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Original Article

Comparison of proximal femoral nail antirotation internal fixation and artificial hip replacement for elderly patients with intertrochanteric fractures

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Abstract: Objective: To compare the effects of proximal femoral nail antirotation (PFNA) internal fixation and artificial hip replacement (AHR) on serum inflammatory factors and hip function recovery in elderly patients with intertrochanteric fractures (IFs). Methods: One hundred and thirty patients with IFs who underwent surgery at the People's Hospital of Pingyang between July 2018 and July 2020 were enrolled. Sixty-five patients received PFNA internal fixation (fixation group) and 65 received AHR (replacement group). Surgical indicators and complications were recorded in both groups. The Harris Hip Scale was used to score hip joint function, the Visual Analog Scale (VAS) to assess pain, the MOS 36-Item Short-Form Health Survey (SF-36) to evaluate life quality, and enzyme-linked immunosorbent assay to measure serum tumor necrosis factor-α (TNF-α), interleukin (IL)-6, and IL-1β. Results: The replacement group experienced notably shorter hospitalization times, less complete weight-bearing time, and earlier time to walk compared to the fixation group (all $P<0.05$). The replacement group also showed a lower incidence of poor fracture healing and complications (both $P<0.05$). Additionally, on postoperative days 3, 15, and 45, the replacement group had notably lower VAS scores (all $P<0.05$). Furthermore, the replacement group exhibited higher Harris Hip Scale scores at 1, 2, and 3 months post-surgery (all $P<0.05$). Higher postoperative SF-36 scores were also observed in the replacement group ($P<0.05$). On postoperative day 30, both groups presented decreases in TNF-α, IL-6, and IL-1β levels compared to preoperative levels, with even lower levels in the replacement group (all $P<0.05$). Conclusions: AHR can help elderly patients with IFs ambulate earlier, speed up hip function recovery, reduce inflammation, and improve life quality with fewer postoperative complications, making it worthy of clinical promotion.

Keywords: Hip replacement, intertrochanteric fractures, elderly, inflammatory factors

Introduction

Hip fractures are a primary cause of death and disability among the elderly and are a major global public health issue [1]. With global population aging, the number of patients suffering from hip fractures is increasing [2]. Among elderly patients with hip fractures, over 60-70% suffer from intertrochanteric fractures (IFs), with an annual mortality rate as high as 15-20% [3]. It is reported that there are over 150,000 cases of IFs each year in the United States [4]. Elderly patients with IFs often have various severe underlying diseases, leading to low surgical tolerance and difficult postoperative recovery, seriously compromising their outcomes [5]. Surgery is the mainstay of treatment for elderly patients with IFs, but there are many surgical modalities and no clear criteria [6].

Currently, the primary surgical methods for senile osteoporosis comorbid with IFs are joint replacement and fixation, aiming to improve patients' quality of life by achieving stable fixation, early mobilization, normal baseline functional activity, and independence [7]. Proximal femoral nail antirotation (PFNA) and dynamic hip screw (DHS) are two commonly adopted fixation methods used in clinical practice. PFNA is an intramedullary fixation device specially designed for IFs, which can effectively fix the proximal femur and thus provide significantly better overall treatment efficacy than DHS [8]. Previous research has recommended artificial

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femoral head replacement due to its shorter operation time, less intraoperative bleeding, quicker postoperative joint function recovery, lower degree of pain, and fewer complications [9, 10]. However, some scholars believe that artificial femoral head replacement should not be the primary operation for IFs but rather a remedy or revision surgery for failed internal fixation of IFs [11, 12]. Elderly patients with IFs often have declining physical function, multiple comorbidities, weak psychological tolerance, and osteoporosis, making the requirements for surgical methods more stringent. Currently, both PFNA internal fixation and artificial hip replacement (AHR) have their advantages and disadvantages, and there is no consensus on which surgical method is more suitable for these patients.

This study enrolled 130 elderly patients with IFs and treated them with PFNA internal fixation or AHR to determine and compare the effects of the two surgical methods. The aim was to provide a more scientific basis for clinical treatment, optimize treatment strategies for elderly patients with IFs, and improve their postoperative quality of life and long-term prognosis.

Materials and methods

Research subjects

This retrospective study enrolled 130 patients with IFs who underwent surgery at the People's Hospital of Pingyang between July 2018 and July 2020. Among them, patients who received PFNA internal fixation were assigned to the fixation group (n=65), and those who received AHR were assigned to the replacement group (n=65).

Inclusion criteria: Age 75 years or older [13]; certain walking ability and normal living ability before injury; a confirmed diagnosis of IF by preoperative X-rays; willingness to undergo surgery; no absolute contraindications.

Exclusion criteria: Mental disorders, comorbid vital organ insufficiency, coagulant abnormalities, defective case data, and loss to follow-ups.

The study was conducted with the approval of the Ethics Committee of the People's Hospital of Pingyang.

Treatment

Fixation group: The patient was placed supine on an orthopedic traction bed and anesthetized with combined spinal-epidural anesthesia. Traction reduction was performed under a C-arm fluoroscope to restore the normal neck angle and anteversion angle of the hip joint. Using the apex of the greater trochanter of the femur as the entry point, a guide pin was driven along the longitudinal axis of the femur, and a PFNA main nail of appropriate diameter and length was inserted into the distal end of the femoral medullary cavity along the guide pin. After adjusting the insertion depth, a spiral blade guide pin was drilled into the femoral neck along the keyhole at the proximal end of the guide. The guide pin was positioned at the middle and lower third of the femoral neck, with a depth of 5 mm below the articular surface of the femoral head under the C-arm perspective. The spiral blade was inserted along the guide pin, tightened, and locked, and the locking screw was inserted at the distal end. A tail cap was installed at the proximal end of the main nail. Finally, the surgical incision was closed.

Replacement group: The patient was placed in a lateral position and anesthetized with combined spinal-epidural anesthesia. A posterolateral incision was made, and the joint capsule was opened to expose the femoral head and trochanter. The femoral head was cut off obliquely 1 cm from the trochanter and removed with a head extractor. Subsequently, 2-3 strands of steel wire were placed in the fracture end of the proximal trochanter to tie the fracture end. The femoral canal was reamed, and a revision femoral stem (non-cemented) of appropriate diameter was selected and driven into the medullary cavity to achieve distal fixation under a properly adjusted anteversion angle. The fracture end was bound with proximal steel wire to maintain the muscle strength of the gluteus medius and prevent the greater trochanter from moving upward. Finally, a bipolar femoral head of corresponding size was installed.

Observation indexes

Main observation indexes: Surgery- and postoperative recovery-related indicators, including operation time, intraoperative blood loss, incision length, intraoperative fluoroscopy times, postoperative drainage volume, hospitalization time, time to walk, and complete weight-bearing time, were recorded. Perioperative complications, such as lower limb deep venous thrombosis, incision infection, poor fracture healing, urinary system infection, coxa vara, and pressure sores, were also documented.

Pain evaluation was conducted on postoperative days 3, 15, and 45 using the Visual Analog Scale (VAS; score range: 0-10), with higher scores indicating more severe pain [14]. Hip joint function was assessed at 1, 2, and 3 months post-treatment using the Harris Hip Scale, which evaluates pain, function, deformity, and mobility, with a maximum score of 100 points; higher scores indicate better hip function [15].

Secondary observation indexes: On postoperative day 30, the Self-Rating Anxiety Scale (SAS) and Self-Rating Depression Scale (SDS) were used to assess anxiety and depression, respectively [16, 17]. Each scale has a total score of 100 points, with higher scores indicating more severe anxiety or depression.

At three months post-treatment, the MOS 36-Item Short-Form Health Survey (SF-36) was used to evaluate patients' quality of life, focusing on cognitive function, physical function, role function, and emotional function [18]. The SF-36 scale also has a total score of 100 points, with higher scores indicating better quality of life.

An enzyme-linked immunosorbent assay (ELISA) kit (Wuhan Elisalab Biotechnology Co., Ltd.) was used to quantify serum tumor necrosis factor-α (TNF-α), interleukin (IL)-6, and IL-1β in patients. Specifically, before treatment and on postoperative day 30, 3 ml of fasting peripheral venous blood was drawn from each patient in the morning, followed by 15 minutes of centrifugation (1,000×g, 4°C) for supernatant collection. Standard and test samples were then prepared according to the ELISA kit instructions, placed into corresponding plates for 30 minutes of incubation (37°C). The plates were washed with a washing liquid. Each well was then incubated for another 30 minutes after the addition of an enzyme-labeled reagent. Following washing, a chromogenic reagent was added to each well, followed by 15 minutes of incubation and the subsequent addition of stop solution.

Statistical analyses

The data were statistically processed with SPSS 19.0 (Yi Yun (Shanghai) Information Technology Co., Ltd.) and visualized using GraphPad Prism 10. Enumeration data were compared by the Chi-square test, while measurement data were compared between groups adopting the independent-sample t-test, within groups before and after treatment via the paired t-test, and among multiple groups using one-way analysis of variance (ANOVA). Additionally, a post-hoc test (Tukey's HSD) was used to verify the correctness of the statistical values. A p-value of <0.05 was considered statistically significant.

Results

Comparison of general data

The two groups were similar in general data, including age, body mass index (BMI), time from injury to surgery, cause of injury, educational level, and gender (all P>0.05) (**Table 1**).

Comparison of surgical indicators

All patients successfully underwent surgery. The replacement group showed more intraoperative blood loss, a longer incision length, a longer operation time, a shorter hospitalization time, shorter complete weight-bearing time, and an earlier time to walk compared to the fixation group (all P<0.05) (**Table 2**).

Comparison of postoperative complications

Primary perioperative complications were recorded in both groups. The two groups were similar in complications such as lower limb deep venous thrombosis, incision infection, urinary system infection, coxa vara, and pressure sores (all P>0.05). However, the replacement group had a lower incidence of poor fracture healing and a lower overall incidence of complications compared to the fixation group (both P<0.05) (**Table 3**).

Comparison of pain degree and hip joint function after surgery

Postoperative pain evaluation revealed that the replacement group had notably lower VAS scores than the fixation group on postoperative days 3, 15, and 45 (day 3: 5.26±1.85 vs.

Table 1. Comparison of general data between the two groups

General data	Fixation group (n=65)	Replacement group (n=65)	χ^2/t	*P*-value
Age (Y)	80.60±3.52	79.62±3.41	1.612	0.109
Body mass index (kg/m^2)	22.69±1.52	22.30±1.55	1.448	0.150
Time from injury to surgery (h)	14.17±6.35	15.75±6.09	1.448	0.150
Cause of injury			0.869	0.351
Fall and fall	46 (70.77)	41 (63.08)		
Traffic accident	19 (29.23)	24 (36.92)		
Education level			0.769	0.381
≤ Junior high school	54 (83.08)	50 (76.92)		
> Junior high school	11 (16.92)	15 (23.08)		
Gender			1.703	0.192
Female	25 (38.46)	18 (27.69)		
Male	40 (61.54)	47 (72.31)		

Table 2. Comparison of surgical indicators between the two groups

Surgical indicators	Fixation group (n=65)	Replacement group (n=65)	t	*P*-value
Operation time (min)	50.23±4.38	56.32±4.47	7.846	<0.001
Intraoperative blood loss (ml)	192.23±34.64	291.11±55.91	12.121	<0.001
Incision length (cm)	6.20±1.66	12.97±2.36	18.917	<0.001
Hospitalization time (d)	17.40±5.41	12.74±4.17	5.50	<0.001
Time to walk (d)	12.52±3.19	10.38±3.03	3.921	<0.001
Complete weight-bearing time (d)	50.97±9.15	42.80±8.24	5.349	<0.001

Table 3. Comparison of postoperative complications between the two groups

Postoperative complications	Fixation group (n=65)	Replacement group (n=65)	χ^2	P
Lower limb deep venous thrombosis	5 (7.69)	2 (3.08)	1.359	0.244
Incision infection	2 (3.08)	3 (4.62)	0.208	0.648
Poor fracture healing	9 (13.85)	2 (3.08)	4.866	0.027
Urinary system infection	5 (7.69)	3 (4.62)	0.533	0.465
Coxa vara	0 (0.00)	3 (4.62)	3.071	0.080
Pressure sores	4 (6.15)	1 (1.54)	1.872	0.171
Total incidence of complications	25 (38.46)	14 (21.54)	4.432	0.035

6.37±1.39; day 15: 3.06±1.34 vs. 5.29±1.29; day 45: 1.88±0.99 vs. 2.34±1.29; all P<0.05). Postoperative hip joint function assessment showed that the replacement group had notably higher Harris Hip Scale scores at 1, 2, and 3 months after surgery compared to the fixation group (the 1st month: 74.35±5.40 vs. 68.78±6.15; the 2nd month: 80.66±4.36 vs. 75.74±5.35; the 3rd month: 86.31±3.60 vs. 84.20±3.95; all P<0.05) (**Figure 1**).

Comparison of depression and anxiety scores

Postoperative assessments of patients' depression and anxiety revealed that the replacement group exhibited notably lower SAS (67.49±9.05 vs. 75.35±7.43) and SDS scores (62.26±9.71 vs. 72.42±6.11) than the fixation group (both P<0.05) (**Figure 2**).

Comparison of life quality scores

The evaluation of life quality showed that the replacement group had higher scores in cognitive function (77.11±7.77 vs. 72.35±8.01), physical function (71.54±6.25 vs. 67.74±6.52), role function (77.72±7.43 vs. 71.02±6.64), and emotional function (67.31±7.77 vs. 64.14±7.30) compared to the fixation group (all P<0.05) (**Figure 3**).

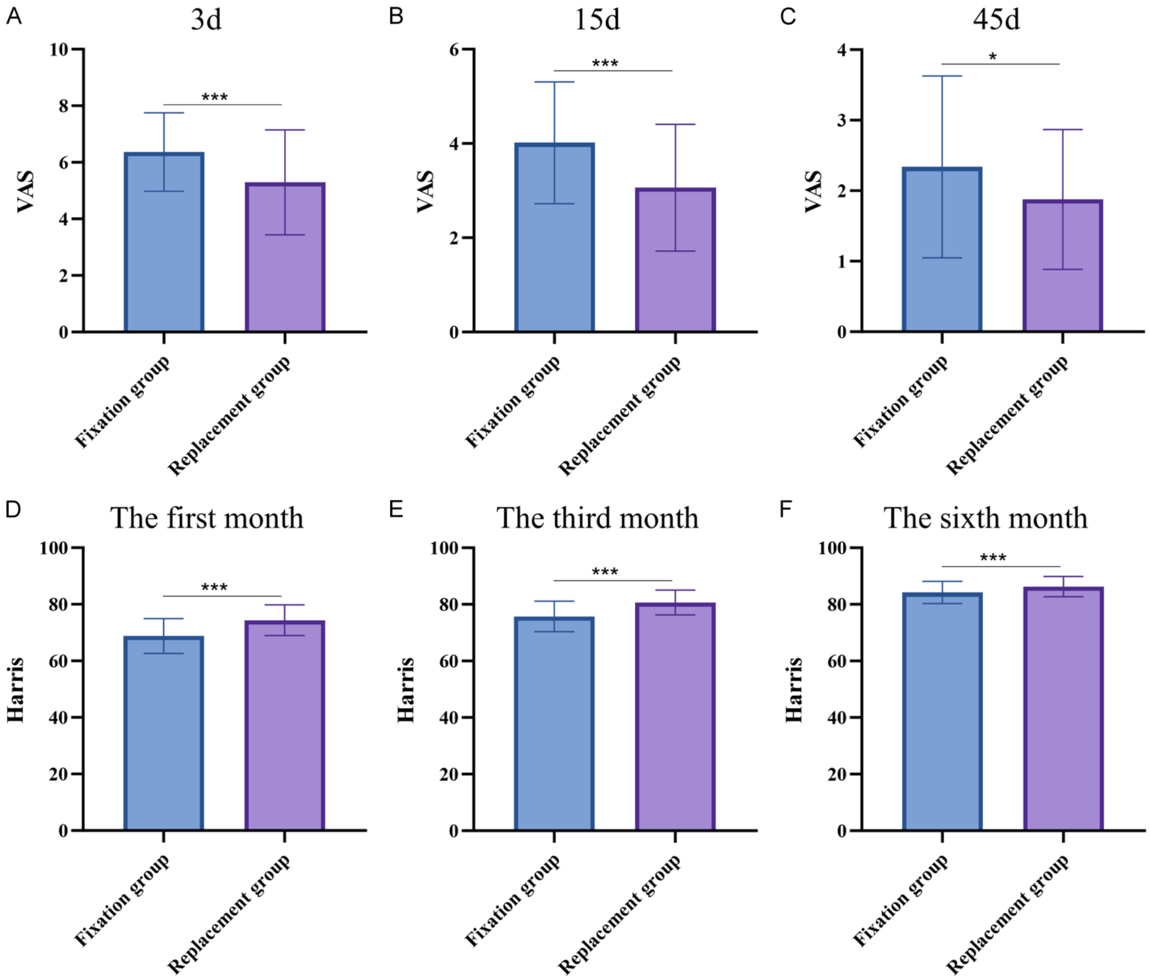

Figure 1. Comparison of pain degree and hip joint function after surgery. A: Visual analogue scale (VAS) scores on postoperative day 3. B: VAS scores on postoperative day 15. C: VAS scores on postoperative day 45. D: Harris Hip Scale scores at the first month after surgery. E: Harris Hip Scale scores at the third month after surgery. F: Harris Hip Scale scores at the sixth month after surgery. Note: ***P<0.001; *P<0.05.

Comparison of serum inflammatory factors

The serum levels of TNF-α, IL-6, and IL-1β showed no notable differences between the two groups before surgery (all P>0.05). However, on postoperative day 30, both groups presented decreases in TNF-α, IL-6, and IL-1β levels compared to preoperative levels, with even lower levels in the replacement group (all P<0.05) (**Figure 4**).

Discussion

IFs are highly hazardous for the elderly, but the optimal treatment remains controversial [19]. Most scholars currently believe that surgical treatment is superior to conservative treatment for IFs due to its advantages in pain relief, early hip function restoration, improved quality of life, and avoidance of complications like cardiovascular accidents and lower limb vein thrombus induced by long-term bed rest [20]. PFNA internal fixation and AHR are the primary surgical methods for IFs, each with certain limitations. PFNA is associated with complications such as screw loosening, difficulty in fracture healing, and displacement of the retropulsed fragment [21]. AHR, although highly effective, carries a relatively high surgical risk due to the severe trauma and physiological disruption it causes in elderly patients. Therefore, finding the most suitable treatment for IFs is essential.

Early ambulation is crucial for patients with IFs to avoid serious complications such as bed-

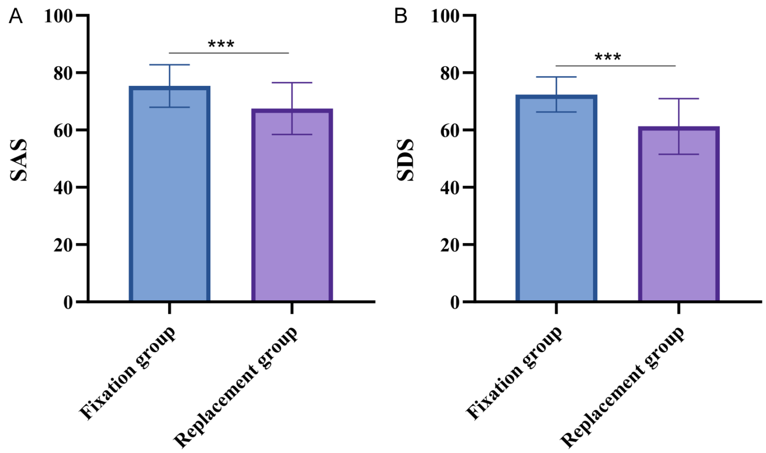

Figure 2. Comparison of depression and anxiety scores. A: Self-Rating anxiety scale (SAS) scores after surgery. B: Self-rating depression scale (SDS) scores after surgery. Note: ***P<0.001.

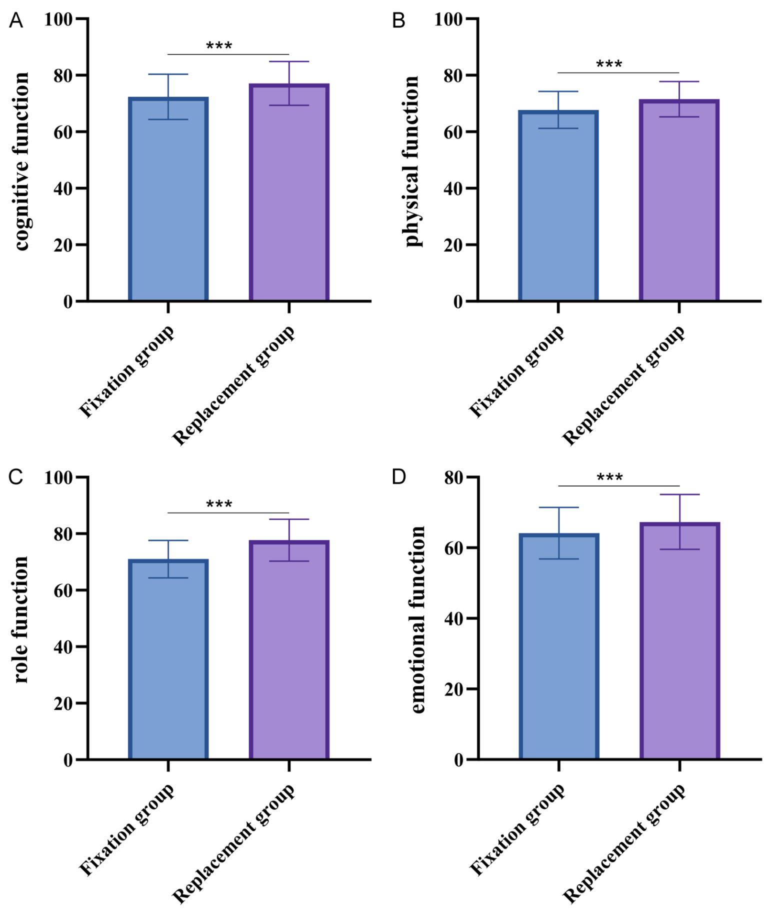

Figure 3. Scores of 36-item short-form health survey (SF-36). A: Cognitive function scores. B: Physical function scores. C: Role function scores. D: Emotional function scores. Note: ***P<0.001.

sores, urinary tract infection, joint stiffness, pneumonia, and thromboembolism [22]. In our study, the replacement group experienced notably shorter hospitalization and complete weight-bearing times, as well as earlier time to walk and a lower incidence of poor fracture healing and overall complications, suggesting that AHR can facilitate early movement and reduce postoperative complications. However, the replacement group also showed more intraoperative blood loss, longer incision length, and longer operation time than the fixation group, limiting the application of AHR to a certain extent. This is because PFNA is performed through a small incision with less bleeding, while AHR requires a larger incision and may involve more soft tissues and blood vessels, leading to greater surgical trauma. Additionally, AHR is usually more complex than PFNA, involving more steps and bone processing, resulting in longer operation time. These findings are consistent with a previous retrospective study which found that hemi-hip replacement enables better patient mobility and reduces dependence on walkers, but increases intraoperative blood loss, blood transfusion needs, and operation time [23], corroborating our results.

The restoration of hip joint function is a crucial indicator for the treatment of IFs. Currently, it is generally believed that joint replacement can improve the hip joint function of patients with IFs at an early stage compared to fixation [24]. According to postoperative hip joint function evaluation results, the replacement group had notably higher Harris Hip Scale scores than the fixation group at 1, 2, and 3

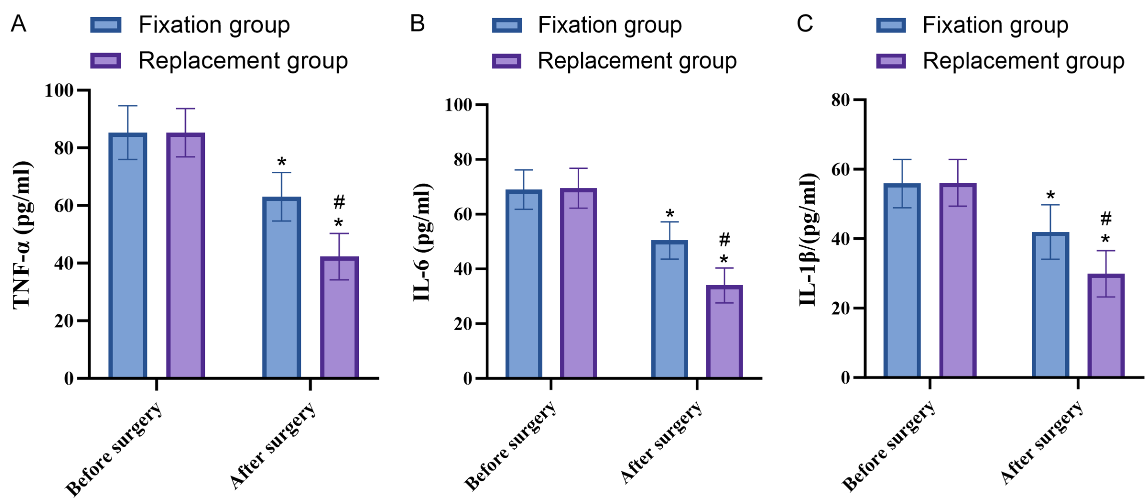

Figure 4. Enzyme-linked immunosorbent assay for the determination of serum tumor necrosis factor-α (TNF-α), interleukin (IL)-6, and IL-1β levels. A: Serum TNF-α levels. B: Serum IL-6 levels. C: Serum IL-1β levels. Notes: Comparison of the same group before surgery, *$P<0.05$; comparison of the fixation group at the same time, #$P<0.05$.

months after surgery, suggesting that AHR can restore the hip function of elderly patients with IFs faster and better than PFNA internal fixation. Prior research has indicated that functional impairment and persistent pain seriously affect patients' emotions, and negative emotions which compromise the results of many common orthopedic procedures [25]. One earlier study revealed the negative effects of hip fractures on patients' health, psychology, and life quality [26]. Therefore, attention should be paid to psychological and emotional changes in patients with IFs during treatment. In our study, the replacement group showed notably lower SAS and SDS scores and higher SF-36 scores than the fixation group. These results are similar to those obtained by Desteli et al. [27], who found that hemiarthroplasty allows elderly patients with unstable IFs to have better life quality scores than internal fixation. This indicates that AHR can more effectively alleviate the negative emotions of elderly patients with IFs and improve their quality of life compared with PFNA internal fixation.

AHR involves treating the soft tissue around the femoral neck and femoral head, replacing the entire hip tissue with a joint prosthesis made of special materials, and fixing it with bone cement, which can accelerate bone healing and rebuild joint function. Additionally, artificial joint prostheses align more closely with human physiological and anatomical characteristics, providing good fixation effects. Furthermore, a longer prosthesis length increases the contact area and interface length between the prosthesis stem and the femoral medullary cavity, dispersing stress and thus improving stability. This helps reduce the risk of refractures after surgery and provides long-lasting joint support, conducive to the long-term maintenance of the patient's quality of life. Moreover, AHR can treat not only IFs but also potential hip arthritis or other bone and joint diseases in patients, providing a more comprehensive treatment effect.

Both fractures and surgery heavily impact the inflammatory stress response of the body. TNF-α promotes the peroxidation of chondrocytes, which synergizes with IL-6 to aggravate inflammatory reactions and promote cartilage absorption [28]. IL-6 aggravates cartilage inflammatory injury by blocking cartilage proteoglycan synthesis and inducing cartilage matrix degradation [29]. IL-1β stimulates osteoblast proliferation and mineralized bone matrix production and suppresses chondrocyte differentiation and proliferation [30]. In our study, on postoperative day 30, both groups presented decreases in TNF-α, IL-6, and IL-1β levels compared to those before surgery, with even lower levels in the replacement group, suggesting a relatively weak inflammatory response and faster recovery in elderly patients with IFs treated with AHR.

There are certain shortcomings in this study. First, the research subjects were all from the same central hospital, and the sample size was small, which may limit the broad applicability of the research conclusions. Second, due to the need for prompt surgical treatment upon admission, the preoperative quality of life and negative emotions of the two groups of patients were not evaluated. Third, the study duration was relatively short and did not provide long-term prognostic outcomes for patients in both groups. It is hoped that these deficiencies can be addressed in future research.

In summary, compared to PFNA internal fixation, AHR can promote early recovery of hip joint function and improve the quality of life in elderly patients with IFs, with fewer postoperative complications. However, AHR is more invasive during surgery, so it should be selected according to the patient's physical condition in practical application.

Disclosure of conflict of interest

None.

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