A Comparative Study on the Effect of Cemented and other Different Biological Type of Artificial Femoral Head Prosthesis in the Treatment of Intertrochanteric Fractures in the Elderly

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Research article

Keywords: cemented type of femoral head, intertrochanteric fracture, biological artificial type of femoral head, hip replacement

Posted Date: August 21st, 2020

DOI: https://doi.org/10.21203/rs.3.rs-37476/v1

Abstract

Background: The aim of this study is to assess comparatively the clinical effect of cemented and other biological type of artificial femoral head in the treatment of intertrochanteric fractures of the femur in elder patients.

Methods: The clinical data of 121 patients with unstable intertrochanteric fractures treated with hip replacement from July 2017 to December 2018 in our hospital were reviewed.

Results: There were 121 patients with unstable intertrochanteric fracture received hip replacement enrolled in this study. Of those patients, 60 patients received bone cement femoral prosthesis (bone cement group), while 61 cases (62 hips) received biological femoral prosthesis (biological group). The results showed that the biological group treated had shorter operation time, less intraoperative bleeding and longer time of complete weight-bearing than the bone cement group ($P < 0.05$), but there was no significant difference in the time of partial weight-bearing and Harris score of hip joint function between the two groups ($P > 0.05$).

Conclusion: The cemented and biological artificial type of femoral head might lead to satisfactory short-term results in the treatment of intertrochanteric fractures for elder patients. Results showed that the biological group had shorter operation time, less intraoperative bleeding and longer time of complete weight-bearing than the bone cement group. For the unstable intertrochanteric fracture of femur with severe osteoporosis and difficult to maintain stability after fracture reset, biological femoral prosthesis stems might be employed for the treatment of artificial hip replacement according to the shape of the proximal femoral cavity, the quality of bone and the range of fracture coverage, which may promote the recovery of hip joint function and obtain good clinical effect.

Background

Intertrochanteric fracture is one of the most common hip fractures in the elderly. With the development of the aging population, the incidence of intertrochanteric fracture is on the rise [1]. At present, there are about 1.6 million patients in the world every year, and it is estimated that by 2050, the number of patients with an intertrochanteric fracture will over 6.3 million [2–3]. Surgical treatment has gradually become the first choice of treatment. Patients who experienced surgical treatment may start functional exercise early, have fewer complications and mortality [4]. The elderly patients with intertrochanteric fractures often have different degrees of osteoporosis, and the fractures are often comminuted and unstable, which may result in the failure of open reduction with internal fixation [5]. However, joint replacement may improve the recovery of limb length, joint function, and the early complete weight-bearing. There was growing evidence indicating that artificial joint replacement was the main choice and even the first choice for the treatment of intertrochanteric fractures in the elderly [6–7]. However, the selection of bone cement and biological type of femoral head in the treatment of intertrochanteric fracture for elder patients remained controversial. The purpose of this study was to compare the clinical effect of cemented type of the

prosthesis with the biological type in the treatment of intertrochanteric fractures of the elderly and to provide guidance for the selection of clinical operation. Thus, one Hundred and twenty-one elder patients (122 hips) with unstable intertrochanteric fractures of the femur since July 2017 to December 2018 in our hospital were reviewed retrospectively.

Patients And Methods

1. Patients

Patients who received the femoral head replacement in our hospital from July 2017 to December 2018 were analyzed retrospectively. The inclusion criteria were as follow: (1) age > 75 years old, (2) patients with comminuted and unstable intertrochanteric fracture of femur, (3) patients suffered from osteoporosis (4) patients who were unsuitable for internal fixation and unable to tolerate long-term bedridden; (5) patients with some degree of walking ability before injury; (3) available medical history and X-ray film to support the diagnosis standard of intertrochanteric fracture of femur (Evans □, □, □); (6) patients who have been followed up for more than one year. This study was approved by the ethics committee of our hospital and written informed consent from all patients were obtained.

2. Surgical treatment

The surgical treatment was performed by the same group of doctors. The femoral head replacement was performed by using epidural or general anesthesia. The third-generation of bone cemented technology was used in the bone cemented group and the conventional or lengthened femoral prosthesis was used in the biological group.

2.1 Preoperative preparation: In the biological group, in order to improve the operating tolerance of elderly patients, routine cardiopulmonary function tests, special examination, and treatment of the original coexisting diseases were indispensable. The average time from injury to operation was 3.3 days. Patients with the cardiopulmonary disease were treated with an active improvement of cardiopulmonary function. The blood pressure was controlled below 160 / 95 mmHg and fasting blood glucose was controlled below 8.0 mmol / L. In addition, patients with the electrolyte disorder, malnutrition and hypoproteinemia received treatment and the liver and kidney functions were assessed. Antibiotics were used one hour before the operation.

2.2 Surgical procedure: The patient lied in the healthy side position. The modified posterolateral approach was performed. We performed a slightly arc-shaped incision along the lower edge by took the surface of the great trochanter of the femur as the center, and 2 / 3 of the incision is located at the lower edge of the great trochanter. We expose the trochanter part following the blunt separation of the gluteus maximus muscle fiber. The separation and displacement of the big and small trochanter fractures were then evaluated. Then, we cut the bone at the predetermined plane of the femoral neck and took out the femoral head. In the total hip replacement group, biological acetabulum prosthesis was implanted. The proximal femur at 15 ° forward was opened and the marrow was reamed in turn. We then hit and install the

appropriate head and neck test mold of the femur handle, and test the anteversion angle, eccentricity, limb length and joint tightness. We selected the matching femur prosthesis handle and insert it into the medullary cavity of the upper femur to achieve the best initial stability. The femoral calcar was compressed and reduced by beating the dummy handle. If the femoral calcar was restored and fixed firmly, other forms of internal fixation may not be added. The large and small trochanteric fractures can be reduced to the anatomic position as far as possible with the support of the prosthesis handle. The free small trochanteric fractures can be fixed by stainless steel wire encircling. However, the large trochanteric fractures can be fixed by Kirschner wire or absorbable suture. In this process, the circumflex muscle and quadrilateral joint capsule flap can be sewed back to the original position of the femur by the way of drilling and threading. We washed and layer by layer and suture the incision if no signs of dislocation development when knee flexion, hip flexion and adduction of the affected limb. In the bone cemented group, bone cement was firstly poured into the medullary cavity of the proximal femur (using the third-generation bone cement technology), and then the femoral stem prosthesis was inserted into the medullary cavity of the upper femur.

2.3 Postoperative treatment: Patients received routine use of antibiotics for 48 hours, and analgesic treatment [8]. Low molecular sodium heparin was used routinely to prevent the occurrence of deep vein thrombosis. Intermittent compression equipment was used to move the affected limb early after operation. On the first day after the operation, we begun to exercise the lower limb function in bed. We encouraged patients to stand and move out of bed as early as possible if the patient's physical condition can bear the pain. Usually, on the fourth day after the operation, the patients were standing with partial weight.

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3. Parameters and statistical analysis

The operative time, intraoperative hemorrhage, partial weight-bearing time and complete weight-bearing time were compared between both groups. Harris score of hip joint function at 6 and 12 months postoperatively was recorded. For the comparison of parameters in two groups Chi-square test for categorical variables and t-test for continuous variables was used. All statistical analyses were performed on SPSS version 25 (IBM Corporation, Armonk, NY). Statistical significance was set at $p \leq 0.05$ with two-tailed.

Results

A total of 121 patients with unstable intertrochanteric fractures treated by hip replacement from July 2017 to December 2018 enrolled in the present study. Of those patients, 60 patients received bone cemented type of femoral prosthesis (bone cement group), while 61 patients (62 hips) experienced biological femoral prosthesis (biological group). In the cemented group, there were 60 patients, 28 males and 32 females. The mean age was 81 ± 6 years old. The mean height and weight were 167 ± 8 cm and 61 ± 8 kg, respectively. There were 23 patients with type III, 28 patients with type IV, and 9 patients with

type V according to Evans Jensen classification. In the cemented group, the most common complication was hypertension (19 patients), followed by diabetes (15 patients), chronic obstructive pulmonary disease (8), coronary heart disease (7 patients), cerebral infarction (5 patients). In the biological type group, 61 patients (62 hips), 25 males and 36 females. The mean age was 82 ± 8 years old. There were 9 patients with type III, 33 patients with type IV and 19 patients type V according to Evans Jensen classification. The most common complication in the biological group was diabetes (18 patients) followed by hypertension (10 patients), chronic obstructive pulmonary disease (6 patients), coronary heart disease (5 patients), old cerebral infarction (3 patients). There was no significant difference between the two groups in gender ($\chi 2 = 0.875$, $P = 0.374$), age ($t = 0.951$, $P = 0.352$), height ($t = 0.856$, $P = 0.421$), weight ($t = 0.776$, $P = 0.394$), fracture type ($\chi 2 = 0.825$, $P = 0.279$), and complications ($\chi 2 = 0.793$, $P = 0.473$).

In the cemented group, the operation time was (52 ± 8) min, intraoperative bleeding volume was (212 ± 49) ml, partial weight-bearing time was (4 ± 1) d, and complete weight-bearing time was (36 ± 14) d. In the biological group, the operation time was (42 ± 7) min, intraoperative bleeding volume was (152 ± 20) ml, partial weight-bearing time was (4 ± 1) d, and complete weight-bearing time was (56 ± 6) d. Compared with the cemented group, the biological group had shorter operation time ($t = -5.230$, $P < 0.001$), less intraoperative bleeding ($t = -5.370$, $P < 0.001$), longer complete weight-bearing time ($t = -6.950$, $P < 0.001$), but no significant difference in partial weight-bearing time ($t = 0.050$, $P = 0.840$, Table 1). In the cemented group, there were 2 patients developed wound infection, 2 patients with bone cement implantation syndrome following surgical treatment. Of those 2 patients with bone cement implantation syndrome, all of them experienced shock, one patient was rescued successfully, while the other patient eventually developed to multiple organ failure and died; There were 2 patients with postoperative pulmonary infection recovered after anti-infection treatment. In the biotype group, 2 patients suffered from early postoperative pulmonary infection and recovered after anti-infection treatment. Moreover, 3 patients experienced thigh pain.

Table 1
Comparison of operation time, intraoperative blood loss, partial weight-bearing time and complete weight-bearing time between the two groups.

Groups	Operation duration(min)	Intraoperative blood loss(ml)	Partial weight-bearing time after operation (days)	Time of complete weight-bearing after operation (days)
Cemented group	52 ± 8	212 ± 49	4 ± 1	36 ± 14
Bioloigical group	42 ± 7	152 ± 20	4 ± 1	56 ± 6
T value	-5.23	-5.37	0.05	-6.95
P value	0.001	0.001	0.84	0.001

There were no complications including loosening, fracture, infection around the prosthesis, instability of joint, dislocation, and injury of blood vessels and nerves during the follow-up period of one year. Harris score of hip joint function at six months after operation: bone cement group was excellent in 13 patients, good in 36 patients, fair in 11 patients, the rate of excellent and good was 81.7%; the biological group was excellent in 14 patients, good in 38 patients, fair in 9 patients. The rate of excellent and good was 85.2%. There was no significant difference in the Harris score of hip joint function at six months after operation between the two groups ($\chi 2 = 0.783$, $P = 0.357$). Harris score of hip joint function at 12 months after operation: bone cement group was excellent in 14 patients, good in 36 patients, fair in 10 patients. The rate of excellent and good was 83.3%; while the biological group was excellent in 15 patients, good in 38 patients, fair in 8 patients. The rate of excellent and good was 86.9%. There was no significant difference in the Harris score of hip joint function at 12 months after operation between the two groups ($\chi 2 = 0.879$, $P = 0.473$, Table 2).

Table 2
Comparison of Harris scores between the two groups in 6 months and 12 months after operation.

Groups	Harris scores 6 months after the operation	Harris scores 12 months after the operation
	Excellent and good rate (%)	Excellent and good rate (%)
Cemented group	81.7	83.3
Biological group	85.2	86.9
$\chi 2$	0.783	0.879
P value	0.357	0.473

In the biological group, 61 patients (62 hips) achieved biocompatibility immediately after the operation, and 12 patients with total hip replacement achieved good biocompatibility. Six months after the operation, the fixation effect of the femoral stem was good, and all patients were stable bone in growth according to Engh fixation/stability standard [9]. In the cement group, the bone cement filling around the femoral stem prosthesis was satisfactory.

Discussion

Intertrochanteric fracture is one of the common types of fracture in the elderly. The choice of treatment method of intertrochanteric fracture for elder patients is still controversial due to several factors such as bone condition, complications and poor physical quality that cannot tolerate high-risk surgery [10]. For Evans Jensen type I and II fractures with stable classification, internal fixation can be conducted. However, internal fixation is not effective for unstable type III, IV and V fractures because of the combination of osteoporosis, which often leads to the failure of internal fixation [5]. Hip arthroplasty has become an effective treatment for unstable intertrochanteric fractures in the elderly. In elderly patients

with unstable intertrochanteric fractures, hip replacement is performed after the failure of internal fixation. Osteoporosis is further aggravated because of the failure of internal fixation, which may occur when the internal fixation device is removed leading to fracture during operation. It was not conducive to implant of prosthesis if the anatomical structure of proximal femur changed; Cutting scar tissue to expose internal fixation device during operation may increase blood loss, prolong operation time, further aggravate the original complications, or generate new complications, which may lead to serious adverse consequences and affect the postoperative recovery [11]. Therefore, for the elderly intertrochanteric fractures who were suitable for hip replacement, one-stage hip replacement should be performed. In general, hip replacement with the artificial femoral head (Hemi hip replacement) is the main treatment for unstable intertrochanteric fractures in the elderly. For those patients with osteonecrosis of the femoral head, failure of internal fixation may lead to acetabular joint surface injury, osteoarthritis of the hip, rheumatoid arthritis, etc., which affect the function of the hip joint. Patients with large amounts of activity before the injury, good general condition, and good tolerance to surgery might receive a hip replacement.

The cemented prosthesis is more likely to be used in the early stage because of the cemented prosthesis may generate a combination and fixation between the upper femur and the prosthesis through the cement, which provided immediate mechanical stability, and facilitated the early bed-out activity after surgery. However, bone cement may cause a toxic reaction, which is associated with a syndrome of prosthetic implantation. The toxic reaction of prosthetic implantation may become a fatal complication in elder patients [12]. In recent years, with the improvement of the stem design of biological artificial hip joint prosthesis and the technology of the artificial joint replacement, hip joint replacement with biological prosthesis has a good clinical effect in elder patients [13–14]. Morshed,et al[15] indicated that biological femoral prosthesis has been used for the treatment of patients with unstable intertrochanteric fractures. Their results showed that no significant difference in the early activity between biological and cemented groups and biological fixation is more suitable for patients with better physical conditions.

The biological prosthesis for the replacement of the femoral prosthesis primarily based on the shape of the proximal femoral cavity, the quality of the bone and the range of the fracture. Conventional femoral treatment may be suitable for patients with Dorr type B of the proximal femoral cavity and unstable intertrochanteric fracture involving only small trochanter or above. The conventional full coated tapered handle can stabilize the prosthesis in the cavity through the contact and compression of the proximal femoral intima. The small trochanter fracture can be fixed with or without wire encircling. The large trochanter fracture can be fixed with Kirschner wire tension band fixation with steel wire or absorbable suture, which may restore the tension of the gluteus medius muscle to maintain the stability of the hip joint.

For the unstable intertrochanteric fracture with Dorr type B of proximal femur medullary cavity, the fracture range is below the trochanter. The fracture and compression of the inner and outer bone of proximal femur may result in different degrees of cortical bone defects at the same time. As for the small trochanter fracture, which has lost major stress-bearing part, and the force line can not be carried on by the small trochanter femur pitch [16], as a result, it is necessary to select a biological prosthesis with

good filling effect and enough fixed length. The lengthened and biological femoral stem may increase the contact area and interface length between the femur and the prosthesis and the widely coated prosthesis may be conducive to bone growth, which have a role of intramedullary fixation in the bone defect between the trochanter and the proximal femur, help the fracture healing, increase the stability of the prosthesis, disperse the stress from the proximal part of the prosthesis to the distal part of the femur, avoid the concentrated stress of the proximal part of the fracture, and reduce the risk of the prosthesis penetrating the medullary cavity of the femur, loosening and sinking.

For the type C of femoral intertrochanteric unstable fracture with a funnel-shaped proximal medullary cavity; Wagner prosthesis was employed to fill and fix the medullary cavity. The long and bulky biological femoral stem prosthesis was identified as a special intramedullary fixation device. The stability of the femoral stem prosthesis was obtained by filling and locking stress between the lengthened femoral stem and the inner wall of the femoral medullary cavity. The mechanical conduction function of the bone was lost due to the destruction of the integrity and continuity of the bone structure of the proximal femur after the intertrochanteric fracture. In addition, the traditional biological femoral stem lost its stability without bony support. The biological stem prosthesis with enough fixed length and good pulp cavity filling effect was the best choice, which may increase the length of the femoral stem, and then the stress concentration range of the prosthesis moved and expanded. The rigid fixation of the femur with widely coated prosthesis was achieved by enlarging the range of fixation. The filling degree and strength of the distal end of the lengthened and biological prosthesis are much higher than that of the traditional prosthesis. The bone loss of the proximal femur was much more than that of the backbone in patients with osteoporosis. The lengthened biological prosthesis can stabilize the prosthesis by filling and locking the distal end of the prosthesis and the medullary cavity of the femur. A little displacement of the prosthesis after biological hip replacement may lead to immediate stability, and secondary stability can be achieved through bone ingrowth[17].

Conclusion

The results of the present study showed that the cemented and biological type of artificial femoral head replacement may result in favorable short-term results in elder patients with intertrochanteric fractures. The fixation stability in the cemented group was better than the biological group, while the risk of cement implantation syndrome was higher than the biological group. Replacement with biological femoral head had the advantages of shorter operation time, less bleeding and higher safety than a cemented prosthesis. Furthermore, we suggested that elder patients with conventional osteoporosis but not extremely serious osteoporosis with the femoral cortex might receive the biological femoral prosthesis for the treatment of the unstable intertrochanteric fractures. It is very important to perform individualized treatment based on the different complexity of the fracture. Moreover, a biological prosthesis should be chosen for the treatment of unstable intertrochanteric fractures in the elderly.

Declarations

Acknowledgements

None

Authors' contributions

Fu Jia and Junmin Li: Planning, collection of data, and data analysis. Writing of manuscript. Zhongzi Zhang, Fu Jia, Zhengzong Yang, and Zhouyang Lei: Planning of study, performing surgery, critical comments, and help in writing of the manuscript. The author(s) read and approved the final manuscript.

Funding

None

Availability of data and materials

Data can be requested from corresponding authors by email

Ethics approval and consent to participate

The Ethics Committee of Yan'an Hospital Affiliated to Kunming Medical University approved the study, and it was carried out in compliance with the Helsinki Declaration of 1975, as revised in 2000.

Consent for publication

All co-authors read and approved the final manuscript.

Conflicts of interests

The authors declare that they have no conflicts of interest.

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