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Clinical outcomes of open reduction and internal fixation combined with sartorius muscle iliac bone graft transplantation for displaced femoral neck fractures in middle-aged and young adults: a retrospective analysis of 24 cases

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Abstract

Objective This study aimed to evaluate the clinical outcomes and complications of open reduction and internal fixation (ORIF) combined with sartorius muscle iliac bone graft transplantation (SIBFT) in the treatment of displaced femoral neck fractures in middle-aged and young adults.

Methods A retrospective analysis was performed on 26 patients under the age of 60 with displaced femoral neck fractures (Pauwels III or Garden III-IV) treated at our institution between April 2019 to July 2022. All patients underwent open reduction and internal fixation (ORIF) through the Smith-Petersen (S-P) approach, augmented with a sartorius muscle iliac bone graft transplantation. The fractures were secured with either three cannulated screws or three cannulated screws combined with a medial support steel plate. Postoperative follow-ups were scheduled at 1, 2, 3, 6, and 12 months to record bone healing time, complications, and assess Harris Hip Scores.

Results Two patients were lost to follow-up, resulting in 24 patients who completed the follow-up with an average duration of 25.7 months. Bone healing was observed in 95.8% (23/24) of the patients, with a mean healing time of 5.0 months. Avascular necrosis of the femoral head occurred in 8.3% (2/24) of the patients after fracture healing. Harris Hip Score at the last follow-up was 89.75 (range 73–98).

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Conclusion Our preliminary results suggest that ORIF combined with sartorius muscle iliac bone graft transplantation for the treatment of displaced femoral neck fractures in middle-aged and young adults achieved satisfactory clinical outcomes.

Keywords Middle-aged and young adults, Displaced femoral neck fractures, Open reduction and internal fixation, Sartorius muscle iliac bone graft

Background

Femoral neck fractures in middle-aged individuals are mainly caused by high-energy trauma [1], such as road traffic accidents and falls from height. These fractures often present with severe displacement, bone loss, or comminution, which can lead to fracture instability. As a result, surgical treatment for these fractures often comes with a relatively high complication rate [2, 3]. The most severe complications of femoral neck fractures in this demographic are nonunion and avascular necrosis of the femoral head, with reported rates of nonunion post-treatment ranging from 10 to 30% and avascular necrosis rates between 15% and 33% [4, 5]. Despite significant advances in internal fixation devices and surgical techniques for treating femoral neck fractures, there is still no gold standard for treatment. Therefore, managing these patients continues to be one of the most significant challenges for orthopedic surgeons [6].

In 1964, Judet et al. reported on the successful management of specific femoral neck fracture types by employing the vastus lateralis osteomuscular graft in conjunction with screw fixation techniques [7]. Subsequent research has suggested that the use of vastus lateralis myo-osseous grafts may improve blood circulation to the femoral head in cases of displaced femoral neck fractures [8, 9]. Numerous studies have chronicled the implementation of vascularized myo-osseous grafts for the treatment of established femoral neck fractures, non-unions, and avascular necrosis of the femoral head, yielding promising clinical results [10–13]. However, literature on the integration of myo-osseous grafts with internal fixation methods for the management of acute displaced femoral neck fractures remains scarce. Consequently, this study aims to assess the therapeutic efficacy of combining sartorius muscle myo-osseous graft transplantation with internal fixation in treating fresh displaced femoral neck fractures in middle-aged individuals.

Patient information and methods

A retrospective analysis was conducted on middle-aged patients who underwent sartorius muscle iliac bone graft combined with internal fixation for the treatment of femoral neck fractures at the Fifth Affiliated Hospital of Southern Medical University from April 2019 to July 2022. The inclusion criteria included: (1) patients aged over 18 and under 60 years; (2) femoral neck fractures classified as Pauwels Type III or Garden Types III-IV; (3)

the availability of comprehensive medical records and imaging studies, along with the patients' ability to follow through with post-treatment monitoring. Exclusion criteria included: (1) pathological or old fractures; (2) severe respiratory or circulatory system diseases; (3) severe cranial brain injuries; (4) concomitant femoral head fractures. Informed consent was obtained from all patients and their families, and the treatment protocol was approved by the hospital's ethics committee. The study comprised 26 patients, 17 males and 9 females, aged from 27 to 60 years with an average age of 45.72 ± 8.72 years. The causes of injury included 9 instances of road traffic accidents, 10 falls from height, and 6 falls during ambulation. According to the Garden classification, there were 9 cases of type III and 16 cases of type IV fractures. Upon admission, all patients received skeletal traction.

Surgical method

All surgical procedures were conducted by the same team of surgeons. Patients were placed in the supine position on a radiolucent operating table after receiving combined spinal and epidural anesthesia. A modified direct anterior Smith-Petersen (S-P) approach was used [14], with the incision starting 2 cm above the anterior superior iliac spine and extending approximately 15 cm towards the distal femur (Fig. 1). The skin, subcutaneous tissue, and fascia were incised, and blunt dissection was used to expose the tensor fasciae latae, sartorius, and vastus lateralis muscles. Care was taken to identify and ligate the ascending branch of the lateral circumflex femoral artery (Fig. 2). A "T"-shaped incision was made in the anterior joint capsule, hematomas within the capsule were evacuated, and one or two Kirschner wires (K-wires) were inserted anterior to the femoral head to control rotation and assist with reduction. Under direct vision, anatomical reduction of the fracture was achieved. A small incision was made on the lateral aspect of the proximal femur, through which three guide wires were inserted. The position of the fracture reduction and K-wires was confirmed with C-arm fluoroscopy, followed by the insertion of three cannulated screws. If the fracture line was located at the junction of the femoral head and neck, a 1/3 tubular support plate was additionally used for fixation. The proximal sartorius muscle and its iliac origin were freed (taking care to protect the lateral femoral cutaneous nerve), and a sartorius muscle iliac bone graft measuring approximately 3 cm x 1.5 cm x 1.5 cm was harvested and



Fig. 1 Incision for anterior approach to the hip

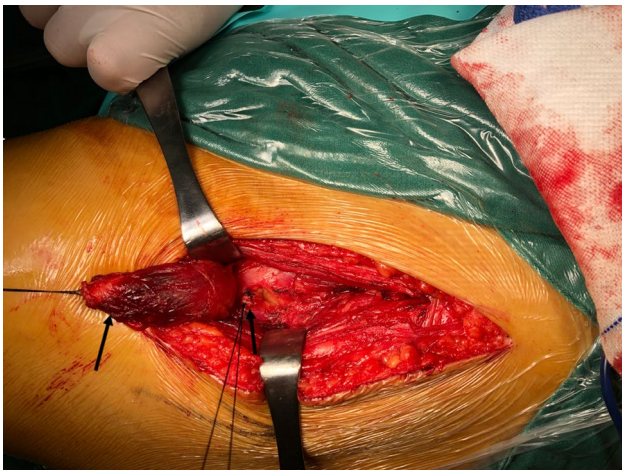


Fig. 2 Arrow show excise rectus femoris and ligation of the ascending branch of the lateral circumflex femoral artery

implanted into a similarly sized bone trough prepared in advance across the fracture line in the anterior femoral head and neck (Fig. 3). Care was taken not to invert the bone graft to avoid compromising its blood supply. The wound was irrigated and sutured in layers, with routine placement of a drainage tube for drainage.

Postoperative management and outcome assessment

Patients received perioperative antibiotics, as well as low molecular weight heparin (4000AxaIU) once daily for a month as antithrombotic prophylaxis. Within 24 h post-surgery, patients were encouraged to begin isometric exercises of the quadriceps and to perform dorsiflexion and flexion movements of the ankle. Weight-bearing activities were prohibited for 6–8 weeks, with partial weight-bearing allowed at 12 weeks with the aid of crutches. The criteria for fracture healing include the absence of pain in the hip when bearing full weight and

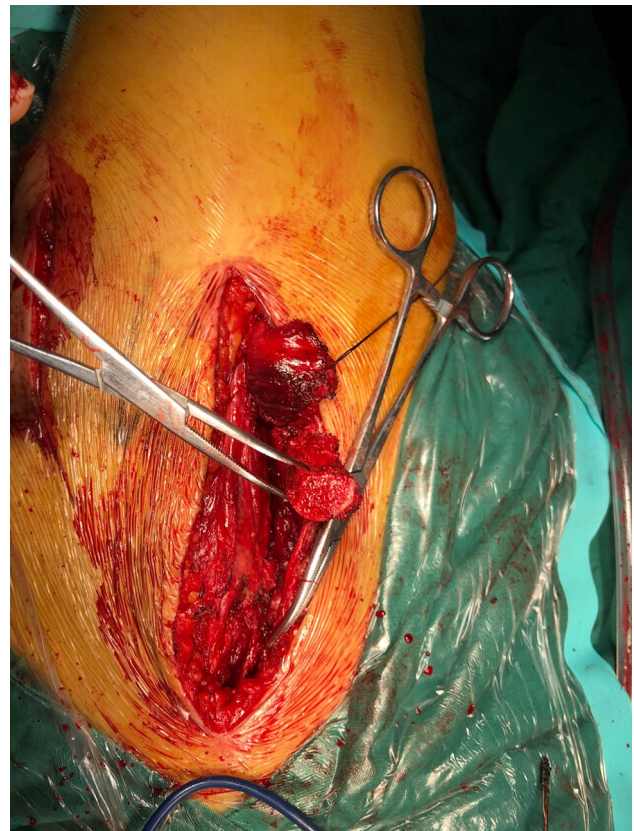


Fig. 3 Perioperative clinical photograph showing the Sartorius muscle iliac bone graft

the visibility of trabeculae across the fracture line on an anteroposterior pelvic or lateral hip joint X-ray. Full weight-bearing was permitted only after fracture union. All patients were scheduled for follow-up visits at the 1st, 3rd, 6th, and 12th month postoperatively.

Fracture healing and complications were evaluated via postoperative radiographic assessments. The vanishing of the fracture line on X-ray films signified fracture healing, whereas its persistence one year postoperative indicated a nonunion. Avascular necrosis of the femoral head was defined as Steinberg stage II or higher [15]. At the final follow-up, The Harris Hip Score (HHS) was used to evaluate the functional outcome of the hip joint. An HHS of ≥ 90 was considered excellent, ≥ 80 was good, and < 80 was deemed poor.

Statistical analysis

Statistical analysis was performed using SPSS version 22.0 (SPSS Inc. Chicago, IL, USA). All quantitative data are presented as mean \pm standard deviation (SD). Levene's test was used to determine the distribution of data. The independent t-test for two samples was used to analyze the data. Categorical data were compared using the χ^2 test or the Fisher exact probability method if the

theoretical frequency was less than 1. A P value < 0.05 was considered statistically significant.

Results

All patients successfully underwent surgery with satisfactory fracture reduction achieved in each case. There were no instances of intraoperative damage to the lateral femoral cutaneous nerve, and no postoperative wound infections were documented. Of the 26 patients, 2 were lost to follow-up after discharge and returned to their local areas, resulting in 24 patients included in the assessment (Table 1). The average follow-up duration was 25.8 months (range 12–52 months); the average time from injury to surgery was 4.17 days (range 1–10 days); the average surgery duration was 124.37 min (range 70–165 min); the average blood loss was 195.83 ml (range 100–300 ml). Fracture healing was achieved in 95.8% (23/24) of the patients, with an average healing time of 5.0 months (range 4–9 months); the average Harris Hip Score at the last follow-up was 89.75 (range 73–98), with 10 cases rated as excellent, 13 as good, and 1 as poor, leading to a favorable outcome rate of 95.8%. Example images of patient radiographs were shown in (Fig. 4).

Additionally, by comparing the patients who underwent fixation with Cannulated screw (CS) and those who underwent fixation with Cannulated screw combined with Medial buttress plate (CS+MBP), we found no significant differences in Harris scores, fracture healing time, and surgical time between the two groups ($p > 0.05$). The incidence of complications in the CS+MBP group was higher than in the CS group ($P = 0.003$), and the amount of bleeding was also greater than in the CS group ($P = 0.009$) (Table 2).

Among the cases, one patient (4.2%) faced nonunion of the fracture, resulting in a Harris Hip Score (HHS) of 73. A computed tomography (CT) scan detected avascular necrosis of the femoral head, which subsequently necessitated total hip arthroplasty for the patient. In two additional cases (8.3%), ischemic necrosis of the femoral head, identified at Steinberg stage III, emerged one year post-fracture healing; nevertheless, both cases were asymptomatic. Positively, no further progression of avascular necrosis was noted in these patients throughout the follow-up duration. Furthermore, one patient (4.2%) developed heterotopic ossification at the anterior region of the hip joint, yet this condition was not associated with any clinical symptoms or mobility impairments.

Discussion

Femoral neck fractures are most commonly seen in the elderly, where hip replacement surgery is typically the treatment of choice. Conversely, minimally invasive internal fixation often leads to satisfactory clinical outcomes for non-displaced femoral neck fractures in

middle-aged and younger adults. Nevertheless, displaced femoral neck fractures in this age group remain a formidable challenge for orthopedic surgeons. This is due to the fractures' inherent complexity and the elevated risk of serious complications, including avascular necrosis of the femoral head and nonunion [16]. The majority of scholars agree that surgical intervention is the preferred treatment method for such intra-articular fractures [17]. Despite extensive research over many years has led to a general clinical consensus, anatomical reduction and stable fixation can enhance the healing rates of femoral neck fractures and reduce the occurrence of avascular necrosis. However, the high-energy nature of these injuries, the vertical orientation of the fracture planes, significant displacement, and frequent bone quality deficits at the fracture ends contribute to instability, increasing the difficulty of achieving stable fixation [18, 19]. Consequently, literature still reports still indicate high incidences of postoperative avascular necrosis and nonunion for these fractures, with rates ranging from 11 to 86% for necrosis and 16–59% for nonunion [3, 20–23]. For middle-aged and young patients determined to preserve their natural hip joint, these complications are catastrophic, as they may ultimately require total hip replacement surgery. Therefore, it is argued that every efforts should be made to preserve the hip joint in these patients.

Muscle-bone graft transplantation can provide vascularized bone support for comminuted fracture areas [24]. Although there is no direct evidence proving its superiority in promoting fracture healing compared to other techniques [24], numerous reports have documented various types of muscle-bone graft transplants for treating early ischemic necrosis of the femoral head, neglected femoral neck fractures, and non-union of femoral neck fractures, achieving favorable therapeutic outcomes. Guptat et al. [25] used the vastus lateralis muscle-bone graft to treat 20 cases of non-union in femoral neck fractures, with an average follow-up of 70 months.

Postoperatively, all fractures healed, with 3 cases (15%) experiencing asymptomatic ischemic necrosis of the femoral head, and an average Harris score of 93. Bhuyan et al. [26] reported an 85% fracture healing rate in neglected femoral neck fractures treated with the sartorius iliac bone graft. Nair et al. [27] used the vastus lateralis muscle-bone graft in 17 middle-aged patients with old femoral neck fractures and non-union, observing delayed healing in 2 cases (11.7%) without any occurrence of avascular necrosis of the femoral head, achieving a postoperative good to excellent rate of 94.1%. Zhou et al. [28] treated 68 patients with ischemic necrosis of the femoral head using the sartorius muscle iliac bone graft transplantation, noting good clinical outcomes and straightforward surgical procedures. Wu et al. [29] conducted a systematic analysis on muscle-bone graft transplantation

Table 1 Clinical details of patients

Case	Case	Age	Mode of injury	Pauwels type	Garden type	Hurt to surgery (day)	Internal fixation	Surgery time (min)	Blood lost (ml)	Union time (mths)	Followup (mths)	H	Result
												H	S
1	M	53	RTA	III	IV	6	CS	80	150	5	45	92	Union
2	F	60	fall	III	IV	1	CS+MBP	135	200	5	13	95	Union
3	M	58	RTA	III	III	2	CS+MBP	125	100	6	17	86	Union
4	M	42	fall	III	IV	4	CS	125	200	6	13	85	Union
5	M	46	fall	III	III	2	CS	110	200	4	19	94	Union
6	F	50	fall	III	IV	7	CS+MBP	140	300	5	33	96	Union
7	F	46	slip	III	IV	7	CS	105	150	5	42	96	Union
8	F	53	slip	III	IV	2	CS+MBP	130	200	5	16	89	Union
9	M	52	slip	III	IV	1	CS+MBP	165	300	-	19	73	Nonunion
10	M	44	fall	III	IV	3	CS+MBP	130	200	6	14	92	Union
11	F	54	fall	III	III	5	CS+MBP	125	300	4	31	85	AVN
12	M	46	RTA	III	III	4	CS	135	150	4	30	89	Union
13	F	38	fall	III	IV	4	CS+MBP	130	300	6	26	98	Union
14	F	46	slip	III	III	5	CS	110	150	5	41	98	Union
15	M	51	RTA	III	III	5	CS+MBP	100	200	4	28	88	Union
16	M	33	RTA	III	III	2	CS+MBP	110	150	4	30	86	AVN
17	M	55	fall	III	IV	3	CS+MBP	120	200	4	25	86	Union
18	M	30	RTA	III	III	6	CS	125	100	4	52	98	Union
19	M	39	fall	III	IV	2	CS+MBP	130	200	5	16	89	Union
20	M	52	RTA	III	IV	2	CS+MBP	145	300	5	18	92	Union
21	M	34	RTA	III	IV	4	CS	110	150	6	12	88	Union
22	M	43	RTA	III	III	10	CS	100	150	7	13	87	Union
23	M	48	slip	III	IV	5	CS+MBP	165	150	5	29	86	Union
24	F	27	RTA	III	IV	9	FNS	135	200	4	36	86	Union

RTA = Road traffic accident; CS: Cannulated screw; MBP: Medial buttress plate

FNS: The femoral neck system; AVN: Avascular femoral necrosis; HHS: Harris hip score



Fig. 4 (a) Pare-operative anteroposterior (AP) radiograph showing displaced femoral neck fracture; (b) AbP radiograph 5 months post-operatively demonstrating fracture union; (c) CT scan 2years post-operatively demonstrating fracture union and no evidence of necrosis

Table 2 Baseline characteristics of patients. Comparison between groups (mean \pm standard deviation)

	CS(n=9)	CS+MBP (n=14)	P
Gender			0.172
Male	7	9	
Female	2	5	
age(years)	42.9 \pm 6.9	49.1 \pm 7.9	0.554
Garden type			0.23
Type III	5	4	
Type IV	4	10	
hurt to sugery (day)	6.3 \pm 4.9	3.1 \pm 1.8	0.175
Surgery time (min)	111.1 \pm 16.2	132.1 \pm 17.9	0.799
Blood lost (ml)	155.6 \pm 30.0	221.4 \pm 67.1	0.009
Union time	5.1 \pm 1.1	5.2 \pm 1.3	0.861
HHS	91.9 \pm 4.9	88.6 \pm 6.1	0.879
complication	0	3	0.003

CS: Cannulated screw; MBP: Medial buttress plate

for treating middle-aged femoral neck fractures, concluding an average good to excellent rate of 73%, a non-union rate of 9.0%, an ischemic necrosis rate of 6.7%, a collapse rate of 4.7%, and a reoperation rate of 7.3%. These results support the belief that vascularized muscle-bone grafts can stimulate vascular reconstruction in the femoral head, enhance blood supply, and thereby promote fracture healing while reducing the risk of avascular necrosis.

In our study, we found the sartorius muscle iliac bone graft transplantation procedure to be straightforward, with a low incidence of surgical complications. Among the 24 patients who underwent the surgery, no significant neurovascular injuries were reported intraoperatively. The surgery was characterized by a short duration, averaging 121.67 min, and minimal blood loss, averaging 193.75 ml. Additionally, no postoperative wound infections were observed. Three patients experienced complications. One patient (4.2%) suffered from non-union of the fracture. Our analysis suggests that this patient did not adhere to medical advice and began full weight-bearing before the fracture had united within a month after surgery, leading to the failure of the internal fixation device and resulting in non-union. Two patients (8.3%) experienced avascular necrosis of the femoral head. Both of these patients had fracture types classified as Garden IV or Pauwels III and underwent medial buttress plate (MBP) combined with cannulated screw (CS) fixation. Despite the fractures being well reduced and fixed, the avascular necrosis of the femoral head may be attributed to the severe displacement of the fracture and the further disruption of the blood supply to the femoral head caused by the use of a medial support plate during surgery. The average Harris Hip Score (HHS) at the last follow-up was 89.75, with a good to excellent rate of 95.8%, which is similar to the results of the study by Ma et al. [30]. Although two patients showed signs of avascular necrosis of the femoral head on X-ray, they did not

experience pain, including no significant pain while walking, so their Harris scores remained high during the last follow-up. This has led to clinically “95.8%” successful but radiographically wise its lower. However, it is believed that as the avascular necrosis of the femoral head progresses, the Harris scores will decrease.

Limitations

Several limitations warrant acknowledgment in this study. The sample size was not determined prospectively, and the follow-up was not long enough to capture certain complications,, especially avascular necrosis of the femoral head. It is imperative that the precise incidence of necrosis be meticulously recorded following extended follow-up within a sizable cohort. The retrospective design of the study introduced a significant risk of bias in patient selection and measurement processes.

Conclusion

In our cohort, Sartorius muscle Iliac Bone graft Transplantation proved to be a valuable adjunct to open reduction and internal fixation for treating displaced femoral neck fractures in young and middle-aged patients. We hypothesize that this benefit may stem from the pedicled iliac bone graft, which supplies partial blood flow to the fracture site, or from the autologous bone grafting that addresses the fracture defect, thereby promoting healing. Naturally, anatomical reduction and robust fixation of the fracture also play crucial roles in achieving favorable outcomes. However, a limitation of this study is the small number of cases, and there is no direct evidence to demonstrate that the iliac bone graft can enhance blood supply to the femoral head.

Author contributions

HC, YL, and HZ conceived and designed the study, and critically revised the manuscript. SC and GW conducted the experiments and drafted the manuscript. SM, FH, and PY contributed to the analysis and collation of experimental data and the revision of the manuscript. HZ provided the funding for the study. All authors have read and approved the final manuscript.

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Data availability

All data generated or analyzed during this study are included in this published article.

Declarations

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Ethics approval

This study was approved by the Human Subjects Division of the Southern Medical University Review Board in accordance with the Declaration of Helsinki. The investigation was performed at the Fifth Affiliated Hospital of Southern Medical University.

This work has not been previously presented or published.

Informed consent

was obtained from all patients and their families, and the treatment protocol was approved by the the Ethics Committee of Southern Medical University.

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