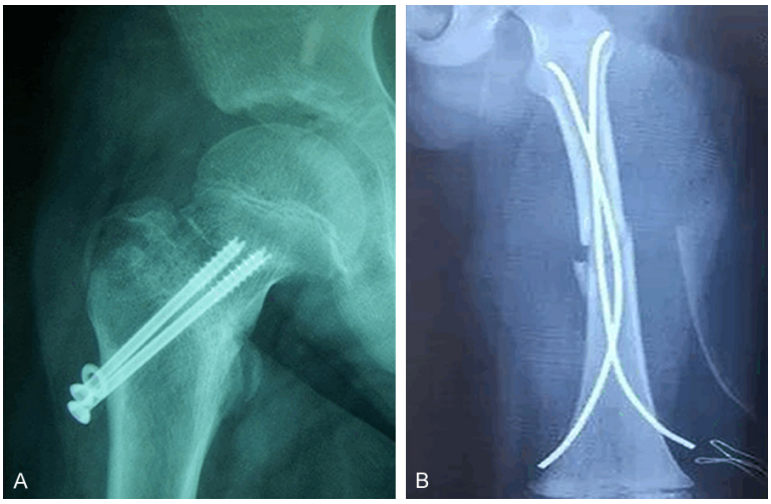

Figure 1. Imaging images of typical cases. A: The X-ray image of internal fixation method in group O; B: The X-ray image of internal fixation method in group E.

operated limb received plaster fixation after the operation.

Outcome measures

Clinical efficacy: Six months after the treatment, the therapeutic effects of group O and group E were observed and analyzed. The specific clinical efficacy after the treatment was as below [8]. Significantly effective: X-ray showed that fractures were completely healed, and joint function was normal, without obvious pain. Effective: X-ray showed that fractures were basically healed, the fracture site was slightly painful, and the joint activity was slightly limited. Ineffective: X-ray showed that the fracture line was fuzzy, the wound site was malformed, with obvious pain. Total effective rate (%) = (significantly effective cases + effective cases)/total cases ×100%.

Hip function: Three and six months after the treatment, the Harris score was used to evaluate the hip function of group O and group E [9]. The main evaluation contents included pain, daily activities, range of motion, etc. The Harris score gave a maximum of 100 points. A total score of 90-100 was considered excellent; 80-89 was considered good; 70-79 was considered fair; <70 was considered poor. Lower scores indicated worse hip function.

Fracture healing time and bone healing time: Six months after the treatment, the clinical fracture healing time and bone healing time of children in group O and group E were observed and analyzed according to the X-ray examination results and clinical manifestations. The standard of fracture healing: X-ray showed a blurred fracture line; there was no local tenderness or percussion pain in the vertical axis; there was no local abnormal activity. The standard of bone healing: the trabecular bone passed through the fracture line; the patient's condition met the clinical healing standard.

Intraoperative and postoperative indexes: In the course of treatment, the intraoperative indexes of group O and group E were recorded and compared, including operation time, intraoperative blood loss and hospitalization time.

Complications: After six months of treatment, the incidence of secondary effects, such as avascular necrosis of the femoral head, premature epiphyseal closure, shortening of the femoral neck and hip pain, were recorded and compared between the two groups.

Imaging images of a typical case: The child was asked to take regular X-ray examinations one month and six months after the operation in the outpatient department. See **Figure 1**.

Statistical analysis

The SPSS 20.0 statistical software was used in this study. The measurement data in the two groups were expressed as mean ± standard deviation ($\bar{x}$±sd). The paired t-test was used for intra-group comparison before and after treatment. The independent-sample t-test was used for comparison between groups. The chi-square test was used for comparison of counting data. $P<0.05$ was considered significantly different.

Results

Comparison of intraoperative situation between the two groups

The mean operation time was (73.09±8.83) min in group O and (68.93±6.43) min in group E. The mean intraoperative blood loss was (143.98±13.45) mL in group O and (113.87±

Table 2. Comparison of intraoperative situation between the two groups ($\bar{x}$±sd)

Group	Operation time (min)	Intraoperative blood loss (mL)	Hospitalization time (d)
Group O (n=31)	73.09±8.83	143.98±13.45	7.64±2.65
Group E (n=31)	68.93±6.43	113.87±11.94	5.98±2.45
t	2.120	9.321	2.561
P	0.038	<0.001	0.012

Table 3. Comparison of clinical efficacy between the two groups (n, %)

Group	Significantly effective	Effective	Ineffective	Total effective rate
Group O (n=31)	10	12	9	22 (70.97)
Group E (n=31)	15	13	3	28 (90.32)
χ^2				4.041
P				0.132

Table 4. Comparison of Harris scores between the two groups (score, $\bar{x}$±sd)

Group	Before treatment	Three months after treatment	Six months after treatment
Group O (n=31)	45.98±5.09	75.73±6.03	82.45±6.23
Group E (n=31)	45.76±5.98	81.36±6.34	90.34±7.34
t	0.156	3.583	4.563
P	0.876	<0.001	<0.001

Table 5. Comparison of fracture healing time and bone healing time between the two groups ($\bar{x}$±sd)

Group	Fracture healing time (weeks)	Bone healing time (weeks)
Group O (n=31)	16.77±2.35	18.13±2.75
Group E (n=31)	12.06±2.41	14.04±1.89
t	4.483	3.487
P	<0.001	<0.001

11.94) mL in group E. The mean hospitalization time was (7.64±2.65) days in group O and (5.98±2.45) days in group E. Compared with group O, the operation time, intraoperative blood loss and hospitalization time in group E were significantly reduced (all P<0.05). See **Table 2**.

Comparison of clinical efficacy between the two groups

After the treatment, the total effective number in group E was 6 cases more than that in group O. The treatment effect in group E was slightly higher than that in group O, but there was no significant difference (χ^2=4.041, P=0.132). See **Table 3**.

Comparison of Harris scores before and after operation between the two groups

Before the treatment, the Harris scores of group O and group E were 45.98±5.09 and 45.76±5.98 respectively, with similar values (P>0.05). Three months after the treatment, the Harris scores of group O and group E were 75.73±6.03 and 81.36±6.34, respectively. Six months after the treatment, the Harris scores of group O and group E were 82.45±6.23 and 90.34±7.34, respectively. Three and six months after the treatment, the Harris scores of group E were significantly higher than those of group O (P<0.001). See **Table 4**.

Comparison of fracture healing time and bone healing time between the two groups

The fracture healing time of group O and group E was (16.77±2.35) weeks and (12.06±2.41) weeks, respectively. The bone healing time of group O and group E was (18.13±2.75) weeks and (14.04±1.89) weeks, respectively. The postoperative fracture healing time and bone healing time of group E were significantly shorter than those of group O (P<0.001). See **Table 5**.

Comparison of secondary effects between the two groups

There were 9 cases of secondary effects in group O and 4 cases in group E. Compared with group O, the incidence of secondary effects in group E was lower, but there was no significant difference (P>0.05). See **Table 6**.

Discussion

Children's activity intensity is higher than that of adults, and the physiological development of their bones is incomplete, making the incidence of children's femoral neck fractures

Table 6. Comparison of secondary effects between the two groups (n, %)

Group	Avascular necrosis of the femoral head	Premature epiphyseal closure	Hip pain	Shortening of the femoral neck	Incidence
Group O (n=31)	2	2	2	3	9 (29.03)
Group E (n=31)	1	1	1	1	4 (12.90)
X^2					0.843
P					0.237

increases [10]. The treatment of femoral neck fractures is difficult. Once the epiphysis of the femoral head is damaged, it may cause many adverse consequences such as early closure of epiphyseal plate. Therefore, the choice of treatment of femoral neck fractures in children has important clinical significance [11].

At present, open reduction and internal fixation is a common treatment for femoral neck fractures in children, but the clinical evaluation of related treatment is relatively rare [12]. This study showed that compared with open reduction and internal fixation with Kirschner wires, elastic intramedullary nail reduction and fixation has a better clinical effect. It can shorten the hospitalization duration, fracture healing time, bone healing time and braking time, possibly due to its stable internal fixation. Coxa vara could happen after the treatment of femoral neck fractures with Kirschner wires or cannulated screws. However, there is no difference in the change of the femoral neck shaft angle before and after the treatment using elastic intramedullary nail reduction and fixation, and no coxa vara occurs; therefore, the stable fixation can prevent the loss of femoral neck shaft angle [13]. Elastic intramedullary nail reduction and fixation can prevent plaster fixation or shorten the fixation time, making it possible for the children to carry out active rehabilitation training early, promoting the prognosis of fractures and ultimately reducing the length of stay in hospital. The results above corroborated the conclusions of previous studies [14-18].

In this study, we showed that compared with the control group, the operation time and blood loss of elastic intramedullary nail reduction and fixation were decreased, which may be related to its simpler operation, smaller wound and shorter operation time, finally reducing the amount of blood loss. Similar research results have previously been reported [19]. Elastic intramedullary nail reduction and fixation significantly reduce the pain of children with femoral head fractures. When we analyzed the hip joint function of the two groups, the hip joint score of elastic intramedullary nail reduction and fixation group was better than that of open reduction and fixation with Kirschner wire group. It may be that the use of elastic intramedullary nail for internal fixation during the operation can maximize the function of the femoral head and hip joint when ensuring the normal operation of blood vessels of the femoral head. Notably, the above results in our study are consistent with previous research results [20, 21].

In terms of postoperative complications, the results of this study showed that the incidence of complications in the open reduction and Kirschner wire internal fixation group was higher than that of the elastic intramedullary nail reduction and fixation group, but there was no statistical difference. It may be that after open reduction and Kirschner wires internal fixation, children were prone to related complications, such as femoral head necrosis, and the loosening of internal fixation might also occur. So the incidence of complications is increased in open reduction and Kirschner wire internal fixation. In this study, there is no statistical difference in incidence of complications between the two groups, which may be related to the insufficient sample size. Therefore, we need to increase the sample size in the future. However, the conclusions in this study are also consistent with previous studies [22-26].

There are some limitations in our research, as only two methods of surgical treatment were compared. More experimental methods should be adopted to provide a more favorable experimental basis for the treatment of femoral neck fractures. Also, this study is a retrospective nested case-control study, which has a certain potential bias. A multicenter prospective trial is needed to further confirm the clinical effective-

ness of elastic intramedullary nail reduction and fixation.

In conclusion, the elastic intramedullary nail reduction and fixation in the treatment of children with femoral neck fractures has a better effect. It can improve the hip function of children, accelerate the fracture and bone healing time.

Disclosure of conflict of interest

None.

Address correspondence to: Longzu Li, Department of Pediatric Surgery, Jinxiang County People's Hospital, No. 117 Jincheng East Road, Jining 272200, Shandong Province, China. Tel: +86-0537-6560939; E-mail: lilongzu3f6g@163.com

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