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Original Article

Internal fixation with cancellous bone screws is effective for femoral neck fractures by lowering the incidence of femoral head necrosis

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Abstract: Aims: The present study is to evaluate the effect of internal fixation with cancellous bone screws in the treatment for femoral neck fractures. Methods: A total of 64 patients with femoral neck fractures hospitalized at our hospital from January 2014 to December 2014 were included in the present study. The 64 patients were randomly divided into Con group (internal fixation by thread needles; n = 32) and Mod group (internal fixation by cancellous bone screws; n = 32). Bone mineral density was determined before surgery. At 0, 1, 3, 6, 10 and 12 months after the surgery, computed tomography was performed on pelvis. In addition, surgery duration, intraoperative blood loss, fracture healing time and rate of femoral head necrosis were measured. Results: The fracture lines in Mod group became more blurred than Con group with time, together with the formation of callus. CT values in Mod group were significantly increased compared with Con group. Treatment with cancellous bone screws reduced the blood loss during surgery, as well as the time used for surgery and fracture healing. Cancellous bone screws caused lower incidence of femoral head necrosis than thread needles. Conclusions: Internal fixation with cancellous bone screws reduces the blood loss during surgery, as well as the time used for surgery and fracture healing. In addition, it is effective in the treatment for femoral neck fractures by lowering the incidence of femoral head necrosis.

Keywords: Internal fixation, cancellous bone screws, femoral neck fracture, femoral head necrosis

Introduction

According to Melton et al., the number of hip fracture cases in 1990 around the world was 10,000, and this number will increase to 4,000,000 in 2025 and 6,300,000 in 2050 [1]. In USA, the number of old people who suffer from hip fracture will increase to 500,000 in 2040 [2]. It is reported that femoral neck fracture cases accounts for 51.97% of all proximal femoral fracture cases, with the percentage of female patients being higher than that of male patients [3]. Bone fractures can easily affect old people due to their various degrees of osteoporosis. Some reports show that the degrees of osteoporosis are related to the degrees of comminuted fractures and the firmness of internal fixation [4, 5]. By contrast, Raaymakers et al. report that the effect of internal fixation for femoral neck fractures is not significantly correlated to bone mineral density [6]. In addition, Soontrapa et al. show that Singh index that is used for the determination of osteoporosis has no clinical value for the prediction of fracture healing [7]. Femoral shaft fractures combined with femoral neck fractures are often missed during diagnosis, reaching a missed diagnosis rate of 30% [8]. In addition, computed tomography (CT) can detect bone structure changes in femoral head, and has values for the prediction of collapse after the diagnosis of femoral head necrosis [9]. The incidence of ischemic necrosis of femoral head after femoral neck fracture is related to age, gender, types of femoral neck fracture, revascularization at fracture site, and internal fixation [10]. Internal fixation materials and their locations can affect blood supply of femoral head [11]. When the internal fixation materials are placed above the outside of femoral head, lateral epiphyseal artery may be hurt [12]. Internal fixation materials such as three-wing screws

Table 1. Basic and clinic information of all subjects

No. of subjects		Con group	Mod group
Gender	Male	24	24
	Female	8	8
Age (years)	35-38	15	16
	39-42	17	16
Other diseases	Yes	0	0
	No	32	32
Infections	Yes	0	0
	No	32	32
Multiple fractures	Yes	0	0
	No	32	32

Note: No statistically significant differences were found between the groups.

Table 2. Bone mineral density of patients (g/cm^2, means ± SD, n = 32)

Groups	Bone mineral density
Con group	1228 ± 0.94
Mod group	1220 ± 0.87

Note: No statistically significant differences were found between the groups.

may separate the fracture end, and repeated knocking may cause bone injury [13]. Multi-needle and multi-screw therapy for femoral neck fractures can reduce damages on blood supply in femoral head, and has been widely accepted in clinical practice [14]. For example, thread needles increases the compressive stress between broken ends of fractures, and the fixing nut at the end of the needle is anti-skidding. Because the size of the needle is small, it is not necessary to cut articular capsule open and hence, reducing its effect on blood circulation. However, thread needles induces pain underneath the skin. Cancellous bone screws prevent rotation, and add pressure. Therefore, these screws can prevent the separation of broken ends, and reduce damages on blood circulation in femoral neck. In the present study, we investigate the effect of cancellous bone screws during the treatment of femoral neck fractures.

Material and methods

Patients

A total of 64 patients (aged 35-42 years) with femoral neck fractures hospitalized at our hospital from January 2014 to December 2014 were included in the present study (**Table 1**). All femoral neck fractures were induced by trauma. All patients were healthy before fractures, and received preoperational examinations before hospitalization. None of the patients had diseases that affect fracture healing. The 64 patients were randomly divided into Con group (internal fixation by thread needles; n = 32) and Mod group (internal fixation by cancellous bone screws; n = 32). Bone mineral density in the two groups was not significantly different from each other (**Table 2**). All procedures were approved by the Ethics Committee of Ningxia Medical University. Written informed consents were obtained from all patients or their families.

CT

At 0, 1, 3, 6, 10 and 12 months after the surgery, CT and volume rendered technique of the pelvis were performed (MEDIX90, MEDILINK, Perols, France). The scanning parameters were 120 kV, 220 mA, 5 mm thickness, and pitch 1. The following equation was used to calculate CT values: CT = α × (μm-μw)/μw (μm, attenuation coefficient of the material; μw, absorption coefficient of water; α, dividing factor). Pixels in CT scans are shown by relative radiodensity. The pixel is displayed according to the mean attenuation of bone tissues that it corresponds to on a scale from +3071 (most attenuating) to -1024 (least attenuating) on Hounsfield scale. Hounsfield unit values are a measurement of the standardized linear attenuation coefficient of tissue, based on a defined scale of 0 for water and -1000 for air. Cancellous bone is +400 HU, and cranial bone can reach 2000 HU or more. Higher CT values correspond to better bone fracture healing.

Surgery

After general anesthesia, the patients lay down in supine position. Tensor fascia was cut off, and lateral femoral muscle was separated before exposure of fracture site. A piece of steel plate was placed on the surface of the bone, and held by a bone holder. After repositioning of fracture ends, the position of screw hole was checked, and the steel plate was temporarily fixed at the fracture site. If the position was optimal, screws were screwed in. Then, closed replacement of femoral neck fractures

Table 3. CT values of each group at different time points (Hu, means ± SD, n = 22)

Groups	CT values					
	0 M	1 M	3 M	6 M	10 M	12 M
Con	382.0 ± 2.8	421.3 ± 2.7#	453.6 ± 2.7#	493.0 ± 2.8#	513.0 ± 2.6#	524.0 ± 1.9#
Mod	382.1 ± 3.6	443.5 ± 1.4*,#	463.7 ± 2.0*,#	512.1 ±3.7*,#	522.1 ± 2.7*,#	535.2 ± 1.7*,#

Note: *P < 0.05 compared with Con at the same time point. #P < 0.05 compared with the same group at 0 M time point.

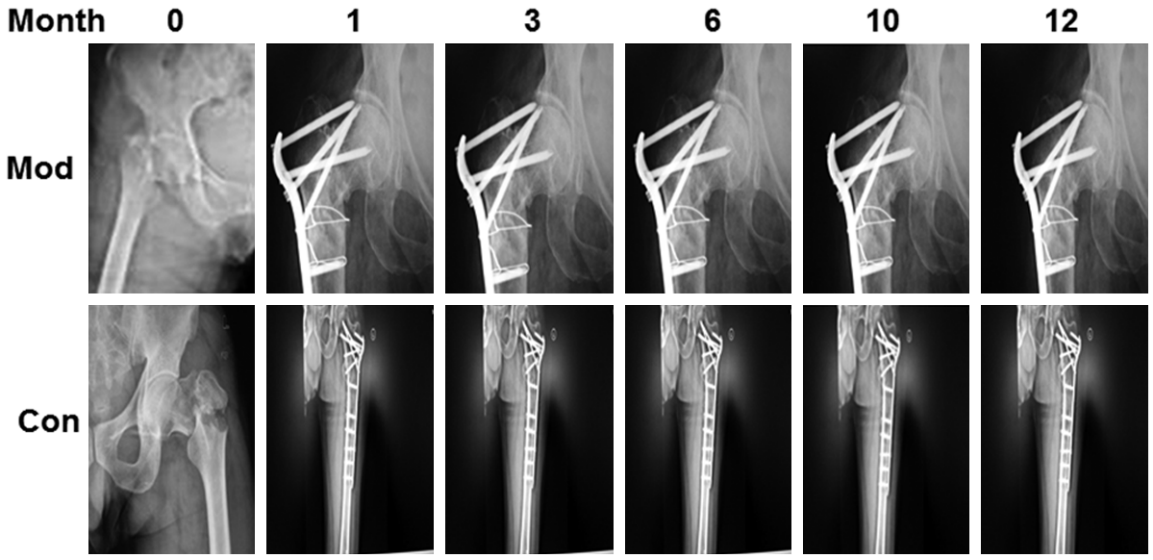

Figure 1. Computed tomography of femoral neck fractures. Con group, internal fixation by thread needles (n = 32); Mod group, internal fixation by cancellous bone screws (n = 32). The images were taken at 0, 1, 3, 6, 10 and 12 months after the surgery.

was performed by traction, followed by fixation of a locating pin at 2 cm below the highest point outside the greater trochanter along femoral neck midline. Subsequently, three guide pins were applied before tapping. At last, three hollow cancellous bone screws were screwed in.

Postoperative treatments

After the surgery, the affected limb was kept raised. In addition, antibacterial drugs were used for 2-3 days, and should be changed within 24 h in case of too much exudant at the wound. On day 14, stitches were removed. Two weeks after surgery, functional training of the ankle of the affected limb was performed. Four weeks after surgery, the patients performed partial weight bearing walking with the help of crutches. Four to six months after surgery, the patients began full weight bearing walking.

Follow-ups

All 64 patients were followed up for 10 to 12 months at month 1, 3, 6, 10, and 12 after the surgeries. Follow-ups included examinations of the firmness of internal fixation, inflammation, malunion, nonunion or femoral head necrosis.

Statistical analysis

All data were analyzed using SPSS13.0 software (IBM, Armonk, NY, USA). Count data were expressed as rates. Differences between two groups were compared using χ^2 test. $P < 0.05$ was considered statistically significant.

Results

Treatment with cancellous bone screws has better femoral neck fracture repair than treatment with thread needles

To examine the levels of femoral neck fractures, CT was performed on pelvis. The data showed trabecular bone disorder at weight-bearing surface of the femoral head and partial absorption at early stage. CT showed that the crescent sign was composed of three layers. Sequestrum was located in the center, and surrounded by

Table 4. Surgery duration, intraoperative blood loss and fracture healing time

Groups	N	Surgery duration (min)	Intraoperative blood loss (ml)	Fracture healing time (months)
Con	32	421.3 ± 2.7	453.6 ± 2.7	7.3 ± 2.8
Mod	32	328.5 ± 1.4*	236.7 ± 2.0*	4.2 ± 3.7*

Note: *P < 0.05 compared with Con group.

transparent bone resorption zone that was encompassed by new bone and sclerotic bone. At late stage, collapse deformation occurred in the femoral head, with low density region being in the center. In addition, shell-shaped fracture sheets appeared below articular cartilage, acetabular labrum was prominent, and dysarthrosis might be observed. On admission, all patients had obvious fracture lines, and the CT values of bone tissues were not significantly different between the two groups (P > 0.05) (**Table 3**). Of note, the fracture lines in Mod group became more blurred than Con group with time, together with the formation of callus (**Figure 1**). Furthermore, the CT values in Mod group were significantly increased compared with Con group (P < 0.05) (**Table 3**). These results suggest that treatment with cancellous bone screws has better femoral neck fracture repair than treatment with thread needles.

Cancellous bone screws reduces the blood loss during surgery, as well as the time used for surgery and fracture healing

To evaluate the efficiency of the two treatment methods, we calculated the surgery duration, intraoperative blood loss and fracture healing time. The data showed that Mod group had significantly shortened surgery duration than Con group (P < 0.05). In addition, the blood loss in Mod group was nearly half of that in Con group (P < 0.05). Furthermore, fracture healing time in Mod group (4.2 ± 3.7 months) was dramatically decreased compared with Con group (7.3 ± 2.8 months) (**Table 4**). These results indicate that treatment with cancellous bone screws reduces the blood loss during surgery, as well as the time used for surgery and fracture healing.

Cancellous bone screws cause lower incidence of femoral head necrosis than thread needles

To test which of the two treatment methods has more severe adverse effects, we measured the incidence of femoral head necrosis. The data showed that the number of patients with femoral head necrosis in Mod group was smaller than that in Con group. Of note, with the prolongation of time, the increase of the number of patients with femoral head necrosis in Mod group was smaller than that in Con group (**Figure 2**). The result suggests that cancellous bone screws cause lower incidence of femoral head necrosis than thread needles.

Discussion

There are three types of classification of femoral neck fractures, and the most widely used type in the world is Garden type, which reflects the degree of fracture damage and the stability of the broken end [15]. Some doctors suggest classifying Garden type I and type II into stable type, and Garden type III and type IV into displacement type. Mao et al. show that the degree of fracture displacement is related to avascular necrosis of femoral head and late collapse of femoral head, but no significant difference exists between Garden types I/II and Garden types III/IV [16]. In addition, Eliasson et al. [17] and Holmberg et al. [18] suggest classifying femoral neck fractures into non-displacement type and displacement type.

The blood supply of femoral head is from arterial loop outside articular capsule, and formed by branches of the inside and outside lateral femoral arteries. When displacement occurs in femoral neck fractures, blood supply can be easily damaged [19-22]. Avascular necrosis of femoral head occurs at the late stage of femoral neck fractures, in which blood circulation in femoral head may be partially or completely damaged. A study shows that the rate of femoral head necrosis in cases with femoral neck shortening is significantly higher than normal subjects [23]. In addition, pressures induced by femoral neck shortening reduce blood supply for femoral head, facilitating femoral head necrosis and late collapse [11, 12]. In addition, shortened femoral head reduces hip abduction [13]. Of note, insufficient bone mass after relocation may cause losses of relocation and ineffectiveness of internal fixation material [14, 24]. Therefore, restoration of bone length and mass is crucial for the relocation of femoral neck fractures.

Aging is considered as an independent risk factor for femoral neck fractures [25, 26]. Thinning

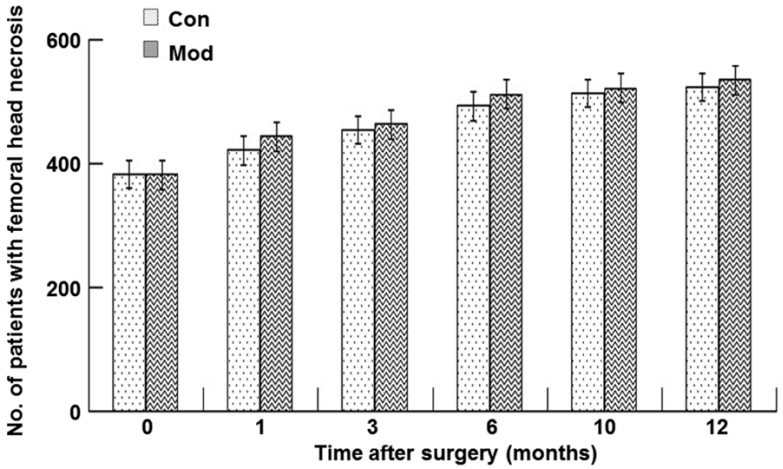

Figure 2. Number of patients with femoral head necrosis at 0, 1, 3, 6, 10 and 12 months after the surgery for femoral neck fractures.

of femoral neck cortical thickness is a key reason for femoral neck fractures in old people [27]. In the present study, we chose patients aged between 35 and 42 to reduce the possibility that the healing of femoral neck fractures is affected by age. Of note, bone mineral density is not significantly different between the two groups in the present study.

In the present study, we compared the effects of thread needles and cancellous bone screws in the treatment of femoral neck fractures. Cancellous bone screws have strong bite force, and three screws together prevent rotation and add pressure. Our data show that the clinical healing time in Mod group was shorter than Con group, suggesting that cancellous bone screws enhance fracture healing rate. In addition, the rate of femoral head necrosis in Mod group was smaller than Con group, indicating that cancellous bone screws can reduce femoral head necrosis rate. Furthermore, the surgery duration and blood loss in Mod group was less than Con group, suggesting that internal fixation with cancellous bone screws uses less surgery time and causes less blood loss.

After femoral neck fractures, the patients should stay in bed for 3-12 weeks. At the same time, prevention of complications and enhancement of functional training will be very important for bone fracture healing [28, 29]. In conclusion, femoral neck fractures have high incidence and various treatment methods. However, the effect of treatments is dependent on various factors like age, fracture type, bone mass, and accompanied diseases [30-34]. Finding an economic and effective treatment method is a challenge facing all doctors. Use of cancellous bone screws may be of help in enhancing treatment effects for femoral neck fractures and reducing femoral head necrosis.

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Disclosure of conflict of interest

None.

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