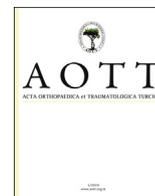




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Comparison of sartorius muscle-pedicle and circumflex iliac deep bone flap grafts in the treatment of early non-traumatic osteonecrosis of femoral head in young adults

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ABSTRACT

Objective: The aim of this study was to retrospectively compare and evaluate the midterm curative effect of two different bone flap grafts in the treatment of early non-traumatic osteonecrosis of the femoral head (ONFH).

Methods: A total of 180 patients (199 hips) with early non-traumatic ONFH received surgical treatment by sartorius muscle-pedicle bone flap graft (SMBF) (104 patients, 64 males and 40 females; mean age 34.67 ± 3.24 years) or circumflex iliac deep bone flap graft (CIDBF) (76 patients, 44 males and 32 females; mean age: 35.54 ± 3.37 years) from July 2004 to July 2009. The comparison between the groups was made with Harris score before and after surgery, length of incision, operative time, amount of bleeding, postoperative X-ray. Association Research Circulation Osseous (ARCO) staging was performed.

Results: The preoperative Harris hip score of two groups were 68.26 ± 1.26 and 69.35 ± 1.31 , respectively. Patients' ARCO staging indicated 36 hips of stage IIa, 115 hips of stage IIb and 48 hips of stage IIc. The etiology of ONFH mainly including hormones (93 patients), alcohol (64 patients) and other (23 patients). The mean follow-up time of SMBF and CIDBF groups were (51.78 ± 2.35) and (52.73 ± 3.71) months, respectively. The time of removing sutures, operation time, amount of bleeding and length of incision in SMBF group were superior to those in the CIDBF group, and those differences between the SMBF and CIDBF groups were not significant (all p values > 0.28). The Harris score between the two groups was similar after operation and postoperative 12 month, and the difference was not statistically significant ($p > 0.05$), whereas the difference of the postoperative 24 and 48 months was statistically significant ($p < 0.05$). X-ray analysis showed improvement of osteonecrosis in both two groups after surgery, and as time went on, the total hip amount decreased, the replacement amount increased.

Conclusion: Both bone flap grafts appear to be effective methods for treatment of early osteonecrosis of femoral head (ARCOII), and the SMBF is a relatively simple technique and easy for mastering, and it is a reliable method for clinical application.

Level of evidence: Level III, Therapeutic Study.

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Introduction

Osteonecrosis of the femoral head (ONFH), also known as ischemic osteonecrosis of the femoral head, is most common in young adults,¹ which has posed a great challenge for orthopedic surgeons. According to the national epidemiological study of Japan, the peak age of incidence of ONFH was 40–50 years old, and numbers of males was slightly more than that of females, and about 65% of the patients had to accept the total hip arthroplasty (THA).² In China, patients with ONFH caused by alcoholism and glucocorticoids accounted for a large proportion of the patients. These

patients often miss timely diagnosis and early treatment, and undergo THA in the late stage, with consequent multiple joint revisions and a huge medical cost.³ Therefore, in the early stage of ONFH, hip-preserving surgery treatment had a high clinical value and was generally accepted and recognized as treatment principles, especially in young adults. Hip-preserving surgery is mainly through reducing the pressure in the joint capsule, removal of necrotic tissue, using tantalum rod or autogenous bone support to strengthen braced force of the subchondral bone of femoral head and prevent the collapse of femoral head deformation, mending and reconstructing the blood supply of bone tissue, promoting repair and reconstruction of the necrotic bone, finally achieved the purpose of preventing femoral head necrosis and further collapse, prolonging the using time of autologous hip joint and maximally preserve and improve hip function. There exist multiple hip-preserving operative approaches, such as osteotomy,⁴ medullary core decompression surgery,^{5,6} fibular support surgery,^{7,8} and vascularized or non-vascularized bone flap grafting surgery,^{9–11} etc. However, the definite clinical efficacy of all the above approaches is full of controversy. The aim of this study was to retrospectively compare and evaluate the mid-term curative effect of two different methods (Sartorius muscle-pedicle bone flap graft and circumflex iliac deep bone flap graft) in the treatment of non-traumatic avascular necrosis of femoral head, in order to explore the advantages of hip surgery of preserving femoral head.

Patients and methods

This study was approved by the Regional Ethics Committee of our hospital and patients who enrolled in this study signed informed consents. We retrospectively reviewed 362 patients with early non-traumatic osteonecrosis of the femoral head who were surgically treated in our hospital from July 2004 to July 2009. The Association Research Circulation Osseous (ARCO) staging criteria was used to evaluate the degree of necrosis of femoral head. Inclusion criteria for this study were as follows: (a) Surgical treatment of patients with non-traumatic osteonecrosis of the femoral head; (b) patients' age between 20 and 55 years old; (c) Body Mass Index < 30; (d) The preoperative ARCO staging: stage II; (e) Surgical procedures for patients with sartorius muscle-pedicle bone flap graft or circumflex iliac deep bone flap graft. Exclusion criteria for this study were as follows: (a) Patients with knee, ankle joint deformity and activity limitation; (b) Patients with cardiovascular disease, and severe medical illness such as lung, liver, kidney and hematopoietic system et al; (c) The follow-up time was less than 48 months and or clinical information that could not be supplemented. According to the transplantation tissues, patients were divided into two groups: sartorius muscle pedicle bone flap graft group (SMBFG, 104 cases, 115 hips) and circumflex iliac deep bone flap graft group (CIDBFG, 76 cases, 84 hips).

Surgical technique

SMBFG: Using the modified Smith-Petersen approach,¹² entered from muscle space of tensor fascia and sartorius muscle, exposed rectus femoris, created muscle gap channel, cut the articular capsule with T font and exposed the femoral head, completely removed the necrotic tissue in the femoral head, and cleaned the necrotic tissue with the arthroscopic drilling. Freed the sartorius and took the sartorius bone flap, impacted the cancellous bone taken from the iliac bone to the femoral head. The bone flap was inserted into the femoral head through the muscle gap channel with preventing the muscle pedicle from traction and torsion. With a absorbable screw fixation, the joint capsule wrapped around the bone flap was sutured on the relaxation position. Suturing surgical

incision, and negative pressure drainage tube was placed in operation, with drainage 24–36 h. Lying in bed after operation, and the skin traction was used for 2–3 weeks in the bed. After removed, early independent flexion exercises of limb was necessary with the patients lying on the bed. 2 months after the operation, functional exercise on operative hip muscles for all patients with holding double crutch was performed systematically under non-weight bearing or partial weight bearing, and full weight bearing walking was permitted depending on individual clinical condition 2 months after the operation.

CIDBFG: The modified S-P incision was also used to find the deep circumflex iliac vessels, and the Full-thickness bone graft was removed with the vascular bundle, and using wet gauze wrapped and set aside. The iliac muscle and periosteum around the vascular bundle were retained. Used a wet gauze strip to lift the straight muscle, and free to the proximal muscles, created the gap channel, measured the length of vascular pedicle, expanded the gap channel, prevented the muscle pedicle from traction and torsion. Exposed femoral head and slotted bone groove through necrosis, and cleaned the necrotic tissue with the arthroscopic drilling. Cancellous bone was taken from the iliac bone, and bone graft was fully suppressed. The bone flap was carefully corrected and implanted in the bone groove, and fixed with 1 absorbable screws and the joint capsule wrapped around the bone flap was sutured. There was no difference between the two groups about postoperative treatment and rehabilitation exercise.

Outcome parameters

Primary index such as age, follow-up time, Harris score before and after surgery, incision length, operative time, intraoperative blood loss were recorded. Patients were reviewed at 6, 12, 24, 36, and 48 months after operation. Pelvis anteroposterior and frog-like roentgenograms were adopted for all patients at each follow-up appointment to evaluate degree of necrosis repair and collapse of femoral head. Imaging evaluation criteria refer to Chen Xiantao's describe.¹³ Computed tomography (CT) or MRI scanning was undertaken additionally to further assess the clinical repair of muscle-pedicle bone graft in osteonecrosis. Improved: Stable morphology of the femoral head with reduced or eliminated cystic area; blurred or disappeared osteopetrosis, without osteoarthritis. Stabilized: The femoral head showed stable morphology or collapse was smaller than 2 mm; the cystic area was reduced or disappeared; Osteopetrosis area became blurred, with or without osteoarthritis. Aggravated: The collapse of the femoral head was larger than 4 mm, with significant osteoarthritis; or hip replacement. Hip-preserving therapy was considered a failure if aggravated outcomes occurred, starting with the day after surgery. Harris hip score (HHS) was used to assess efficacy based on pain level, joint function and mobility. In this system, both subjective and objective clinical data are included, with a maximum score of 100 points.

Statistical analysis

Statistical analyses were processed by SPSS19.0 (USA). Chi-square test was employed for count data, and analysis of variance was used for completely random measurement data. Comparison between preoperative and different periods after treatment was applied with Dunnett-test.

Results

According to the inclusion and exclusion criteria, a total of 180 patients (199 hips) were finally included in this study. All patients were followed-up successfully. The mean follow-up duration was

Table 1
Preoperative data in the two groups (*p* value > 0.05).

Group	Number (hips)	Gender		Age (year)	Pathogenic reason			Location			Preoperative HHS (score)	ACRO stage II		
		Males/ females			Hormones	Alcohol	Other	Right	Left	Bilateral		a	b	C
SMBFG	104	64	40	34.67 ± 3.24	52	39	13	51	42	11	68.26 ± 1.26	20	64	27
CIDBFG	76	44	32	35.54 ± 3.37	41	25	10	37	31	8	69.35 ± 1.31	16	51	21
Total	180	108	72		93	64	23	88	73	19		36	115	48
χ^2/t		0.012		1.375	1.247			0.269			1.427			0.215
<i>p</i>		0.75		0.18	0.53			0.81			0.23			0.91

There is not a significant difference between preoperative demographics of both groups (*p* value > 0.05).

31.22 ± 4.23 months (12–48 months). Patients' ARCO staging indicated 36 hips of stage II a, 115 hips of stage II b and 48 hips of stage II c (Table 1). The mean age of SMBFG and CIDBFG were 34.67 ± 3.24 and 35.54 ± 3.37, respectively. The preoperative Harris hip score of two groups respectively were 68.26 ± 1.26 and 69.35 ± 1.31 (Table 1). There is not a significant difference between preoperative demographics of both groups. There were 8 patients with fat liquefaction and surface infection in SMBFG, and the same complications occurred in 7 patients of CIDBFG. After continuous local surgical dressing changes, incision healed gradually. The stitches removal time, intraoperative blood loss, operative time and incision length were statistically significant differences in two groups (Table 2). Table 3 showed that the Harris scores in each stage of follow-up were significantly improved compared with pre-surgical value, and the differences were statistical difference. The difference in the two groups was statistically significant except for stages of 12 months and 24 months. Between the two groups, the difference of the any stages were statistically significant except for stage of 12 months. In terms of clinical effect, the recovery of CIDBFG was superior to the SMBFG, and since 12 months later, the score of the two groups decreased gradually. At the last follow-up, imaging analysis showed that 81 hips in SMBFG and 59 hips in CIDBFG were improved, 10 hips in SMBFG and 8 hips in CIDBFG were stabilized, and the aggravated hips of SMBFG and CIDBFG were 13 and 9, respectively, as shown in Table 4. The difference between preoperative staging and improvement rate and hip preservation rate was statistically significant. Among them, hip preservation rate was high in stage II, A and B, and low hip preservation rate in stage II C. There was no significant difference between the two groups in the improvement rate and the hip retention rate in each period.

Discussion

ONFH is most common in young adults aged 30–50 years.¹⁴ The pathogenetic condition is more progressive, resulting in arthralgia and loss of function of hip joint, and about 50% of patients emerging questions of femoral head collapse.¹⁵ In the United States and Western Europe, about 10% patients undergo THA each year, compared with 50%–65% in South Korea and Japan.^{2,16,17} Whereas, the number of patients who underwent THA in China is even more

amazing. Despite advances in THA and joint prosthesis techniques, young patients may need to consider the duration of joint prosthesis and subsequent hip revisions, as well as related surgical complications and expenses.^{18,19} The clinical significance and value of hip-preserving surgery are relieve pain, reconstruct hip function, and avoid or delay hip replacement. The treatment of ONFH depends mainly on the stage of necrosis and the choice of the clinical surgeons. Korompilias et al²⁰ regarded that the affective factors of hip-preserving surgery were the pathogen of ONFH, and the classification as well as the range of necrosis area. Thus, the indications of hip-preserving operative treatment are relative. There are multiple hip-preserving operations available at present, as well as high risks of failure.^{21,22}

Yi-Rong Zeng et al²² reported a clinical research included a total of 60 patients (66 hips) who accepted hip-preserving surgery by grafting a vascularized greater trochanter flap combined with a free iliac flap which was tightly filled by hammering, and regarded that this kind of operative approach reconstructs the biological stability of femoral head, which promotes repair of necrotic areas and indirectly preserves the femoral head of patients and a majority of hip function, which is definite curative efficacy, especially for those young and middle-aged patients who suffer ONFH. Dewei Zhao et al¹³ retrospectively reviewed 197 patients (226 hips) with osteonecrosis treated with a combination of autologous cancellous bone impaction and pedicled iliac bone block transfer perfused by the ascending branch of the lateral femoral circumflex artery, and determined the long-term clinical and radiologic outcomes, and came to the conclusion that this procedure is used in patients younger than 45 years who have Stages II or III osteonecrosis with mild-to-moderate collapse of the femoral head but integrity of the weight-bearing surface, the patients had satisfying results regardless of the extent of the sequestrum. Xiantao Chen et al²³ performed the clinical efficacy of sartorius muscle-pedicled bone graft in 58 ONFH patients, with a total good rating of 79.68% and 81.25% survival rate of femoral head. Mehmet Bekir Ünal et al²⁴ retrospectively reviewed 28 hips of 21 patients who had undergone free vascularized fibular grafting for the treatment of osteonecrosis of femoral head, with 7.6-year follow-up and arrival at a conclusion that free vascularized fibular grafting yields extremely good results, particularly in pre-collapse stages of disease in young patients.

Table 2
Clinical data at the operation in the two groups (mean ± SD).

Group	Number (hips)	Stitches removal time	Intraoperative blood loss	Operation time	Incision length
		day	ml	min	cm
SMBFG	104	13.53 ± 0.17	265.62 ± 17.44	79.25 ± 3.47	17.24 ± 1.34
CIDBFG	76	15.32 ± 0.75	314.71 ± 22.27	86.70 ± 3.86	20.92 ± 1.38
<i>t</i>		–30.211	–21.012	–5.375	–5.247
<i>p</i>		0.00	0.00	0.00	0.00

Table 3
Comparison of preoperative and postoperative Harris score.

Group	Number (hips)	Preoperative	Postoperative				
			6 month	12 month	24 month	36 month	48 month
SMBFG	104	68.26 ± 1.26	85.32 ± 3.21	91.37 ± 3.34	89.18 ± 3.16	87.27 ± 2.93	83.94 ± 2.75
CIDBFG	76	69.35 ± 1.31	86.41 ± 3.72	91.53 ± 3.52	90.17 ± 3.09	88.12 ± 2.86	85.22 ± 2.28
t		1.374	1.878	54.112	70.147	69.152	3.985
p		0.178	0.080	0.000	0.001	0.001	0.001

Table 4
Imaging results during follow-up.

Preoperative stages	SMBFG					CIDBFG				
	Number (hips)	Improved	Stabilized	Aggravated	Stability (%)	Number (hips)	Improved	Stabilized	Aggravated	Stability (%)
ARCO stage IIa	13	13	0	0	100	10	10	0	0	100
ARCO stage IIb	64	57	2	5	92.19	46	40	3	3	93.47
ARCO stage IIc	27	11	8	8	70.37	20	9	5	6	70
Total	104	81	10	13	87.50	76	59	8	9	88.16
χ^2					27.362					11.247
p					0.00					0.00

This study reviewed and analyzed two bone flap grafts for the treatment of early ONFH: ① Compared with SMBF, the CIDBF group had long time of stitches, a large amount of blood loss, a long operation time and a long incision, in addition, due to the modified Smith-Petersen approach was an arc incision, so postoperative fat liquefaction was prone to occur. ② The postoperative Harris score indicated that: The deep iliac bone flap provided more effective blood supply, and accordingly in the postoperative rehabilitation, patients of SMBF group were superior to that of CIDBF group. In addition, we deduced that the postoperative Harris score of two groups decreased gradually over time, which was related to the progression of osteonecrosis. ③ Preoperative and postoperative X ray staging results showed that bone flap grafts hip-preserving surgery can not completely prevent the progress of ONFH, but it can effectively delay its progress. It also showed that two bone flap grafts hip-preserving surgery had good effect on ACRO II A and ACRO II B stage, and the curative effect was reduced by half in phase II C stage. Therefore, for ONFH, early surgical intervention is particularly critical.

It is necessary to reconstruct the spatial structure of the femoral head in the reconstruction of the bone defect in the weight-bearing part of the femoral head. The more closed to the elastic modulus of the implanted material of the elastic modulus of the femoral head, the more closed to normal of the stress distribution in the femoral head, so that a better clinical effect can be achieved. The autogenous cancellous bone can be used for compression and bone grafting, which can make the filling material have a certain initial mechanical strength, integrate with the surrounding bone as soon as possible, shoulder the load and realize the normal distribution of stress of the femoral head. The clinical results obtained in this study were very well documented.

In this study, we conclude that two bone flap grafts for the treatment of early ONFH can achieve good clinical results, which were effective methods for ONFH hip preservation. Compared with the two groups, the CIDBF group was better than that of the SMBF group as a whole, but there were also some shortcomings in the CIDBF group, correspondingly the clinical curative effect of the SMBF group were also satisfactory, and had many advantages, such as simple operation, less bleeding, shorter operation time, and we believed that this is a reliable method to promote hip preservation in primary hospitals. So additional studies with a larger sample size with an adequate number of patients, multicenter and the long-term follow-up are required to investigate and evaluate.

Conflict of interest

All authors declare no conflicts of interest.

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