

Comparison of postoperative effectiveness of less invasive short external rotator sparing approach versus standard posterior approach for total hip arthroplasty

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Abstract

Background

Studies assessing corrective posterior total hip arthroplasty (THA) mostly focused on the mini-incision approach, with few exploring the short external rotator sparing approach. This study aimed to compare the effectiveness of standard posterior approach versus short external rotator sparing approach.

Methods

This prospective observational study included patients treated in the Orthopedics Department of Jinhua Central Hospital in 06/2017-06/2018. Patient grouping was based on the surgical methods. Surgical data were recorded postoperatively. Postoperative hip joint recovery was assessed by the times to ambulation and independent stair use, and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score and Harris score and Oxford hip score (OHS) at 2 and 8 postoperative weeks. The visual analog scale (VAS) was used for postoperative pain assessment.

Results

Postoperative changes of creatine kinase (CK), myoglobin, CRP, and prosthesis position were similar in both groups. However, intraoperative blood loss and postoperative 6-h drainage volume, hospital stay, and blood transfusion rate were significantly reduced in the corrective (short external rotator sparing) group, as well as times to ambulation and independent stair use. Oxford and WOMAC scores in both groups decreased significantly postoperatively. The VAS score was more overtly decreased postoperatively in the corrective group compared with the standard group.

Conclusions

The corrective THA causes less damage and reduces perioperative blood loss, shortening functional recovery time, maintaining prosthesis stability and improving pain postoperatively.

Background

Multiple approaches to the hip joint have been proposed for total hip arthroplasty (THA), including the posterior (Moore or Southern), lateral (Hardinge), anterolateral (Watson Jones), direct anterior approach (Smith-Peterson) and posterolateral approaches (1, 2).

The posterolateral approach has several advantages such as sufficient exposure of the acetabular fossa and femur, and the preservation of abductor muscles in THA, and has been widely applied (3, 4). On the other hand, corrective surgical approaches for THA in recent years attract increasing attention from

surgeons, due to the advantages of mini-incision and rapid postoperative recovery (5, 6). These modifications could be broadly classified as mini-incision and external rotator sparing approaches (5–7).

However, no universally accepted standards are currently available for the exploration of corrective approaches. In addition, studies assessing corrective posterior THA mostly focused on the mini-incision approach, with few exploring the short external rotator sparing approach. Interestingly, a matched cohort study performed in 2010 showed that the corrective approach sparing the quadratus muscle of thigh could reduce intraoperative blood loss, alleviate postoperative resting pain, and shorten postoperative rehabilitation time; however, indicators reflecting intraoperative inflammation, such as C-reactive protein (CRP) and creatine kinase (CK), did not change significantly (8). The surgery sparing the piriformis muscle resulted in longer distance in the six-minute walking test and higher degree of patient satisfaction compared with the standard operation, while the acetabular anteversion angle was not significantly different between the two groups; in addition, the corrective group also had advantages such as reduced intraoperative injuries and faster postoperative recovery (8). However, these investigators indicated that the surgery was highly challenging, and suggested the operation was not worth applying, especially in obese patients, for short-term benefits (9–11). Additional reports suggested that based on soft tissue and muscle contusions induced by the surgical apparatuses and dilators, corrective surgeries could only provide limited additional benefits, with no objective clinical evidence supporting their advantages (12–14).

The above findings clearly indicate that the benefits of corrective surgeries in THA remain unknown. Therefore, the present prospective cohort study aimed to compare the effectiveness of standard posterior approach versus short external rotator sparing approach.

Methods

Patients

This prospective study included consecutive patients who underwent THA in the Orthopedics Department of Jinhua Central Hospital between June 2017 and June 2018. Inclusion criteria were: 1) age ≥ 18 years; 2) THA for diseases such as osteonecrosis of the femoral head, hip osteoarthritis, and femoral neck fracture; 3) no previous hip arthroplasty. Exclusion criteria were: 1) traumatic arthritis 2) language or communication difficulties, or psychiatric disorders that could not be followed up; 3) concurrent severe internal diseases or severe osteoporosis; 4) BMI > 30 ; 5) old acetabulum fractures accompanied by pelvic deformities or acetabular defects. The patients were assigned to the corrective and standard groups based on the applied surgical methods. This study was approved by the Ethics Committee of Jinhua Central Hospital (approval number LGF19H060005). All the included patients provided signed informed consent.

Surgical methods

All surgeries were performed by the same surgical team comprising 1 chief surgeon (15 years of experience) and 2 attending surgeons (6 years of experience). All patients were implanted a cementless prosthesis (Zimmer, USA) under general anesthesia by tracheal intubation. The blood lost during the operation and within 6 h postoperatively was collected with an autogenous blood recovery system, and blood loss volume was recorded. In patients with intraoperative blood loss >500 ml, autogenous blood transfusion was conducted. The patients were grouped into the corrective and standard groups, respectively, according to the administered surgical approaches, which were selected by surgeons based on disease condition and patient wishes. However, standard surgery was suggested for obese patients.

Surgery in the standard group

After general anesthesia, the patient was placed in the lateral position on the unaffected side, followed by routine disinfection and draping. A line of about 14 cm was drawn from the proximal end of the greater trochanter of the femur to the distal end. Next, the skin, subcutaneous tissues, and fascia were incised layer by layer, and blunt dissection of the gluteus maximus was performed. Next, the hip joint was slightly internally rotated to expose the piriformis muscle, the internal obturator muscle, the gemellus superior and inferior, and the quadratus muscle of the thigh. Muscle terminations were resected with an electric scalpel, and the muscles were folded upward to expose the articular capsule. A T-shaped incision was made to cut open the articular capsule. This was followed by hip joint dislocation and femoral neck resection at 1 cm above the lesser trochanter. Then, the femoral head was retrieved with a special apparatus, with the femoral neck trimmed to an appropriate length. After clearing the acetabular margin, the ligamentum capitis femoris was resected and residual soft tissues in the occipital area were cleared to expose the osseous acetabulum. Acetabular prostheses of different sizes were implanted to determine the ideal match and the osseous coverage. An appropriate prosthesis was selected and placed in the acetabular cup at the position of 45° abduction and 15° anteversion, and screws were used for fixation if necessary. The affected limb was upheld and kept adducted as much as possible. Grooving and reaming at the proximal end of the femur was performed to obtain the ideal size, and the testing model was placed. The femoral head was implanted, and hip joint reduction was performed. The lower leg length, range of motion and hip joint stability were examined.

Surgery in the corrective group

After general anesthesia, the patient was placed in the lateral position on the unaffected side, and routine disinfection and draping were performed. A posterolateral incision at the affected hip was made. Then, an oblique, arch-shaped incision of about 14 cm was made posterior to the greater trochanter of the femur. Next, the skin, subcutaneous tissues, and the fascia were incised, and the quadratus muscle of the thigh, the inferior gemellus, and the distal internal obturator muscle were resected along the posterior margin of femoral tuberosity. The internal obturator muscle was vertically incised, and an L-shaped incision was made for the articular capsule. The tendon of the piriformis muscle, the gemellus superior, the upper part of the internal obturator muscle, and the posterosuperior articular capsule were preserved. Afterwards, the procedures described for the standard group were performed, with hip joint dislocation by

internal rotation, hip bending, and knee bending. Then, osteotomy at the femoral neck was performed while the femoral calcar was preserved, and the femoral head was retrieved with a special apparatus. The cavitas glenoidalis and the round ligament were resected, and the acetabular margin was cleared to expose the osseous acetabulum. Acetabular prostheses were implanted to determine the ideal match, and screws were used for fixation if necessary. The affected limb was upheld and kept adducted as much as possible, with grooving and reaming at the proximal end of the femur to obtain the ideal size. Then, the testing model was placed. The femoral head was implanted, and hip joint reduction was performed. The lower leg length, range of motion and hip joint stability were examined.

Data collection and follow up

The baseline data of patients in both groups, including sex, age, body mass index (BMI), initial diagnosis, American Society of Anesthesiologists Classification (ASA) score (assessed according to patient condition and surgical risk before anesthesia) (15), Western Ontario, visual analog scale (VAS) score for the pain, and McMaster Universities Osteoarthritis Index (WOMAC) score, and Oxford hip score (OHS), were collected. Intra- and post-operative parameters in both groups, including incision length, operation time, intraoperative blood loss volume, blood transfusion volume, postoperative drainage volume, and hospital stay, were recorded. The injury degree before and at 48h postoperatively, as well as changes of inflammation-related indicators, including creatine kinase (CK), myoglobin, and 72-h postoperative C-reactive protein (CRP), versus preoperative levels, were also recorded. Postoperative parameters, including times to bedside ambulation, independent stair use and joint dislocation rates 8 weeks postoperative, were recorded. Pain intensity (postoperative 1 to 7 days) was assessed using the VAS. The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score was used to assess arthritis severity and treatment effects preoperatively and at 8 weeks postoperatively, according to patient symptoms and signs (16). The Harris score and OHS score were used to assess the recovery of hip joint functions. X-ray and CT were performed to assess prosthesis position after operation (17).

The patients were followed up twice by clinical visits or telephone calls at the second and the eighth weeks postoperatively. The Harris score, OHS, WOMAC score, X-ray film and CT scan were assessed and recorded at each follow-up.

Statistical analysis

SPSS22.0 (IBM, Armonk, NY, USA) was used for statistical analysis. GraphPad Prism 7.0 (GraphPad, San Diego, USA) was used for graphing. Continuous variables with normal distribution are mean \pm standard deviation (SD); those with skewed distribution were described as median and range. Independent samples t-test was performed for comparisons between the two groups. The chi-square test was carried out for comparing categorical data. Multi-factor analysis of variance was adopted for assessing postoperative Harris, WOMAC and Oxford scores, as well as VAS score on postoperative day 7. P<0.05 was considered statistically significant.

Results

Baseline patient data

A total of 126 patients were included in this study, with a median follow up time of 8 weeks (2-14 weeks). Fifty-four patients, including 28 males (51.8%) and 26 females (48.2%) underwent standard THA, and were aged 68 ± 6 years. Forty-six (85.2%) of them had osteonecrosis of the femoral head, 4 (7.4) had hip osteoarthritis, and 4 (7.4) were femoral neck fracture cases. Seventy-two patients, including 34 males (47.2%) and 38 females (52.8%), underwent the corrective operation, and were 65 ± 5 years old. Fifty-seven (79.2%) of these patients had osteonecrosis of the femoral head, 6 (8.3%) had hip osteoarthritis, 8 (11.1%) were femoral neck fracture cases, and 1 (1.4%) had congenital hip dysplasia. The Crown stage of the patient with congenital hip dysplasia was <grade I; the lengths of bilateral limbs were identical with no gluteus atrophy, and the disease was mild. WOMAC score ($P=0.03$), Oxford score ($P=0.04$), CK ($P=0.04$) and myoglobin ($P=0.04$) were significantly different between the two groups (Table 1).

Surgery-related data

Surgery-related data in both groups are shown in Table 2. Incision lengths were not significantly different between the corrective (short external rotator sparing) and standard groups. However, operation time ($P<0.001$), intraoperative blood loss ($P<0.001$), and postoperative 6-hour drainage volume ($P=0.03$) reduced in the corrective group. In addition, significantly less patients in the corrective group required autogenous blood transfusion compared with the standard group ($P=0.03$).

CK and myoglobin at 1st and 2nd day postoperatively were not significantly different between the two groups ($P>0.05$). Idem for CRP at 3 days postoperatively ($P>0.05$).

Postoperative recovery of the hip joint

The distances in the six-minute walking test after surgery were not significantly different between the two groups. However, times to bedside ambulation ($P=0.04$) and independent stair use ($P=0.02$) were significantly shorter in the corrective group compared with the standard group. Joint dislocation rates were 3.7% ($n=2$) and 1.3% ($n=1$) in the standard and corrective groups, respectively; the difference was not statistically significant ($P=0.399$) (Table 2).

Comparison of hip joint functions and quality of life

Compared with preoperative values, Harris scores ($P=0.007$) and Oxford scores ($P=0.047$) in both groups were significantly decreased after surgery. At 2 weeks postoperatively, Harris scores ($P=0.003$) and Oxford scores ($P<0.001$) were both improved in the corrective group. However, both groups showed similar values at 8 weeks postoperatively. Multivariate analysis of variance showed that there were statistically significant differences in the effects of surgical methods on hip function score (Harris score, $P=0.007$; Oxford score, $P=0.047$) (Table 3, Figure 1A, 1B).

WOMAC scores in both groups were decreased significantly after surgery; they were also significantly lower in the corrective group at 2 postoperative weeks (Table 3, Figure 1C).

Based on VAS scores, postoperative hip joint pain was significantly reduced. In addition, pain at 24 hours, 3 days and 7 days postoperatively were significantly reduced in the corrective group compared with the standard group ($P=0.001$, 0.043 and 0.037 , respectively) (Table 3). Multivariate analysis of variance showed that surgical method had substantial effects on postoperative pain improvement ($P<0.001$).

Discussion

The current study demonstrated that THA via the short external rotator sparing approach causes less damage and decreases perioperative blood loss compared with the standard approach, shortening functional recovery time, maintaining prosthesis stability and improving pain postoperatively.

THA through the posterolateral approach has several advantages, including relatively easy operation, clearly exposed surgical field, minimal injuries to soft tissues, and improved preservation of abductor muscles; meanwhile, the standard posterolateral approach damages the continuity between the posterior external rotators and the greater trochanter of the femur, resulting in a higher postoperative dislocation rate compared with the anterior approach. However, the dislocation rates were not significantly different between the standard and corrective groups in this study. This could be associated with restricted patient activities within 3 months after surgery, and the increased joint anteversion angle during surgery (18), which increased hip joint stability.

Previous studies assessing THA through the posterolateral approach mostly investigated the differences between the mini-incision and standard surgeries (19, 20). In addition, operations with external rotator sparing mainly preserved the quadratus muscle of the thigh (8, 21, 22) or the piriformis muscle (9, 11), while those sparing a larger extent of the short external rotator are scarce. In contrast to mini-invasive surgeries pursuing small incisions, muscle sparing operations do not necessarily minimize the incisions, thus having more indications. For instance, such surgeries could be performed in obese patients, and incisions could be expanded according to intraoperative conditions.

The articular capsule, and inter- and extra-articular ligaments of the hip, as well as the surrounding muscles play important roles in stabilizing the joint (23). External rotators including the piriformis muscle, the internal obturator muscle, and the gemellus superior are resected in standard THA. Despite muscle suturing and reconstruction later during surgery, the trauma and inflammatory damage remain more pronounced than observed with the external rotator sparing approach. A randomized, controlled clinical trial of piriform-sparing THA showed that corrective surgery not only has the advantages of conventional posterolateral approach surgeries, but also involves the concept of mini-invasiveness (11). In this procedure, no osteotomy of the greater trochanter or resection of the piriformis muscle was required during the operation, and only piriformis muscle terminations on the articular capsule were dissected, resulting in significantly less trauma, reduced postoperative blood loss, and shortened hospital stay (11). The corrective surgery in this study preserved the short external rotators, including the tendon of the

piriformis muscle, the upper part of the internal obturator muscle, and the gemellus superior, to a larger extent. As shown above, intra- and post-operative blood loss was reduced, less patients required autogenous blood transfusion, and hospital stay was shortened significantly, thus confirming the advantages of surgeries sparing the short external rotators to a large extent.

The time to hip joint recovery was shorter in the corrective group compared with the standard group; in addition, bedside ambulation and independent stair use occurred earlier in the corrective group. Damage to the short external rotators was reduced in the corrective group compared with the standard group, as well as postoperative pain, in agreement with findings in piriformis-sparing studies (11). The tendon of the piriform muscle was resected in the standard surgery, with suturing adding to the tension of the ischiadic nerve; meanwhile, postoperative inflammatory edema of the muscles further increased the muscular tension, which finally increased the duration of postoperative pain. As shown above, hip joint function and patient condition scores were decreased in both groups after operation compared with presurgical values, but showed no significant difference between the corrective and standard groups postoperatively. These findings corroborated Khan et al. also showing that hip joint function and patient condition scores in the corrective group differ from those of the standard group at 6 postoperative weeks, but without statistical significance (24).

Incision sizes in both groups were similar; in addition, CK and myoglobin changes on the first and second days after surgery were not significantly different between the two groups. CKP and myoglobin have been used as indicators of muscle damage severity, while CRP amounts reflect the severity of inflammation (25, 26). However, the actual values of such indicators in surgical trauma remain unclear. Multiple studies have shown that surgical trauma differs in patients administered distinct modifications of THA, while CKP and myoglobin increases are not significantly different (27) corroborating the current findings. These changes could be induced by contusion injuries due to the apparatuses (e.g., retractors and dilators) used perioperatively in both groups.

The limitations of this study should be mentioned. First, it was a prospective observational study, whose evidence level is inferior to that of a randomized controlled clinical trial. However, consecutive patients treated in our hospital between 2017 and 2018 were included, and the current findings could reflect the actual clinical situation. However, this was also a single-center study with a relatively small sample size, which decreases the generalizability of the findings. Finally, follow-up was somewhat short. Therefore, large multi-center randomized clinical trials with long-term follow up are required to confirm our results.

Conclusions

In summary, corrective THA surgery sparing short external rotators could reduce the damage to the nerves and soft tissues, decrease perioperative blood loss, maintain prosthesis stability, alleviate hip joint pain, and accelerate postoperative hip joint recovery, thereby improving short-term patient condition.

Abbreviations

THA
total hip arthroplasty
WOMAC
Western Ontario and McMaster Universities Osteoarthritis Index
OHS
Oxford hip score
VAS
visual analog scale
CK
creatine kinase
CRP
C-reactive protein
BMI
body mass index
ASA
American Society of Anesthesiologists Classification

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Jinhua Central Hospital (approval number LGF19H060005). All the included patients provided signed informed consent.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

TW and YZ carried out the concepts, design, definition of intellectual content, literature search, data acquisition, data analysis and manuscript preparation. XL and SG provided assistance for data acquisition, data analysis and statistical analysis. TW and YZ carried out literature search, data acquisition and manuscript editing. TW and QY performed manuscript review. All authors have read and approved the content of the manuscript.

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References

1. Barrett WP, Turner SE, Leopold JP. Prospective randomized study of direct anterior vs postero-lateral approach for total hip arthroplasty. *J Arthroplast*. 2013;28(9):1634–8.
2. Galakatos GR. Direct Anterior Total Hip Arthroplasty. *Missouri medicine*. 2018;115(6):537–41.
3. Peters RM, van Beers L, van Steenbergen LN, Wolkenfelt J, Ettema HB, Ten Have B, et al. Similar Superior Patient-Reported Outcome Measures for Anterior and Posterolateral Approaches After Total Hip Arthroplasty: Postoperative Patient-Reported Outcome Measure Improvement After 3 months in 12,774 Primary Total Hip Arthroplasties Using the Anterior, Anterolateral, Straight Lateral, or Posterolateral Approach. *J Arthroplast*. 2018;33(6):1786–93.
4. Amlie E, Havelin LI, Furnes O, Baste V, Nordsletten L, Hovik O, et al. Worse patient-reported outcome after lateral approach than after anterior and posterolateral approach in primary hip arthroplasty. A cross-sectional questionnaire study of 1,476 patients 1–3 years after surgery. *Acta Orthop*. 2014;85(5):463–9.
5. Gautam D, Malhotra R. Total Hip Arthroplasty in Ankylosing Spondylitis With Extension Contracture of Hips. *J Arthroplast*. 2019;34(1):71–6.
6. Rosenlund S, Broeng L, Holsgaard-Larsen A, Jensen C, Overgaard S. Patient-reported outcome after total hip arthroplasty: comparison between lateral and posterior approach. *Acta Orthop*. 2017;88(3):239–47.
7. Chow J, Penenberg B, Murphy S. Modified micro-superior percutaneously-assisted total hip: early experiences & case reports. *Curr Rev Musculoskelet Med*. 2011;4(3):146–50.
8. Fink B, Mittelstaedt A, Schulz MS, Sebena P, Singer J. Comparison of a minimally invasive posterior approach and the standard posterior approach for total hip arthroplasty A prospective and comparative study. *J Orthop Surg Res*. 2010;5:46.
9. Prigent F. Incidence of capsular closure and piriformis preservation on the prevention of dislocation after total hip arthroplasty through the minimal posterior approach: comparative series of 196 patients. *Eur J Orthop Surg Traumatol*. 2008;18(5):333–7.

10. Procyk S. Initial results with a mini-posterior approach for total hip arthroplasty. International orthopaedics. 2007;31(Suppl 1):17–20. Suppl 1.
11. Khan RJ, Maor D, Hofmann M, Haebich S. A comparison of a less invasive piriformis-sparing approach versus the standard posterior approach to the hip: A randomised controlled trial. The Journal of bone joint surgery British volume. 2012;94(1):43–50.
12. Woolson ST, Mow CS, Syquia JF, Lannin JV, Schurman DJ. Comparison of primary total hip replacements performed with a standard incision or a mini-incision. The Journal of bone joint surgery American volume. 2004;86(7):1353–8.
13. Wright JM, Crockett HC, Delgado S, Lyman S, Madsen M, Sculco TP. Mini-incision for total hip arthroplasty: a prospective, controlled investigation with 5-year follow-up evaluation. J Arthroplast. 2004;19(5):538–45.
14. Ogonda L, Wilson R, Archbold P, Lawlor M, Humphreys P, O'Brien S, et al. A minimal-incision technique in total hip arthroplasty does not improve early postoperative outcomes. A prospective, randomized, controlled trial. The Journal of bone joint surgery American volume. 2005;87(4):701–10.
15. Doyle DJ, Goyal A, Bansal P, Garmon EH. American Society of Anesthesiologists Classification (ASA Class). StatPearls. Treasure Island (FL): StatPearls Publishing. Copyright © 2020, StatPearls Publishing LLC.; 2020.
16. Ebrahimzadeh MH, Makhmalbaf H, Birjandinejad A, Keshtan FG, Hoseini HA, Mazloumi SM. The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) in Persian Speaking Patients with Knee Osteoarthritis. The archives of bone joint surgery. 2014;2(1):57–62.
17. Jiang M, He C, Feng J, Yan F, Chen Z, Lu Y. X-ray, CT and MRI diagnosis of complications with hip arthroplasty. Chinese Computed Medical Imaging. 2015;21(3):278–82.
18. Liu J, Lv M, Wu J, Guo SJ, Han N, Zhou YX. [Estimation of femoral version based on broach geometry after femoral-neck osteotomy]. Beijing da xue xue bao Yi xue ban = Journal of Peking University Health sciences. 2016;48(2):279–82.
19. Henderson RA, Good RP, Levicoff EA. Mini-posterior approach for primary total hip arthroplasty. Annals of Joint. 2017;2(6).
20. Ye X, Lai X, Shen X, Zhang C. Retrospective Comparison of Total Hip Arthroplasty Through a Modified Mini-incision Versus Standard Posterolateral Approach. Journal of Practical Orthopaedics. 2008;14(9):522–5.
21. Dorr LD, Maheshwari AV, Long WT, Wan Z, Sirianni LE. Early pain relief and function after posterior minimally invasive and conventional total hip arthroplasty. A prospective, randomized, blinded study. The Journal of bone joint surgery American volume. 2007;89(6):1153–60.
22. Kim YH. Comparison of primary total hip arthroplasties performed with a minimally invasive technique or a standard technique: a prospective and randomized study. J Arthroplast. 2006;21(8):1092–8.
23. Bolia I, Chahla J, Locks R, Briggs K, Philippon MJ. Microinstability of the hip: a previously unrecognized pathology. Muscles ligaments tendons journal. 2016;6(3):354–60.

24. Tan BKL, Khan RJK, Haebich SJ, Maor D, Blake EL, Breidahl WH. Piriformis-Sparing Minimally Invasive Versus the Standard Posterior Approach for Total Hip Arthroplasty: A 10-Year Follow-Up of a Randomized Control Trial. *J Arthroplast*. 2019;34(2):319–26.
25. Keltz E, Khan FY, Mann G. Rhabdomyolysis. The role of diagnostic and prognostic factors. *Muscles ligaments tendons journal*. 2013;3(4):303–12.
26. Vekaria AS, Brunner PM, Aleisa AI, Bonomo L, Lebwohl MG, Israel A, et al. Moderate-to-severe atopic dermatitis patients show increases in serum C-reactive protein levels, correlating with skin disease activity. *F1000Research*. 2017;6:1712.
27. Cohen RG, Katz JA, Skrepnik NV. The relationship between skeletal muscle serum markers and primary THA: a pilot study. *Clin Orthop Relat Res*. 2009;467(7):1747–52.

Tables

Table 1 Baseline and preoperative characteristics of the patients.

	Corrective group (n=72)	Standard group (n=54)	P
Age (year), mean ± SD	65.6 ± 5.8	66.4 ± 7.7	0.76
Male, n (%)	34 (47.2)	28 (51.8)	0.02
BMI	24.7 (3.9)	22.1 (4.7)	0.04
Initial diagnosis, n (%)			0.49
Osteonecrosis of the femoral head	57 (79.2)	46 (85.2)	
Hip osteoarthritis	6 (8.3)	4 (7.4)	
Femoral neck fracture	8 (11.1)	4 (7.4)	
Congenital hip dysplasia	1 (1.4)	0	
ASA score, n(%)			0.53
1	6 (8.3)	4 (7.4)	
2	41 (56.9)	30 (55.6)	
3	25 (34.7)	20 (37.0)	
CK, mean ± SD	126 ± 36.9	109 ± 29.4	0.04
Myoglobin, mean ± SD	48.0 ± 17.7	36.0 ± 14.7	0.04
CRP, mean ± SD	4.8.0 ± 1.9	4.6 ± 2.5	0.39

BMI, body mass index; ASA score, American Society of Anesthesiologists Classification score; WOMAC score, Western Ontario and McMaster Universities Osteoarthritis Index score; CK, creatine kinase; CRP, C-

reactive protein.

Table 2 Intraoperative and postoperative patient data.

	Corrective group (n=72)	Standard group (n=54)	P
Intraoperative			
Incision length (cm), mean ± SD	13.8 ± 0.9	13.4 ± 0.7	0.4
Operation time (min), mean ± SD	51 ± 11.7	45 ± 10.3	<0.001
Intraoperative blood loss (ml), mean ± SD	278.4 ± 132.7	349.6 ± 189.1	<0.001
Postoperative 6-hour drainage (ml), mean ± SD	290.7 ± 174.3	509.6 ± 280.7	0.03
Number of patients requiring autogenous blood transfusion, n (%)	5 (6.9)	13 (24.1)	0.03
Location of prosthesis (°), mean ± SD			
Anteversion angle	42.6 ± 6.7	43.1 ± 6.2	0.53
Abduction angle	20.7 ± 4.8	19.9 ± 4.2	0.48
Postoperative			
CK, mean ± SD			
1 st day postoperative	559.1 ± 361.7	578.9 ± 476.1	0.71
2 nd d postoperative	436.3 ± 265.8	395.4 ± 293.7	0.21
Myoglobin, mean ± SD			
Change at 1-d postoperative	178.9 ± 147.3	199.5 ± 11.6	0.43
Change at 2-d postoperative	62.9 ± 54.2	76.3 ± 33.5	0.26
CRP change at 3-d postoperative, mean ± SD	79.1 ± 47.5	82.5 ± 39.6	0.63
Time to ambulation (days), mean ± SD	3.0 ± 2.3	4.1 ± 2.2	0.04
Distance in 6-min walking test (m), mean ± SD	29 ± 9.7	27 ± 7.9	0.68
Time to using stairs independently (days), mean ± SD	5.5 ± 2.0	7.2 ± 2.7	0.02
Hospital stay (days), mean ± SD	9.2 ± 3.1	10.8 ± 3.8	0.62
Joint dislocation, n (%)	1 (1.4)	2 (3.7)	0.399

CK, creatine kinase; CRP, C-reactive protein.

Table 3 Comparison of hip joint functions between two groups.

	Corrective group (n=72)	Standard group (n=54)	P
Harris score			
Preoperative	40.1 ± 7.7	39.5 ± 8.2	0.986
2 weeks postoperative	80.2 ± 10.3	73.7 ± 12.3	0.003
8 weeks postoperative	91.3 ± 12.7	89.2 ± 13.5	0.636
P	0.007		
OHS score			
Preoperative	43.7 ± 7.4	40.7 ± 13.4	0.043
2 weeks postoperative	30.4 ± 9.3	37.2 ± 10.2	0.001
8 weeks postoperative	25.3 ± 8.2	27.5 ± 9.7	0.562
P	0.047		
WOMAC score			
Preoperative	49.7 ± 10.7	44.3 ± 14.9	0.131
2 weeks postoperative	30.7 ± 12.2	37.6 ± 16.2	0.031
8 weeks postoperative	21.3 ± 16.9	23.9 ± 18.7	0.706
P	0.379		
VAS score			
Preoperative	3.32 ± 1.73	3.26 ± 1.42	0.999
24 hours postoperative	2.21 ± 1.35	2.9 ± 1.21	0.001
48 hours postoperative	1.62 ± 0.87	1.95 ± 0.73	0.352
3 days postoperative	0.92 ± 0.61	1.42 ± 0.64	0.043
7 days postoperative	0.45 ± 0.48	0.96 ± 0.59	0.037
P	<0.001		

WOMAC score, Western Ontario and McMaster Universities Osteoarthritis Index score; OHS score, Oxford hip score; VAS, visual analog scale.

Figures

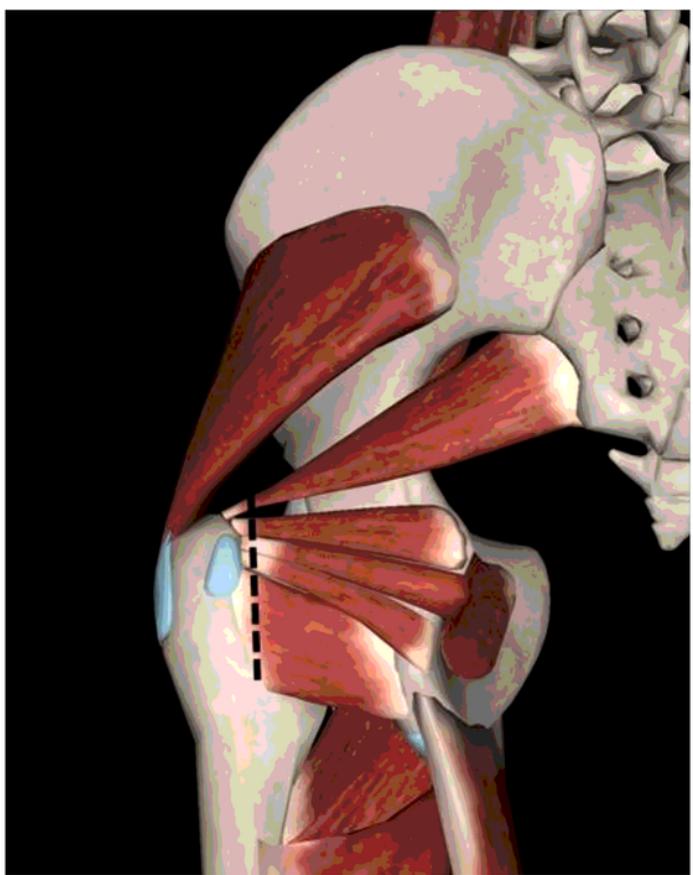
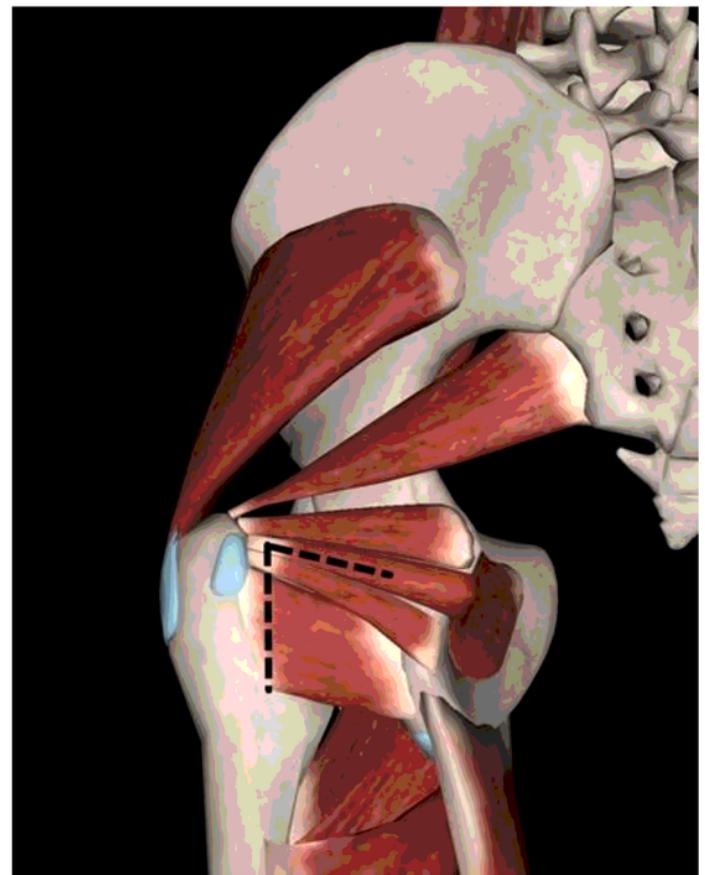
A**B**

Figure 1

Surgical approaches in surgical methods. (A) Standard surgery. Cutting off the piriformis, obturator internus, gemellus superior and inferior, and quadratus femoris. (B) Corrective surgery. Transecting the quadratus femoris, inferior gemellus, and distal obturator internus, longitudinally splitting the obturator internus, and conserving the piriformis tendon, superior gemellus and upper part of the obturator internus.