Original Article

Core decompression or quadratus femoris muscle pedicle bone grafting for nontraumatic osteonecrosis of the femoral head: A randomized control study

Deqiang Li, Ming Li, Peilai Liu, Yuankai Zhang, Liang Ma, Fei Xu

Abstract

Background: The traditional management for osteonecrosis of the femoral head (ONFH) includes core decompression (CD) and quadratus femoris muscle pedicle bone graft (QF-MPBG). The aim of this study was to investigate the effects of CD and QF-MPBG on the patients with nontraumatic ONFH in an early stage.

Materials and Methods: 39 patients (47 hips) with ONFH in an early stage (Ficat Stage I or II) were randomly divided into two groups according to random number table method. One group was treated with CD and cancellous bone grafting. Another group was treated QF-MPBG with cancellous bone grafting. The hip function was evaluated using Harris hip score (HHS). The repair of the femoral head was estimated through X-ray, computed tomography (CT), or magnetic resonance imaging (MRI). The surgical time and intraoperative blood loss was calculated.

Results: All patients were followed for an average 2.5 years (range from 1.5 to 4 years). Two hips in CD group progressed into stage 3 and three hips in QF-MPBG group processed into stage 3. No patient accepted the THA at the last followup. The HHSs significantly increased in both groups after surgery ($P < 0.05$). No statistical differences were found between CD and QF-MPBG groups in postoperative HHSs at last followup ($P > 0.05$). X-ray and CT showed that the femoral head did not progress to collapse after operation in both groups. In addition, MRI showed that the edema signals decreased. However, the surgical time was longer in QF-MPBG group than that in CD group ($P < 0.05$). The intraoperative blood loss was more in QF-MPBG than that in CD group ($P < 0.05$).

Conclusion: The CD with bone graft could relieve hip pain, improve hip function with much lesser surgical trauma compared to QF-MPBG. Hence, the CD with bone graft should be generally used for the treatment of patients with an early stage (Ficat Stage I or II) ONFH.

Key words: Bone graft, core decompression, osteonecrosis of the femoral head, quadratus femoris
MeSH terms: Osteonecrosis, grafting, bone, femur head, hip joint

Introduction

Osteonecrosis of the femoral head (ONFH) occurs in 10,000–20,000 adults every year in the USA, typically between 20 and 60 years of age.[1-4] The etiology and pathogenesis of ONFH are not very clearly described.[3] Clinical observations have established that glucocorticoid use and alcohol abuse are among the most widely recognized risk factors for nontraumatic ONFH.[5] Among the pathogenesis, intraosseous hypertension[6] and abnormalities of blood supply are some well-accepted theories.[5] The most accepted staging of ONFH is the radiographic staging of Ficat.[7] In the early stages of ONFH, osteocyte's repairing activities forms a thick scar of fibrous tissue around the necrotic zone and prevents the

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Access this article online	
Quick Response Code:	Website: www.ijoonline.com
	DOI: 10.4103/0019-5413.193478

How to cite this article: Li D, Li M, Liu P, Zhang Y, Ma L, Xu F. Core decompression or quadratus femoris muscle pedicle bone grafting for nontraumatic osteonecrosis of the femoral head: A randomized control study. Indian J Orthop 2016;50:629-35.

revascularization into the necrotic area.[8] Untreated ONFH ultimately progresses to femoral head collapse, with a concomitant hip osteoarthritis and the need for total hip arthroplasty.[9]

The results of femoral head preserving operations were inconsistent, as seen following different osteotomies,[10-13] core decompression (CD),[14,15] nonvascularized bone grafting,[16] free vascularized fibular grafting,[17-19] vascular-pedicle iliac crest grafting,[20-22] and quadratus femoris muscle pedicle bone graft (QF-MPBG).[23] Recently, innovative therapeutic methods were applied for treatment of early ONFH including application of mesenchymal and bone marrow mononuclear stem cells or growth factors.[4,24-26] These approaches must be combined with the traditional decompression operation which has been introduced by Ficat and Arlet.[7,9] However, none of these approaches were found to be superior to any other treatment, as determine by randomized studies, and some of these surgical procedures are technically demanding.[27]

Here, we report midterm results in nontraumatic ONFH treated by CD or QF-MPBG. All patients presented with persisting pain at a relatively early stage of the diseases (Ficat I–II).

Materials and Methods

39 patients with 47 ONFH (Ficat Stage I or II) operated by head preserving surgeries from January 2007 to June 2009 were included in study. The average age was 36.5 years (range 23-59 years). Twenty seven were male and 12 female. Nineteen had osteonecrosis on the right hip, 12 on the left, and 8 had bilateral involvement. Eight patients (11 hips) had a history of corticosteroids used for systemic lupus erythematosus, asthma, and so on. Twenty three patients (27 hips) had a history of alcohol intake of >500 ml a day. No associated risk factors were found in the remaining eight patients (9 hips). The diagnosis of ONFH was made using anteroposterior (AP) radiographs, computed tomography (CT) scanning and magnetic resonance imaging (MRI). All patients were graded according to the Ficat and Arlet classification. The exclusion criteria included the history of trauma and operation for hip. The patients were classified into Stage I (21 hips), Stage II (26 hips). The patients were divided into two groups through the method of random number table according to their orders of hospitalization. One group with twenty patients (23 hips) were operated with CD and cancellous bone grafting. Another group with nineteen patients (24 hips) underwent the QF-MPBG with cancellous bone grafting. The average followup time was 2.5 years (range from 1.5 to 4 years). This study was conducted in accordance with the Declaration of Helsinki. This study was conducted with approval from the Ethics Committee of our University. Written informed consent was obtained from all participants.

Operative procedure

Core decompression with cancellous bone grafting

The operation was performed with the patient in a supine position on operation table. The affected hip, and ipsilateral iliac crest were prepared and draped. A 2.0 mm K-wire was inserted along the femoral neck axis toward the necrosis area until reaching 5 mm inferior to the subchondral bone of the femoral head under image intensifier [Figure 1a-c]. A 2 cm longitudinal skin incision was made centered over the K-wire and the subcutaneous fascia was dissected. Then, two different sized cannulated drillers with 6 mm, and 10 mm outer diameter were inserted along the K-wire to 5 mm inferior to the subchondral bone of the femoral head [Figure 1d]. The K-wire was removed. Then, the sequestrum in the necrosis area was removed using a long-handled curette. Another skin incision was made over the ipsilateral iliac crest, and cancellous bone was obtained. The bone graft was prepared to small pieces of about 0.5 mm × 0.5 mm × 0.5 mm using the rongeur forceps. The bone particles were filled in an aseptic pipe. The pipe was inserted into the femoral head through the CD bone channel. Then, the bone particles in the pipe were inserted into the core channel through pressing with a metal bar. Finally, moderate pressure was applied for impaction bone grafting. The wound was closed in layers [Figure 1e].

Quadratus femoris muscle pedicle bone graft with cancellous bone grafting

The operation was conducted with the patient in a lateral position. The affected hip was prepared and draped in a sterile fashion. The hip was exposed using a posterior approach. The gluteus maximus muscle was bluntly split in the direction of its fibers and the sciatic nerve was protected carefully. The quadratus femoris muscle was identified. The other short external rotators were divided close to their insertion, and the hip capsule opened through a T-shaped incision. The femoral neck was exposed. Then, a bone window was made close to the junction of head and neck. The size of the bone window was about 1.5 cm × 2.5 cm determined preoperatively for all patients in the QF-MPBG group. The sequestrum in the necrosis area was removed using curette. When the normal cancellous bone was seen in all directions, the end point of curettage was arrived. And the volume of bone removed was about 4–5 ml calculated through injecting physiological saline into the bone defect of the femoral head. We identified the femoral terminal end of the quadratus femoris muscle. The osteotomy was performed to obtain the QF-MPB block. Cancellous bone graft was obtained from the ipsilateral greater trochanter. The bone defect in the necrosis area

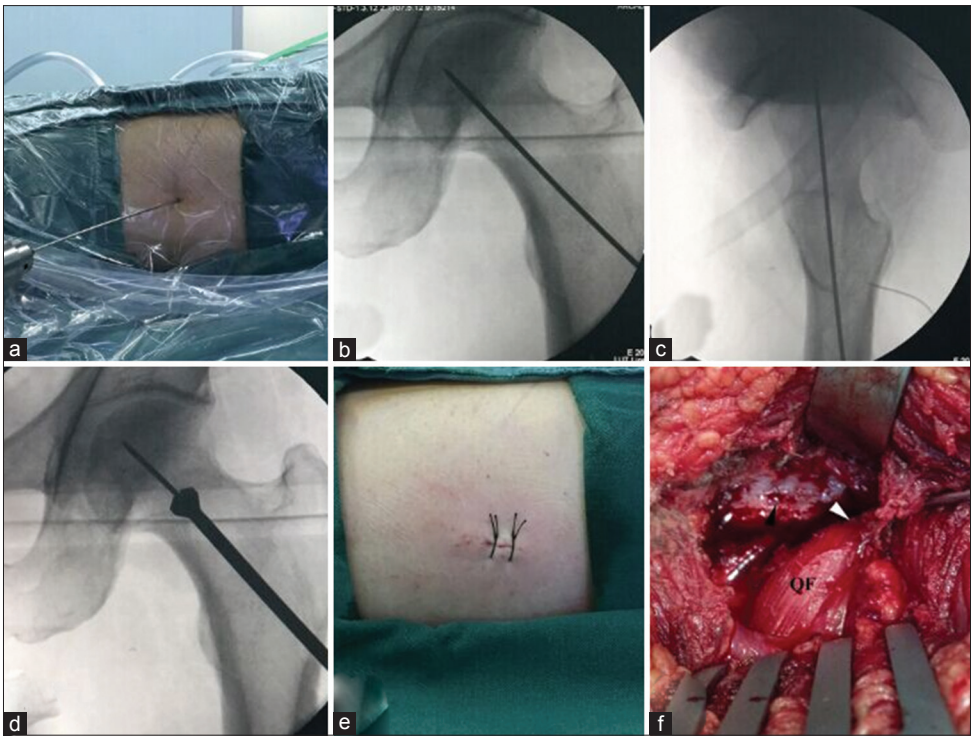

Figure 1: (a) Intraoperative photograph showing K-wire being inserted along the femoral neck axis toward the necrosis area (b-d) The fluoroscopy images showing K-wire reached the necrosis area and 5 mm inferior to the subchondral bone of the femoral head. The cannulated driller being inserted into the necrosis area (e). The incision was about 1.5 cm long (f). The quadratus femoris muscle pedicle bone block was obtained from the terminal end of femur about 1.5 cm × 2.0 cm. The quadratus femoris muscle pedicle bone block was rotated and implanted into the femoral head through the bone window (white arrow head)

was filled with autogenous cancellous bone. The QF-MPB block was mobilized, rotated, and grafted into the femoral head through the bone window [Figure 1f]. The rotated quadratus femoris graft was sutured around the capsule. And the hip joint was kept in the external rotatory position for about 4 weeks. The incision was closed in layers.

Postoperative protocol

After CD or QF-MPBG, patients were allowed to start isometric, then isotonic exercises. After 6 weeks, the patients were allowed approximately 30% weight bearing. And then, approximately 60% weight bearing was allowed for the next 6 weeks. The partial weight bearing was continuously increased to achieve full body weight within 6 months postoperatively. Postoperative pain was relieved through using nonsteroidal anti-inflammatory drugs.

The followup was performed every 3 months in the 1st year, every 6 months during the 2nd year and at the last followup visit. Clinical function and Harris hip score (HHS) were evaluated on every visit.

Radiographic followup included AP X-ray, CT scanning or MRI. Radiographs were evaluated for progression of the necrosis lesion, changes in the contour of the femoral head or the presence of secondary osteoarthritis. CT scans were evaluated for bone necrosis and formation before and after the operation. And, MRI was evaluated for aseptic inflammatory reaction and edema in the femoral head. A radiographic failure was defined as the onset or the progression of collapse or progressive osteoarthritis.

The surgical time was calculated from incision to closure. The loss of blood was calculated during the operative procedure. Postoperative blood loss was not accounted. The intraoperative blood loss was the sum of the volume in the aspirator and the volume in the gauze. The volume in the gauze was calculated through weighing method.

Statistical analysis

To find out whether patients improved clinically, a samples *t*-test was applied. The clinical variables were presented as a mean ± standard error. All statistical assessments were two-sided and evaluated at the 0.05 level of statistical significance. Statistical analyses were performed using SPSS 19.0 statistical software (SPSS Inc., Chicago, IL, USA).

Results

Changes in Harris hip scores

The HHSs were evaluated before and after surgery in both groups [Figure 2]. The mean HHSs were all lower than

70 in both groups before surgery. However, the mean HHSs were all higher than 80 in both groups at last followup. The HHSs significantly increased when compared before surgery in both CD and QF-MPBG groups at last followup ($P < 0.05$). However, no significant differences were found between CD and QF-MPBG groups either in preoperative HHSs or in postoperative HHSs ($P > 0.05$).

Surgical time and blood loss

The surgical time was calculated from incision to suture in both groups [Figure 3a]. The surgical time in QF-MPBG group was longer than that in CD group. The difference had statistical significance ($P < 0.05$). The intraoperative blood loss was also accounted from incision to suture in both groups [Figure 3b]. The blood loss of QF-MPBG group was much more when compared with CD group. And the results had significant statistical difference ($P < 0.05$). No blood transfusion was performed in both CD and QF-MPBG groups.

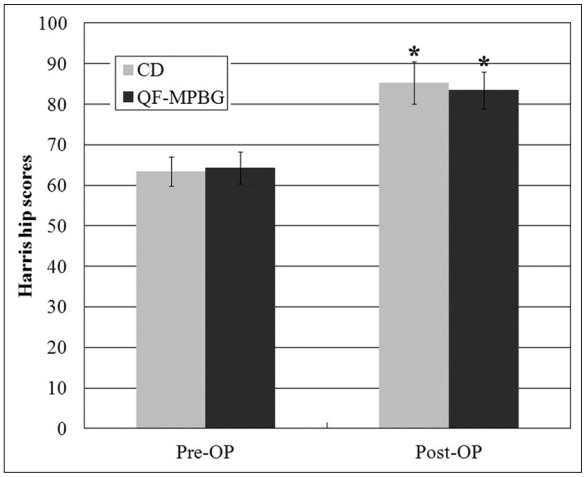

Figure 2: Harris hip scores in both core decompression and quadratus femoris muscle pedicle bone graft groups. The postoperative Harris hip scores were higher than preoperative Harris hip score in both core decompression and quadratus femoris muscle pedicle bone graft groups at last followup ($P < 0.05$). No significant differences were found between core decompression and quadratus femoris muscle pedicle bone graft groups either in preoperative Harris hip score or in postoperative Harris hip score ($P > 0.05$)

Radiographic evaluation

In CD group, the collapse of femoral head occurred in two hips. In QF-MPBG group, the femoral head collapsed in three hips. These results were identified according X-ray examination. The X-ray examination and CT scanning showed that the necrosis of other hips did not progress to collapse of the femoral head in both CD and QF-MPBG groups [Figures 4 and 5]. In addition, MRI showed that the edema significantly reduced or even disappeared [Figure 6].

Discussion

There are many head-preserving operations for treatment of ONFH in early stage. From traditional CD, rotational osteotomy and muscle pedicle bone graft to vascular pedicle bone graft, artificial scaffold, growth factor and stem cell implanted, none of these methods could completely preserve the femoral head and avoid the collapse of the femoral head successfully forever.[28] These methods could relieve the pain of the hip and delay the progression of the disease to some degree. In the traditional head-preserving operations, CD and muscle pedicle bone graft were generally utilized in clinical treatments.[23] In this research, we investigated the results of CD and QF-MPBG for treatment of ONFH in an early stage through a randomized control study.

In this study, large diameter CD was used for patients. The large diameter CD could supply better decompression than small diameter multichannel CD for ONFH.[29] The small diameter multichannel CD was only suitable for Ficat Stage I ONFH with a small range of necrosis. And, bone grafting could not be performed through small diameter channel and the necrotic bone could not be removed using curette under the monitoring of C-arm. This approach could sufficiently remove the sequestrum in the femoral head. And the normal cancellous bone could be sufficiently grafted into the necrosis area through the large diameter

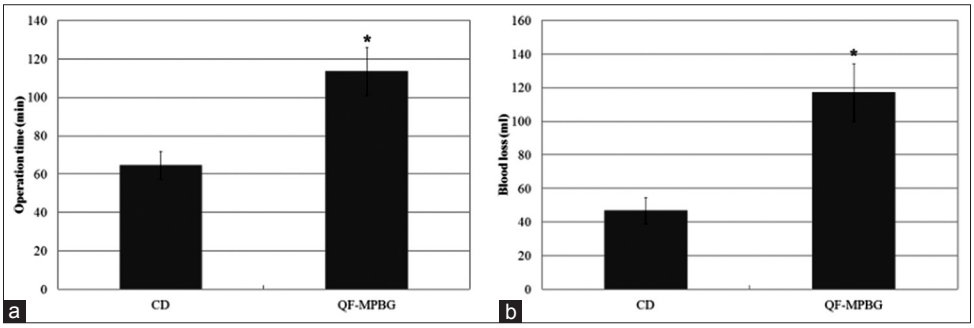

Figure 3: Surgical time and blood loss in both core decompression and quadratus femoris muscle pedicle bone graft groups. The surgical time in core decompression group was shorter than that in quadratus femoris muscle pedicle bone graft group ($P < 0.05$) (a). The blood loss in core decompression group was lesser than that in quadratus femoris muscle pedicle bone graft group ($P < 0.05$) (b)

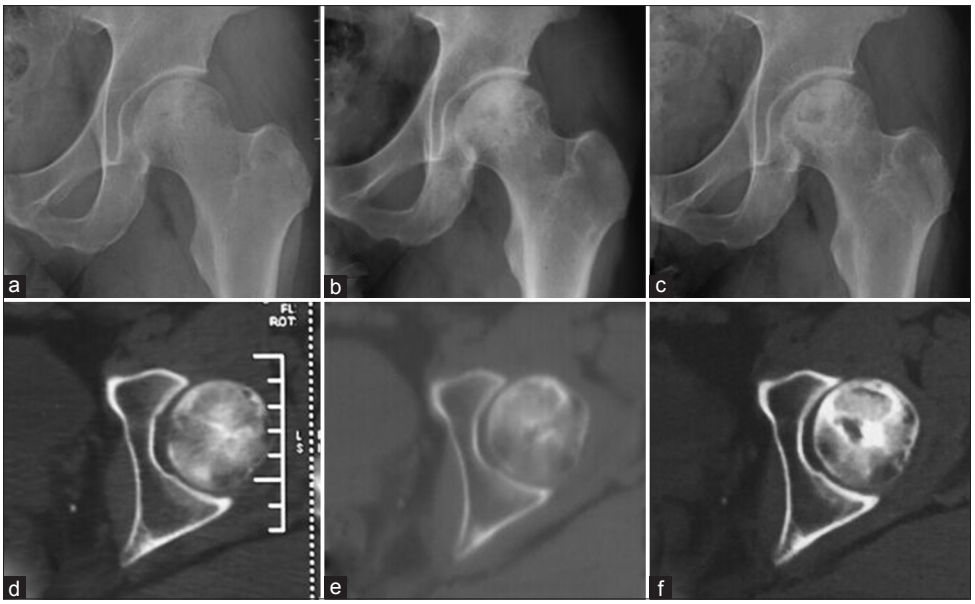

Figure 4: X-ray examination and computed tomography scanning in core decompression group. The preoperative X-ray and computed tomography images showed the osteonecrosis of the femoral head in an early stage (a and d). The postoperative X-ray and computed tomography images showed that the osteonecrosis did not get worse 8 months after core decompression with bone grafting (b and e). The X-ray and computed tomography examination showed that the femoral head did not collapse with slight progression 2 years after core decompression with bone grafting (c and f)

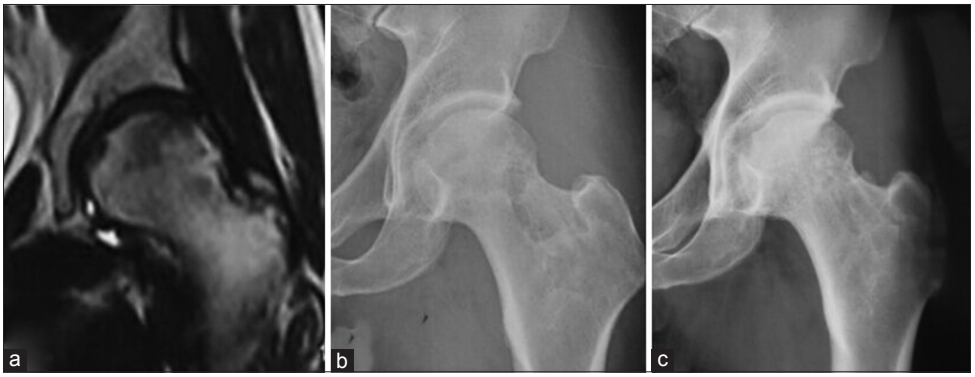

Figure 5: Magnetic resonance imaging and X-ray examination in quadratus femoris muscle pedicle bone graft group. The preoperative magnetic resonance imaging showing the osteonecrosis of the femoral head in an early stage (a). The X-ray film showed that the necrosis did not progress 3 months after surgery (b). The X-ray showed that the femoral head did not collapse 2 years after surgery, and some new bone formed in necrosis area (c)

bone channel. In this study, X-ray and CT scanning showed that a new bone formed in the necrosis area. The MRI showed that the edema decreased dramatically in T2-weighted images. The cancellous bone obtained from iliac bone contained mesenchymal stem cells which were of benefit in repair of ONFH.[30-32] The cancellous bone supplied the scaffold and cells which were essential factors for the formation of new bone. And the availability of sufficient support reduced the collapse of the femoral head in patients. At last followup, only two hips deteriorated into the collapse of the femoral head in CD group. The survival rate was about 91.3%.

In QF-MPBG group, the decompression was carried on through curetting necrotic bone via the bone window opened at the posterior aspect of the femoral head neck area. This surgical technique has been reported in the previous study.[23] The patient was operated in lateral position or prone position. The location of necrotic area was more difficult compared with CD operation. Hence, the removal of necrotic bone was not very accurate. For curetting the necrotic bone completely, the removed bone volume was usually more than that in CD group. And the normal bone was also curetted partially. In some patients with a wide necrotic area, the femoral head was like an eggshell after curetting the necrotic bone. Although the bone graft was sufficient, the support of the cancellous bone was limited. Three hips deteriorated into the collapse of the femoral head in QF-MPBG group at last followup. The survival rate was about 87.5%. The muscle pedicle bone graft could provide

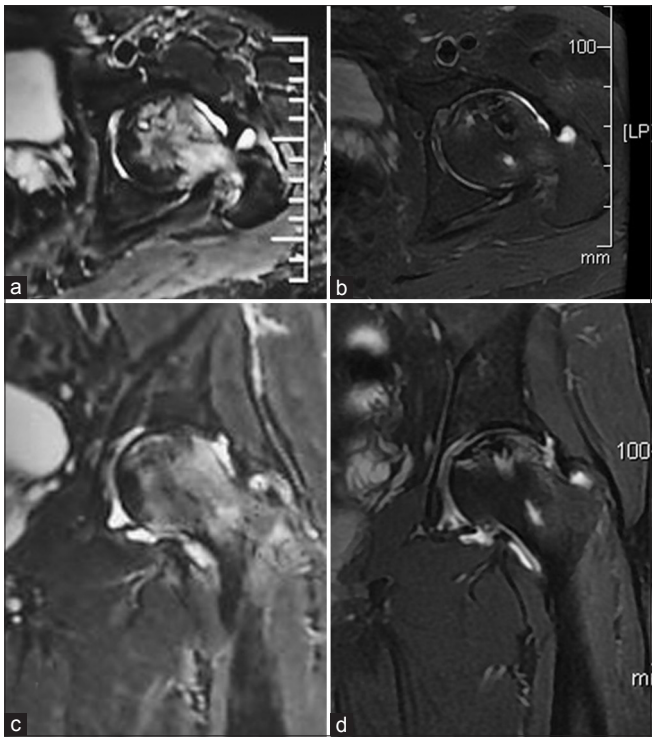

Figure 6: Magnetic resonance imaging in core decompression group. The preoperative magnetic resonance imaging showed extensive edema signal in the femoral head (a and c). The edema signal significantly decreased 2 years after core decompression with bone grafting (b and d)

blood supply to promote the repair of ONFH. The pain relief was also satisfactory.

This is the first study to compare the effects of CD and QF-MPBG for treating the ONFH through a randomized control study. The both approaches could significantly decrease hip pain and improve hip function. And the X-ray and CT examination showed that new bone trabeculae formed in the necrotic area in the femoral head. MRI showed that the edema signal significantly decreased or even disappeared in T2-weighted images. These results suggested that the necrotic area could be repaired to some extent. The HHSs were similar in both groups. And, no statistical difference was found between CD and QF-MPBG groups. The collapse of femoral head occurred in both CD and QF-MPBG groups. The survival rate of the femoral head was similar in both CD and QF-MPBG groups. However, the surgical time was longer than that in CD group; the surgery trauma was greater compared with CD/group. And the blood loss was much more than that in CD group.

The limitations of our study are that the population was relatively small and it requires a long followup. Another, the reasons for nontraumatic ONFH includes glucocorticoid use and alcohol abuse. In this study, we didn't respectively observed the effects of CD and QF-MPBG for ONFH caused by different risk factors.

Conclusion

We found that a large diameter CD with bone graft could significantly relieve hip pain, improve hip function, and decrease collapse of the femoral head in patients with ONFH in an early stage. The surgical trauma was much lesser compared with QF-MPBG. Hence, we believe that a large diameter CD with bone graft should be generally used for patients with an early stage ONFH.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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