Core decompression versus nonvascularized bone grafting in patients with osteonecrosis of femoral head

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Research Article

Keywords: Osteonecrosis of femoral head, Non-vascularized bone grafting, Core decompression, Hip-preserving procedure

Posted Date: March 17th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-304057/v1>

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Abstract

Background Core decompression and nonvascularized bone grafting are used in the early stage of osteonecrosis of femoral head for a period. Since the comparison of the core decompression and nonvascularized bone grafting are less reported, the purpose of our study was to investigate the clinical outcomes of two procedures in patients with earlier stages of the osteonecrosis of femoral head.

Methods Between January 2018 and January 2019, 46 patients (48 hips) are divided into core decompression group and non-vascularized allogeneic fibula grafting group according to their procedures. The mean follow-up were 28.31 ± 3.7 months (24–36 months) and 29.23 ± 4.7 months (24–36 months) respectively. the primary outcomes were VAS and HHS. Survivorship was analyzed with the collapse of femoral head or conversion to total hip arthroplasty (THA) as the endpoint. Results At the final follow-up, two hips underwent THA in core decompression group and three hips in non-vascularized allogeneic fibula grafting group. The radiographic survival rates are 76.9% and 77.3% in the two groups. Statistically significant improvements were seen in both groups on the VAS and HHS. The radiographic survival rate of hips was significantly inferior in lateral type lesion ($P = 0.03$; CI, 0.765–2.114) and ARCO III stage ($P = 0.28$; CI, 1.254–58.752) in core decompression group. ARCO III stage ($P = 0.02$; CI, 1.351–49.344) and BMI>25 ($P = 0.35$; CI, 0.999–2.131) were independent risk factors for the collapse of femoral head in non-vascularized allogeneic fibula grafting group.

Conclusion In this study, two procedures all can reduce the patient's pain and improve functional activity. Arco stage III is a common risk factor for the collapse of femoral head in both groups. lateral lesion and BMI>25 are risk factors for the collapse of femoral head in core decompression group and non-vascularized allogeneic fibula grafting group, respectively. Both groups had good hip survival rates during the follow-up period.

Background

The osteonecrosis of femoral head (ONFH) has been a worldwide health problem[1-2]. Hip arthroplasty is the main treatment and gets good outcomes[3], but hip-preserving techniques are also important for young patients with the osteonecrosis of femoral head[4]. Because with the development of current diagnostic methods and the improvement of patients' health awareness [5], the number of young patients with avascular necrosis of the femoral head has increased. Current hip-preserving procedures include core decompression, nonvascularized/vascularized bone grafting, and osteotomy[6-9].

Core decompression is a safe, effective, and less invasive surgery. At the same time, it is also the most cost-effective procedure in hip-preventing techniques[10]. It can be divided into multiple drilling techniques and conventional core decompression. Core decompression can reduce the pressure in the femoral head, remove the femoral head necrosis tissue, stimulate the formation of blood vessels, promote the formation of new bone, and delay the process of avascular necrosis of the femoral head[11].

Nonvascularized bone grafting was first proposed by Phemister in 1949[12]. It can provide good support that is beneficial to the repair and reconstruction of subchondral bone, thereby delaying the progress of

avascular necrosis of the femoral head and the time to hip arthroplast. The most commonly used surgical methods include the "Phemister technique", "lightbulb" and "trapdoor"[13].

Core decompression and nonvascularized bone grafting were used in the early stage of osteonecrosis of femoral head frequently. Both procedures have good results. However, under different circumstances, which procedure has higher priority still needs to be discussed. This study aims to explore the difference between core decompression and nonvascularized bone grafting in hip preservation.

Materials And Methods

We retrospectively reviewed the data of all patients at Affiliated Hospital of Chengdu University of Traditional Chinese Medicine during the period between January 2018 and January 2019. All methods were carried out in accordance with relevant guidelines and regulations. Patients who meet the following criteria were included: (1) They underwent either core decompression or nonvascularized bone grafting for ONFH. (2) The staging of avascular necrosis of the femoral head is between Arco I-Arco II(pre-collapsed stage) or Arco III (early collapsed stage)[14]. (3) The age of the patient is 18-60 years old. And patients who meet the following criteria were excluded (1) Patients with an advanced stage of osteonecrosis of femoral head (worse than ARCO IIIA or collapsed). (2) Broken skin or infection to the index hip. (3) Patients who have received other types of hip-preserving procedure.

All patients were diagnosed as ONFH on anteroposterior radiographs or MRI. They underwent laboratory evaluation including complete blood count, liver and kidney function tests, and electrolytes. The baseline variables of patients including age, gender, etiology, Arco stage, lesion size, location of lesion, and BMI(body mass index) were recorded. lesion size can be divided into three types according to the percent of lesion size on femoral head. The involvement of lesion size on femoral head less than 15% was defined as small type, 15%-30% was medium type and more than 30% was large type. The estimation of lesion size base on a mid-coronal section of the femoral head and the involved layers on CT(Computed Tomography) or MRI(Magnetic Resonance Imaging)[15]. The location of lesion was classified as medial, central, and lateral(Fig. 1). The VAS(visual analogue score) and HHS(Harris hip scores) were also recorded.

Surgical procedures

Core decompression

All cases are completed by a senior surgeon (Zhongchao Jiang) with the same surgical technique:

Patients were placed in the supine position on an operating table after anesthesia. Three to five 2.5-mm-diameter Kirschner wire were drilling through the greater trochanter with a low rotating speed. We determined the direction, position, depth, and area of the drilling according to the preoperative radiographs or MRI. The tip of the nail reached a position 5 mm from the subchondral bone of the femoral head with the assistance of fluoroscopy.

Non-vascularized allogeneic fibula grafting

All cases were completed by a senior surgeon (Zhongchao Jiang) with the same surgical technique:

Patients were placed in the supine position on an operating table after anesthesia. We exposed the greater trochanter of the femur via a longitudinal incision and locate the femoral head lesion by using fluoroscopic screening. A 2 mm Kirschner wire was inserted from the basement of the greater trochanter into femoral head lesion. the K-wire was advanced to a position 5 mm from the subchondral bone of the femoral head. And then a bone tunnel was made by the reamer(diameter=13mm). Necrotic bone tissue in femoral head was removed by a curette. After allogeneic bone chips and non-necrotic bone were filled into the femoral head, non-vascularized allogeneic fibula was implanted.

All patients were educated to keep their operative limb unweighted with the crutche for 3 months. For the next 3 months, partial weight-bearing was allowed for patients. Patients were then advised to start walking without crutches. High-intensity sports and higher impact loading activities were not recommended.

Outcomes

Conversion to total hip replacement is defined as the endpoint of clinical outcome and an occurrence of the collapse of femoral head is defined as the endpoint of radiographic outcome. The procedure is defined as Clinical success if the patients preserved the native femoral head and don't have hip arthroplasty. VAS and HHS were recorded at pre-operative and 6 months,1 year, and 2 years after procedure. The Harris hip score of fewer than 70 points is ranked as poor,70-79 points is fair,80-89 points is good, and more than 90 points is excellent.

Statistical analysis

Normality test was performed for numerical variables if all group satisfied the normal distribution and the variances between the two groups are equal, mean $\pm$ SD(standard deviation) was used to describe and two independent sample t-test for the comparison between groups. The number of cases (percentage) was used for categorical variables, and χ^2 test was performed between groups. Paired *t*-test was performed to compare preoperative VAS and HHS with those after procedure. Kaplan-Meier survival curves with the endpoint of collapse or conversion to THA and log-rank analysis was used for statistical differences in survival rate. A binary logistic regression test was used to analyze risk factors that lead to collapse or conversion to THA. $P < 0.05$ was considered significant in statistical comparisons. All statistical comparisons were performed by the Statistical Package for Social Sciences (SPSS) (version 22).

Results

Between January 2018 and January 2019, 46 patients(48 hips) are divided into core decompression group and non-vascularized allogeneic fibula grafting group according to their procedures(Fig. 2). 26 hips in core decompression group and 22 hips in non-vascularized allogeneic fibula grafting group. In core decompression group, 2 hips are ARCO stage I, 15 stage II, and 9 stage III. One hip is ARCO stage I, 14 stage II, and 7 stage III in non-vascularized allogeneic fibula grafting group. The mean follow-up were 28.31 ± 3.7 months (24–36 months) and 29.23 ± 4.7 months (24–36 months) respectively The patients are 22-59 years of age (mean, 46.2 ± 10.6) and 22-57 years of age (mean, 39.8 ± 11.4) in core decompression group and non-vascularized allogeneic fibula grafting group, respectively. Baseline variables of patients including age, sex, height, weight, BMI (Body Mass Index) and mean follow-up period were collected(Table 1). Baseline variables of disease including etiology, Arco classification, lesion size, and location of lesion were also collected. There were no significant differences between patients of core decompression group and non-vascularized allogeneic fibula grafting group in terms of the baseline variables.

The primary outcomes included VAS and HHS were recorded(Table 2). The mean pre-operative VAS was 5.70 points (range, 4-8 points)in core decompression group. And the mean pre-operative VAS was 5.86 points (range, 4-9 points)in non-vascularized allogeneic fibula grafting group. Two sets of baseline data are comparable($P > 0.05$). The last follow-up score was 3.61 ± 1.53 points and 3.55 ± 1.53 points in core decompression group and non-vascularized allogeneic fibula grafting group respectively. The difference is significant compared with baseline scores($P < 0.05$). The mean pre-operative HHS were 51.4 points (range, 42-61 points) and 52.8 points (range, 41-63 points) in core decompression group and non-vascularized allogeneic fibula grafting group respectively. Two sets of baseline data are comparable($P > 0.05$). The last follow-up score was 76.5 ± 12.9 points and 79.2 ± 10.0 points in core decompression group and non-vascularized allogeneic fibula grafting group respectively. The difference was significant compared with baseline scores($P < 0.05$).

Radiographic failure

The collapse of femoral head in anteroposterior radiography is defined as radiographic failure. The Kaplan-Meier survival curve of core decompression group and non-vascularized allogeneic fibula grafting group(Fig. 3). The radiographic survival rate is 76.9% in core decompression group at last follow-up time. And in non-vascularized allogeneic fibula grafting group, the radiographic survival rate is 77.3%.

Conversion to THA

An occurrence of THA in patients after the procedure was defined as clinical failure. The Kaplan-Meier survival curve of core decompression group and non-vascularized allogeneic fibula grafting group(Fig. 4). Two hips underwent THA at 23 months after core decompression and the clinical survival rate was 92.3% at a mean of 28.3 months. Three hips underwent THA after non-vascularized allogeneic fibula grafting and the clinical survival rate was 86.4% at a mean of 29.2 months.

A binary logistic regression test showed that lateral type lesion ($P = 0.03$; 95% CI, 0.765–2.114) BMI>25 ($P = 0.35$; 95% confidence interval [CI], 0.999–2.131) and ARCO III stage ($P = 0.28$; 95% CI, 1.254–58.752) were independent risk factors for the collapse of femoral head and conversion to THA in core decompression group. In non-vascularized allogeneic fibula grafting group, ARCO III stage ($P = 0.02$; 95% CI, 1.351–49.344) and BMI>25 ($P = 0.35$; 95% confidence interval [CI], 0.999–2.131) were independent risk factors for the collapse of femoral head and conversion to THA.

Complications

No complications occurred in core decompression group. However, two patients had severe complications after non-vascularized allogeneic fibula grafting. One patient had an intertrochanteric fracture after the procedure and the other one had an infection at 28 months after the procedure.

Discussion

This trial is the first to compare core decompression and non-vascularized allogeneic fibula grafting for ONFH. In our study, the HHS and VAS of patients were all improved at 2 years, but there was no significant difference between the core decompression and non-vascularized allogeneic fibula grafting groups at any time point out to 2 years on the HHS and VAS. The radiographic survival rates are 76.9% and 77.3% in core decompression and non-vascularized allogeneic fibula grafting respectively.

Pain and functional activity are the main concerns of patients in hip-preserving procedure. Because it affects the quality of daily life of patients. In our study, core decompression group and non-vascularized allogeneic fibula grafting group all can reduce the pain of patients and improve their functional activities. Core decompression is mainly to reduce the pain of the patient by reducing the high pressure in the bone, and non-vascularized allogeneic fibula grafting reduces subchondral microfractures and relieves pain by the support of allograft. But there is no significant difference between the two groups in the degree of improvement.

The osteonecrosis of femoral head is characterized by the death of osteoblasts and the collapse of the joint surface of the femoral head due to the interruption of the vascular supply. The pain and dysfunction at the late-stage can seriously affect the patient's quality of life. Total hip replacement is still the main option for the treatment of advanced femoral head necrosis. However, younger patients may need revision considering the limited life span of the prosthesis. Although the development of prosthetic materials, such as high cross-linked polyethylene materials, metal-to-metal joints, and ceramic-to-ceramics, reduces the osteolysis caused by polyethylene wear particles and extends the period of use of prostheses, shortcomings still exist. 7% of small and 80% of large lesions patients collapse by eight years without intervention[16]. Hip-preserving treatment can relieve pain, delay the collapse of the articular surface, and delay the time to THA. There are many treatments for hip preservation. Core decompression and non-vascularized allogeneic fibula grafting are more hip-preserving treatments used in the early stage of femoral head necrosis.

Lesion size may influence the survival rate of femoral head in core decompression. In the hip with a small necrosis area, the failure rate reached 14%-25%, while in the femoral head with a larger necrosis area, the failure rate reached 42%-84% [4]. This was also confirmed in our article. Sebastian S found that the effect of core decompression is related to age, and patients older than 40 years old have a higher failure rate, but there is no significant correlation with gender [17]. However, we did not find this correlation in our study. Strong repair capabilities of young patients may lead to this, but they also have a higher impact on loading activities. Octavian A found in a meta-analysis that 38% of the 1,134 hips that underwent core decompression had THA at an average follow-up time of 26 months[18]. Core decompression combined with other therapies(bone marrow stromal cells) can also achieve good results in the early stages of femoral head necrosis[19-20]. Different procedures may result in varied outcomes. Al Omran A proposed that there is no difference between traditional core decompression and multiple drilling[21]. Song WS reported that 88% of hips with small and medium lesion size didn't have THA in multiple drilling core decompression group[22]. Multiple drilling core decompression has less invasive compare to traditional core decompression.

Non-vascularized allogeneic fibula grafting has shown a good survival rate of hips in the literature[23-24]. Sultan AA concluded in a review that the survival rate of non-vascularized allogeneic fibula grafting hips is between 62% and 86% within an average follow-up time of 24-104 months after surgery [25]. Wu CT reported the long-term outcomes of non-vascularized allogeneic fibula grafting. In a study with an average follow-up time of 14 years, the clinical survival rate of the hips was 62.5%. [26].In our study, the clinical survival rate was 86.4% at a mean of 29.2 months in non-vascularized allogeneic fibula grafting group. ARCO III stage was a risk factor in non-vascularized allogeneic fibula grafting group. Advanced ARCO stage was portended unsuccessful clinical results .this was proved in many studies[4-27]. Nelson LM also pointed out that non-vascularized allogeneic fibula grafting is not recommended for patients with femoral head collapse [28]. We also found that BMI>25 is an independent risk factor for the collapse of femoral head in non-vascularized allogeneic fibula grafting. This may provide advice to the surgeon.

There are some limitations in this study, including small number of patients and short follow-up time(mean, 28.3 months and 29.2 months). However, the minimum 2-year follow-up period is enough to evaluate the pain and activities of patients. The design of the study is retrospective cohort and patient selection and disease characteristics are well-defined. Besides, the definition of clinical and radiographic failures was well. All the baseline data and outcomes were recorded in detail and completely. This renders our results representative of the short term outcomes of the core decompression versus non-vascularized allogeneic fibula grafting in the treatment of ONFH. But long-term follow-up clinical trials still need to be conducted

Conclusion

In this study, core decompression group and non-vascularized allogeneic fibula grafting group all can reduce the patient's pain and improve functional activity. Arco stage III is a common risk factor for the collapse of femoral head in both groups. The lateral lesion is more likely to cause the collapse of femoral

head in core decompression group, and BMI>25 is more likely to cause the collapse of femoral head in non-vascularized allogeneic fibula grafting group. Both groups had good hip survival rates during the follow-up period.

Declarations

Competing interests

The authors declare that they have no conflict of interests.

Funding

This research did not receive any funding.

Availability of data and materials

The datasets of this study are available from the corresponding author when there is a reasonable request.

Authors' contributions

Jin Mei: Responsible for the collection of articles and writing of manuscript.

Lili Pang: Responsible for drawing pictures.

Zhongchao Jiang: Responsible for providing advice and guidance.

Consent for publication

Written informed consent for publication was obtained from all participants.

Ethics approval and consent to participate

The Ethical Review Committee of Affiliated Hospital of Chengdu University of Traditional Chinese Medicine approved this study. All patients signed informed consent before this procedure.

Acknowledgments

Not applicable

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Tables

Due to technical limitations, tables are only available as downloads in the supplementary files section.

Figures

Fig. 1 (A) A medial type lesion occupied the medial one-third of the femoral head and not involving the weight-bearing portion. (B) A central type lesion occupied the medial two-thirds or less of the weight-bearing portion (C) A lateral type lesion occupied more than the medial two-thirds of the weight-bearing portion.

Figure 1

The location of lesion was classified as medial, central, and lateral(Fig. 1). The VAS(visual analogue score) and HHS(Harris hip scores) were also recorded.

Fig. 2 A 39-year-old male patient with alcohol-related ONFH on the right hip. (A) Pre-operative radiograph. (B) non-vascularized allogeneic fibula was grafted at post-operative radiograph. (C)(D)(E) The necrotic area is being repaired by the support of allograft at post-operative 3, 6, and 12 months. (F) Follow-up radiography at post-operative 33 months showing no radiography progress on his right hip.

Figure 2

Between January 2018 and January 2019, 46 patients(48 hips) are divided into core decompression group and non-vascularized allogeneic fibula grafting group according to their procedures(Fig. 2).

Figure. 2 Kaplan-Meier Survival curve of radiographic failure with collapse as the endpoint

Figure 3

The Kaplan-Meier survival curve of core decompression group and non-vascularized allogeneic fibula grafting group(Fig. 3).

Fig. 3 Kaplan-Meier Survival curve of clinical failure with conversion to THA as the endpoint

Figure 4

The Kaplan-Meier survival curve of core decompression group and non-vascularized allogeneic fibula grafting group(Fig. 4).

Supplementary Files

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