Dynamic compression locking system vs. dynamic hip screw in the treatment of femoral neck fractures: A comparative study

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Abstract

Background: There is still a lack of consensus on which internal fixation method can better maintain the stability of femoral neck fractures (FNF), promote fracture healing, and avoid and reduce postoperative complications such as femoral head necrosis and nonunion. Therefore, the purpose of this study was to evaluate the clinical efficacy of the novel dynamic compression locking system (DCLS) versus dynamic hip screw (DHS) in the treatment of FNF.

Methods: Fifty cases of FNF admitted from July 2018 to December 2020 were retrospectively analyzed. According to different treatment methods, they were divided into DCLS group (26 cases) and DHS group (24 cases). Baseline data, intraoperative and postoperative clinical data, complications, and Harris score were collected to evaluate the clinical efficacy.

Results: All patients were followed up for 24 months, all of which were caused by falls. The baseline data of the two groups were comparable (P>0.05). There were not significant differences in the length of hospital stay and mobility between the two groups (P>0.05). The operation time, blood loss, incision length, fluoroscopy times and the degree of femoral neck shortening in the DCLS group were significantly less than those in the DHS group (all P<0.05). Harris score in the DCLS group was significantly higher than that in the DHS group (P<0.05). Complications of femoral head necrosis and nonunion in the DHS group were slightly higher than those in the DCLS group, but there was not statistical significance (P>0.05).

Conclusion: DCLS is superior to DHS in the treatment of FNF, with advantages of less surgical trauma, simplified surgical procedures, lower radiation exposure dose for patients, good stability of internal fixation and better control of femoral neck shortening. However, there is not significant difference in fracture healing complications, which requires further study.

Background

Femoral neck fractures (FNF) is a common hip injury, accounting for about 57% of hip fractures, and has become one of the major health problems, with its incidence and economic burden increasing year by year [1, 2]. Patients' dysfunction and decreased quality of life could increase mortality [3]. Most of these injuries require surgery to prevent bedridden complications. For young patients, joint replacement is usually not used because the implant life span usually does not last more than 20 years and is associated with multiple surgical complications, including infection and aseptic loosening [4]. Moreover, hip replacements are invasive, bleeding, expensive and often require revision surgery years later [5]. Hip replacement surgery has high requirements for patients' physical health status, and patients' activities are more limited in the later stage, which is often inferior to patients' own hip function. For young FNF patients, reduction and internal fixation is the preferred treatment, with the advantage of preserving autogenous femoral head [6].

The optimal fixation strategy for FNF is still controversial [7]. At present, no internal fixation treatment for FNF has been shown to be superior to other internal fixation [8].The internal fixation methods for FNF include cancellous bone screws, dynamic hip screw (DHS), head nail, proximal femoral locking plate, etc. However, the postoperative failure rate of these fractures is very high, ranging from 20–80% [9]. Dynamic compression locking system (DCLS) is a new internal fixation system for FNF, which can not only apply axial, parallel, uniform and precise compression of fracture ends during surgery, but also has a stable frame structure, as well as a dynamic compression effect after surgery [10]. So DCLS has good initial stability and continuous stability. The DCLS has obvious advantages over three cannulated screws in clinical efficacy and biomechanics, suggesting that DCLS is a potential choice for treatment of FNF [11].

There is still a lack of consensus on which internal fixation method can better maintain the stability of fracture end, promote fracture healing, avoid and reduce postoperative femoral head necrosis, internal fixation failure and other complications [7]. Therefore, the purpose of this study was to compare the clinical efficacy of DCLS and DHS in the treatment of FNF in our hospital from July 2018 to December 2020, and to evaluate the strengths and weaknesses of the two internal fixation methods.

Methods

Cases selection

Inclusion criteria were as follows: A clear history of trauma; A Garden II-III fracture of FNF; Follow up for more than 2 years; Unilateral fractures; The informed consent of the surgery and implant were signed by these patients; The applied implant were DCLS or DHS. Closed reduction and internal fixation of the fracture site. Exclusion criteria were as follows: A history of hip trauma in the past; Pathological fractures other than osteoporosis; Senile dementia and other diseases of poor compliance and uncooperative treatment; Fractures in other parts; Concomitant acetabular fracture; Serious medical disease interferes with clinical efficacy.

General Information

The cases of FNF treated in our hospital from July 2018 to December 2020 were retrospectively collected. A total of 50 cases of FNF treated by DCLS (Suzhou Kangli Orthopaedic Medical Instrument Co. LTD, Jiangsu, China) (Fig. 1) and DHS (Shandong Weigao Orthopaedic Material Co. LTD, Shandong, China) in our hospital were included. According to different treatment methods, the patients were divided into DCLS group (26 cases) and DHS group (24 cases). Both groups were injured due to falls. There were not statistical differences in preoperative clinical data (Table 1).

Table 1 Comparison of baseline data between the two groups

Data	DCLS group	DHS group	t/χ^2	*P*
The number of cases	26	24	-	-
Age (years)	33-84（69.3±11.2）	32-89（68.5±11.9）	1.758	0.079
Gender			0.206	0.650
Male (cases)	8	6		
Female (cases)	18	18		
Time from injury to surgery (days)	0-5（2.7±1.4）	0-5（2.6±1.4）	0.017	0.986
Garden classification (cases)			0.025	0.874
II	6	6		
III	20	18		

Surgical Methods

These surgeries were performed under epidural anesthesia. These patients were supine on a traction bed. Closed reduction was performed under C-arm X-ray fluoroscopy. The criteria for satisfactory reduction were Garden index 160° to 175°, fracture displacement < 2 mm, and lateral angulation deformity < 10°. ① Surgical procedures in the DCLS group were based on previous studies [10, 11], and the surgical principles were shown in Fig. 1. ② DHS group was treated with DHS. The lateral side of the upper segment of the femur was selected as the approach to make a 6–10 cm surgical incision. The subcutaneous tissue and fascia were cut layer by layer to expose the trochanter and the upper segment of the femur. A 135° guide was selected to drill in the guide needle, which was directed towards the vertex of the femoral head. Intraoperative fluoroscopy ensured that the guide needle was located in the lower 1/3 of the femoral neck in the anterior and posterior fluoroscopy, and was located in the middle of the femoral neck in the lateral fluoroscopy, with tip apex distance value < 25 mm. After the guide needle was in a good position, surgeon measured its length and screwed in the DHS main nail. After installing the lateral plate, surgeon installed corresponding screws in the lateral plate. Incision suture and drainage were routinely performed in both groups, and infection prevention was performed in all patients.

Postoperative Management

Ankle flexion and extension exercises were usually performed on the first day postoperatively. Patients at high risk of thrombosis were selectively treated with low-molecular weight heparin once daily for anticoagulant therapy until discharge. After discharge, these patients were instructed to take rivaroxaban orally for at least 1 month. These patients after the third day postoperatively began to do active heel movement and hip knee flexion exercise. 1–2 weeks after the operation, the patients were selectively started to walk without weight with the aid of walking aids. About 1 month after the surgery, these patients gradually started partial weight-bearing walking assisted by walking aids according to the patient's condition, and gradually transitioned to full weight-bearing walking after 3 months postoperatively. These patients underwent X-ray review within 3 days after the operation. After discharge, these patients were instructed to make a routine out-patient re-visit at 1, 2 and 3 months after the operation and follow up every 6 months thereafter until the fracture healed completely.

Observation Index And Evaluation Criteria Of Curative Effect

The hospital stay, operation time, intraoperative blood loss, incision length, intraoperative fluoroscopy times, femoral neck shortening length, hip joint Harris score, mobility and complications of the two groups were collected. The length of femoral neck shortening was the difference between the affected side and the normal side measured on the anteroposterior radiograph of the pelvis. The measured value of femoral neck shortening was the vertical direction of femoral neck shortening, that is, the difference between the measured value of the normal side and the affected side from the femoral head to the greater trochanter. Ficat method was used to classify avascular necrosis of femoral head [12]. The hip function was evaluated according to Harris hip joint score, and the score was given from four aspects of pain, function, deformity and movement, with a full score of 100 [13]. Nonunion was judged by Dhar criteria [14], that is, the fracture was still no union 6 months after surgery, no sign of union, internal fixation failure for 3 consecutive months, or internal fixation penetrated the femoral head. Mobility was assessed according to a 4-level walking scale, namely walking without any aids, walking with crutches, walking with a walker, and walking with a wheelchair [15].

Statistical analysis

SPSS 19.0 software (IBM Corporation, New York, USA) was used for statistical analysis. Count data were expressed in absolute logarithm and analyzed by χ^2 test. Measurement data were expressed as mean ± standard deviation. Levene test was used to test homogeneity of variance of data, and independent sample T test was used for comparison between the two groups. $P < 0.05$ was considered statistically significant.

Results

All patients were followed up for 2 years (Table 2). There was not significant difference in hospitalization time between the two groups ($P > 0.05$). The operation time, blood loss, incision length, times of fluoroscopy and the degree of femoral neck shortening in the DCLS group were significantly less than those in the DHS group (all $P < 0.05$). The Harris score of DCLS group was significantly higher than that of DHS group ($P < 0.05$). Femoral head necrosis occurred in 1 case and nonunion occurred in 1 case in the DCLS group, and all of them were operated again later. In the DHS group, 3 cases of femoral head necrosis and 1 case of nonunion occurred, and all of them were re-operated later. Although the complications in the DHS group were slightly higher than those in the DCLS group, there was not statistical significance ($P > 0.05$). In the DCLS group, 1 case of postoperative mobility decreased by 1 grade and 1 case decreased by 3 grades, and the rest were the same as the preoperative mobility. However, 4 patients of the postoperative mobility in the DHS group were one grade lower than that of the preoperative, and the rest were the same as the preoperative mobility. There was not significant difference in the postoperative mobility between the two groups ($P > 0.05$).

Table 2 Comparison of clinical data between the two groups

Data	DCLS group	DHS group	t/χ^2	*P*
Length of stay (days)	15.3±4.2	15.0±4.2	1.034	0.301
Operation time (min)	59.7±9.2	78.3±10.1	-55.477	0.000
Blood loss (ml)	51.1±7.4	66.4±18.0	-29.906	0.000
Incision Length (cm)	4.1±0.48	7.3±1.07	-33.921	0.000
Fluoroscopy (times)	18.5±1.6	22.5±1.6	-38.531	0.000
Femoral neck shortening length (mm)	6.9±1.4	8.6±2.0	-9.466	0.000
Harris score	92.4±6.0	89.7±9.1	11.740	0.000
Complications (cases)	2	4	0.952	0.329
Necrosis of femoral head	1	3		
Nonunion	1	1		
Mobility (cases)			3.089	0.213
Remained	24	20		
1 level down	1	4		
3 level down	1	0		

Discussion

No matter which treatment method is chosen, FNF has a significant impact on the quality of life of these patients, and brings a greater economic burden to society and families. Compared with hip replacement, internal fixation has become the main treatment method for FNF due to its advantages of less trauma, short operation time, less bleeding and low early mortality. The choice of surgical method should consider patient-related factors such as mobility, life expectancy, comorbidities and other fracture related factors such as fracture location, direction, and comminution [16]. The prognosis of FNF is uncertain.

Bone nonunion and necrosis of femoral head are recognized as serious complications after internal fixation of FNF, which often require reoperation. The type of fracture and improper treatment are considered to be the main factors leading to nonunion and necrosis of femoral head [17]. However, there is still a lack of consensus on which internal fixation method can better maintain the stability of fracture end, promote fracture healing, avoid and reduce postoperative femoral head necrosis, internal fixation failure and other complications.

Three cannulated screws can be used for compression fixation of the fracture, but they do not lock each other to form a frame structure. The resistance of the three cannulated screws to vertical shear force and rotation force is reduced, which could lead to the loosening and displacement of the fracture end, thereby increasing the risk of femoral head necrosis, femoral neck nonunion or malunion [18–20]. The distribution pattern of cannulated screws was greatly affected by the subjective effect of the surgeon, so the clinical efficacy of cannulated screws in the treatment of FNF was significantly different between related studies. Previous studies have found that the DCLS treatment of FNF is superior to the three cannulated screws, with the advantages of small surgical trauma, good stability, early healing time, high fracture healing rate, early postoperative functional rehabilitation, low complication of fracture healing, and good recovery of hip function [11].

DHS fixation has the dual function of dynamic and static compression, so the fracture ends can contact closely. DHS can withstand twice the compressive stress of cancellous bone screws and have a higher fixation success rate. The lateral steel plate provides good angulation stability. The sliding mechanism of lag screws transforms the shear force into compressive stress, which is beneficial to fracture healing. However, it has been pointed out in the literature that its large trauma, long force arm, stress concentration and eccentric fixation may lead to fracture of locking plate and screw, fracture of femur, femoral head cutting and varus of hip [21]. Poor rotational stability, especially when the hip screw is screwing in the femoral head, is easy to cause poor rotational alignment of the femoral head and neck [22]. DHS require greater soft tissue exposure and hip screw placement causes greater damage to the cancellous bone of the femoral head and neck, which disrupts the blood supply to the femoral head and neck and affects the healing of FNF.

DCLS is a new method of FNF fixation, which is in the initial clinical application stage. The main features are as follows. ▯ The positions of the three parallel cannulated screws are distributed on the triangular carina of the section of the axial screw placement of the femoral neck. These screws are close to the bone cortex at the highest and second highest bone density of the femoral neck, which conforms to the principle of "cortical support". Therefore, these screws have the characteristics of maximum screw dispersion and holding force with good biomechanical stability [10]. ▯ When the system inserts three cannulated screws, the three cannulated screws can apply axial and uniform pressure to the fractured end through the lateral plate. ▯ The system forms a triangular frame structure with good shear and torsion resistance. ▯ There is no thread in the middle of these screws of the system, so as to realize the dynamic compression of the fracture end after operation and promote the healing of the fracture.

Therefore, synthesizing the functions of the DCLS system, it is found that DCLS is the integration of three cannulated screws and DHS, which is further optimized and improved.

This study found that the operation time, blood loss, incision length, number of fluoroscopy, and shortening of the femoral neck in the DCLS group were significantly less than those in the DHS group, indicating that the DCLS group had simpler intraoperative procedures, less trauma, and better control of femoral neck shortening than those in the DHS group. The DCLS is equipped with an intraoperative guide. After the first guide needle is placed in the femoral neck in a good position, the remaining guide needles can be operated with the guide, which simplifies the surgical process and improves the accuracy of screw placement. At the same time, the trauma and the number of intraoperative fluoroscopy are reduced, so the operation time and intraoperative radiation exposure of patients are reduced. Previous studies also found that femoral neck shortening was a common complication of FNF in the DHS group [23–25]. DCLS is locked into a triangular frame structure, which has good postoperative stability and can axially and evenly compress the fracture end. On the one hand, it can promote fracture healing. On the other hand, the degree of shortening of the femoral neck is controlled so that it will not be excessively shortened.

In this study, 1 patient (3.8%) in the DCLS group had femoral head necrosis and 1 patient (3.8%) had nonunion. In the DHS group, 3 cases (12.5%) had femoral head necrosis and 1 case (4.2%) had nonunion. Although the complications in the DHS group were slightly higher than those in the DCLS group, there was not statistical significance ($P > 0.05$). The Harris score in the DCLS group was significantly higher than that in the DHS group, but there was not significant change in postoperative mobility between the two groups. A previous study found that about 11.3% of the cases of FNF in the DHS group had femoral head necrosis, and 9.4% of the cases had nonunion [26]. The rate of osteonecrosis of the femoral head in our study was similar to that of previous studies, but the nonunion rate was significantly lower than that in previous studies, which may be related to the study population, fracture type, reduction quality, and operators. Several studies have also found that DHS combined with anti-rotation screws for displaced FNF can prevent rotational displacement of the femoral head during hip screw placement, which could increase biomechanical stability, with better mechanical support, shorter operative time, less radiation exposure, and higher hip Harris score [22, 23]. DHS technique and cannulated cancellous screws technique are the two main fixation techniques for the treatment of FNF. The Meta-analysis study found that the nonunion rate of the cannulated cancellous screws group was significantly higher than that of the DHS group, but there was no difference in the incidence of femoral head necrosis between the two groups. For vertically oriented FNF, the DHS technique is more favorable than the cannulated cancellous screws technique, with a lower risk of nonunion [27]. The DCLS group had a higher Harris score, a lower incidence of femoral head necrosis and nonunion than those in the DHS group, which may be related to the excellent characteristics such as the better stability of the "cortical support", triangular frame structure, intraoperative uniform compression and postoperative uniformly dynamic pressure.

Limitations

In this study, the incidence of femoral head necrosis and nonunion in the DCLS group was lower than that in the DHS group, but there was not statistical significance, which was compared with the small number of cases in these groups. So further large sample research is urgently needed. The retrospective analysis is prone to data bias. Moreover, this study was a preliminary single-center study of this system. In order to further verify the clinical efficacy of DCLS, further multi-center randomized, controlled, and double-blind clinical trials are required.

Conclusions

DCLS is superior to DHS in the treatment of FNF, with advantages of less surgical trauma, simplified surgical procedures, lower radiation exposure dose for patients, good stability of internal fixation and better control of femoral neck shortening. However, there is not significant difference in fracture healing complications, which requires further study.

Abbreviations

FNF: Femoral neck fractures; DCLS: Dynamic compression locking system; DHS: Dynamic hip screw

Declarations

Ethics approval and consent to participate

This study was approved by the institutional review boards/Ethics Committees of CR & WISCO General Hospital and Tongren Hospital of Wuhan University, and was conducted in compliance with the ethical principles of the Helsinki Declaration of 1975. Informed consent was obtained from all subjects.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

No potential conflict of interest relevant to this article was reported.

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Authors’ contributions

All authors made substantive intellectual contributions in this study to qualify as authors. X Y-P and B M-J designed this study. C J-Z and L L participated in collecting and analyzing raw materials. B M-J and X Y-P played an important role in statistical analysis and language editing. An initial draft of the manuscript was written by C J-Z and L L. X Y-P re-drafted parts of the manuscript. X Y-P and B M-J provided helpful advice on the final revision. All authors were involved in writing the manuscript. All authors read and approved the final manuscript.

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Figures

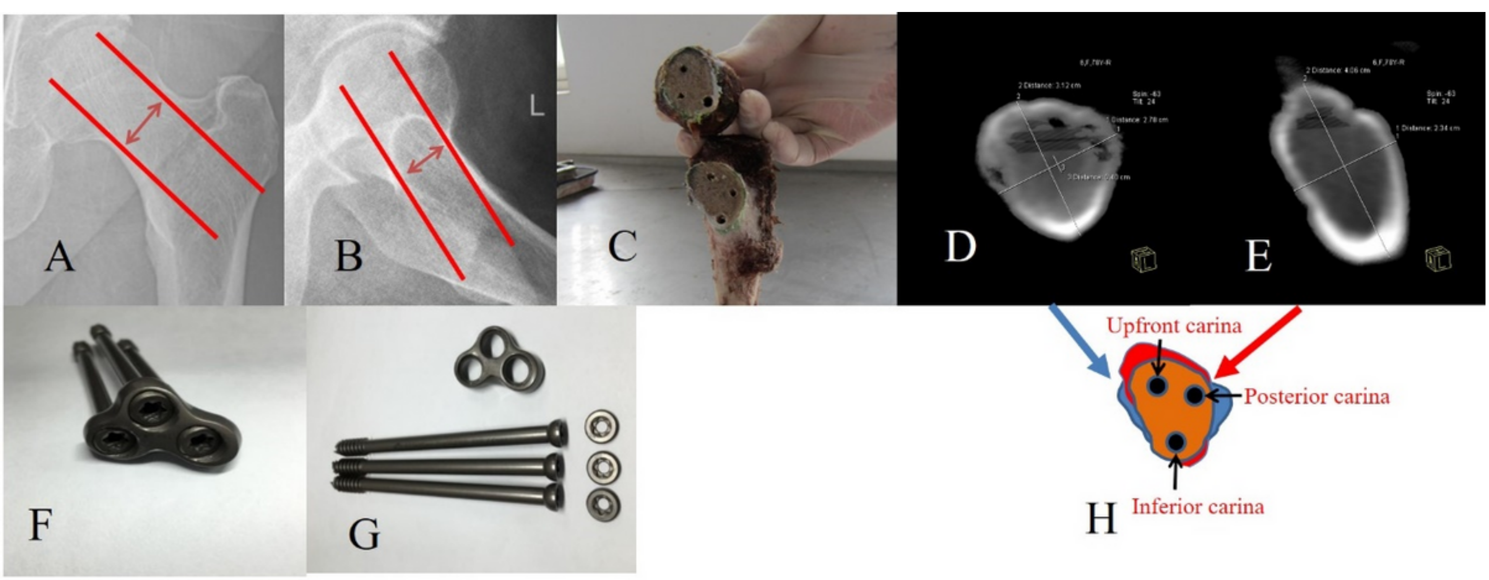

Figure 1

The triangular carina structure of the femoral neck and the composition of the DCLS system. A: The shortest distance between the upper and lower diameter of the femoral neck; B: The shortest distance between the anterior and posterior diameter of the femoral neck; C: The structure of the triangular carina and the position of the screws in the anatomical specimen; D: CT scan specimen showing cross-section of the minimum upper and lower diameter of the femoral neck; E: CT scan specimen showing the cross-section of the shortest distance of the anteroposterior diameter of the femoral neck; F and G: Components of the DCLS system; H: D+E cross-sections overlap to form a shared cross section of the femoral neck (saffron yellow area), triangular carina structure and screws placement (black circle)