Supercapsular percutaneously assisted total hip arthroplasty versus conventional posterior approach: Comparison of early functional results

Heng Jiang¹, Li-Hong Wang², Yong-Xin Jin³, Zhi-Ming Liu¹, Liang-Feng Xu¹, Xian-Yun Chen¹

¹Clinic of Orthopedics, Tianxiang East Hospital, Yiwu, China
²Department of Orthopedics, Dongyang People’s Hospital, Wenzhou Medical University, Wenzhou, China

ABSTRACT

Objective: This study aimed to explore the early functional results of total hip arthroplasty (THA) using the supercapsular percutaneously assisted total hip (SuperPATH) microposterior approach.

Methods: In this retrospective study, 58 patients treated with THA from October 2015 to April 2016 in our hospital were enrolled. A total of 28 patients (11 men and 17 women; mean age: 74.95±7.06 years) were operated on using the SuperPATH approach (group 1), and the remaining 30 patients (12 men and 18 women; mean age: 75.63±7.89 years) were operated on using the conventional posterior approach (group 2). To summarize the early functional results of the SuperPATH approach, we retrospectively analyzed the following demographics, perioperative factors, and measures of joint function: age, sex, preoperative diagnosis, preoperative visual analog scale (VAS) for pain, body mass index, the American Society of Anesthesiologists physical status, operation time (skin-to-skin), intraoperative bleeding, incision length, postoperative Harris Hip Score (HHS), Barthel Index (BI), length of hospital stay, positioning of the implants, and postoperative complications.

Results: All 58 operations were successfully completed, and the average follow-up time was 45 (45.03±4.84) months. The patients in group 1 had shorter incision length (8.84±0.59 versus 13.26±2.41 cm) and length of stay (7.86±0.51 versus 10.80±1.93 days), lower postoperative VAS score (2.43±0.69 versus 3.13±0.94), and better postoperative HHS (86.37±4.31 versus 83.81±6.00) and BI (91.47±5.27 versus 81.59±6.83) at 3 months than the patients in group 2; however, group 1 patients had longer operation time (113.95±25.36 versus 87.22±25.43 min) than group 2 patients (all P<0.05). No significant intergroup differences were found with respect to intraoperative bleeding, cup abduction angle, anteversion angle, and stem positioning. During the follow-up, no deep venous thrombosis, postoperative infection, and hip dislocation were observed in any patient.

Conclusion: Compared with the conventional posterior approach, the SuperPATH approach provided better early functional results with less postoperative pain and shorter hospitalization time. However, the operation time was longer in the SuperPATH approach group.

Level of Evidence: Level III, Therapeutic study

Introduction

An increasing number of patients and clinicians opt for minimally invasive surgical techniques over the traditional methods of surgery. Accordingly, minimally invasive hip arthroplasty has received increasing attention (1). With special equipment and required minimally invasive surgical skills, surgeons can shorten the surgical incision and reduce tissue damage, and patients can achieve good recovery. Reportedly, the use of minimally invasive incision in hip arthroplasty can reduce surgical trauma, bleeding, and postoperative joint dislocation (1, 2). However, the disadvantages of minimally invasive hip arthroplasty include poor positioning for joint prosthesis and increased risk of neurovascular injury (3).

Chow et al. introduced a novel approach called the supercapsular percutaneously assisted total hip (SuperPATH) for minimally invasive joint replacement (4). The advantages of the SuperPATH approach include maximizing the soft tissue protection, optimizing the hip soft tissue cover, and reducing the dislocation rate, which likely improves short- and long-term results. Furthermore, the SuperPATH approach is a muscle-sparing surgical approach, with an average incision length of 7.4 cm. This operation can be performed by the surgeon and a single assistant, without the need for complex equipment. The procedure was performed with the patient’s hips in a naturally buckling position, which was easily achieved, and a truly resting position. Gofton et al. also reported good applicability of the SuperPATH approach (5, 6). With this technique, patients have shorter hospitalization times and do not require additional rehabilitation, which in turn would significantly reduce the hospital costs.

The initial reports for the SuperPATH approach for hip arthroplasty have been encouraging. However, a randomized controlled study comparing the SuperPATH and posterior approaches for total hip arthroplasty (THA) is still ongoing (7). In light of the relatively few available reports, whether the SuperPATH approach for THA has functional advantages compared with the posterior approach needs further validation. Therefore, this study aimed to compare the SuperPATH approach with the conventional posterior approach and analyze the early functional results.
Materials and Methods

Ethical considerations
All the study protocols were approved by the institutional review board of our hospital (TXDFPH-2017KY091). Given the retrospective design of the study, the need for informed consent was waived.

Study design and inclusion and exclusion criteria
This is a retrospective case-control study, and the cases were not enrolled based on the principle of randomization.

Inclusion criteria: Unilateral primary THA with the SuperPATH approach or conventional posterior approach.

Exclusion criteria: Partial or systemic infection, other surgical contraindications, inability to cooperate to complete the pain score assessment or other data collection, lost to follow-up, and/or incomplete follow-up data.

Participants
In accordance with the inclusion and exclusion criteria, 61 patients treated with THA by a single surgeon in our hospital from October 2015 to April 2016 were enrolled. Of these, 3 patients were excluded because of lost to follow-up, and the remaining 58 patients were included for the final analysis. Of these, 28 patients were operated on using the SuperPATH approach (group 1), and the remaining 30 patients were operated on using the conventional posterior approach (group 2). The preoperative diagnosis of 38 patients was aseptic necrosis of the femoral head or osteoarthritis, and the remaining 20 were diagnosed with femoral neck fracture.

Preoperative preparation
Anteroposterior pelvic, ipsilateral anteroposterior, and lateral femur radiographies were acquired in all the patients. Preoperative template measurements were used to predict hip rotation center, offset, and acetabular and femoral prosthesis size. Antibiotics were administered 30 min before the start of the procedure to prevent infection.

SuperPATH approach technique
All the patients were induced with general anesthesia and operated on by the same surgeon and team. The artificial joint prostheses were purchased from a commercial company (MicroPort Orthopedics Inc., Shanghai, China). The lateral position was used, and a fixed bracket was placed at the appropriate position to stabilize the pelvis. However, it was important to ensure that the fixed bracket did not interfere with the radiographic acquisition during the operation and hamper the flexion and internal rotation activities of the operative limb. The operative limb was placed in a mild flexion-and-adduction position, and the main incision was performed from the rear top of the greater trochanter to the proximal end along the femoral axis, with a length of about 7-9 cm. The skin, subcutaneous tissue, fascia lata, and gluteus maximus were incised, and the gluteus medius was pulled forward. If necessary, the piriformis insertion was partially loosened. The capsule was revealed through the gap of the gluteus minimus and piriformis, and a longitudinal incision was made along the femoral neck. Special right angle hooks were placed at the sides of the femoral neck to expose the neck and protect the capsule (Figure 1). After exposing the femoral intertrochanteric fossa, a reamer was used to open the femoral medullary cavity. The direction was probed, and the medullary cavity was enlarged along the femoral axis without dislocation. An arc osteotome was used to remove the upper bone of the femoral neck and head to insert the broaches. Consecutive broaches were used to enlarge the medullary cavity until an appropriate broach was placed, and the depth of the broach was decided based on the preoperative plan and intraoperative photography. The femoral neck osteotomy was guided by the superior aspect of the last broach, and the head was removed. The broach was removed, and the definitive femoral stem prosthesis was placed. The femur was then pulled anteriorly. A trial cup was placed into the acetabulum, and a portal guide was used for the auxiliary incision. A reaming cannula was placed posterior to the trochanter. This cannula was in line with the planned direction of acetabular placement, and it was kept close to the femur to ensure safety of the sciatic nerve. Consecutive sizes of the acetabular basket reamer were used through the main incision and the cannula in auxiliary incision to allow for acetabular preparation. The definitive cup and liner were then inserted into the acetabulum through the main incision and pressed through the cannula. A trial head and neck were placed, and the femoral head was inserted for the final analysis. Of these, 28 patients were operated on using the SuperPATH approach (group 1), and the remaining 30 patients were operated on using the conventional posterior approach (group 2). The preoperative diagnosis of 38 patients was aseptic necrosis of the femoral head or osteoarthritis, and the remaining 20 were diagnosed with femoral neck fracture.

Preoperative preparation
Anteroposterior pelvic, ipsilateral anteroposterior, and lateral femur radiographies were acquired in all the patients. Preoperative template measurements were used to predict hip rotation center, offset, and acetabular and femoral prosthesis size. Antibiotics were administered 30 min before the start of the procedure to prevent infection.

SuperPATH approach technique
All the patients were induced with general anesthesia and operated on by the same surgeon and team. The artificial joint prostheses were purchased from a commercial company (MicroPort Orthopedics Inc., Shanghai, China). The lateral position was used, and a fixed bracket was placed at the appropriate position to stabilize the pelvis. However, it was important to ensure that the fixed bracket did not interfere with the radiographic acquisition during the operation and hamper the flexion and internal rotation activities of the operative limb. The operative limb was placed in a mild flexion-and-adduction position, and the main incision was performed from the rear top of the greater trochanter to the proximal end along the femoral axis, with a length of about 7-9 cm. The skin, subcutaneous tissue, fascia lata, and gluteus maximus were incised, and the gluteus medius was pulled forward. If necessary, the piriformis insertion was partially loosened. The capsule was revealed through the gap of the gluteus minimus and piriformis, and a longitudinal incision was made along the femoral neck. Special right angle hooks were placed at the sides of the femoral neck to expose the neck and protect the capsule (Figure 1). After exposing the femoral intertrochanteric fossa, a reamer was used to open the femoral medullary cavity. The direction was probed, and the medullary cavity was enlarged along the femoral axis without dislocation. An arc osteotome was used to remove the upper bone of the femoral neck and head to insert the broaches. Consecutive broaches were used to enlarge the medullary cavity until an appropriate broach was placed, and the depth of the broach was decided based on the preoperative plan and intraoperative photography. The femoral neck osteotomy was guided by the superior aspect of the last broach, and the head was removed. The broach was removed, and the definitive femoral stem prosthesis was placed. The femur was then pulled anteriorly. A trial cup was placed into the acetabulum, and a portal guide was used for the auxiliary incision. A reaming cannula was placed posterior to the trochanter. This cannula was in line with the planned direction of acetabular placement, and it was kept close to the femur to ensure safety of the sciatic nerve. Consecutive sizes of the acetabular basket reamer were used through the main incision and the cannula in auxiliary incision to allow for acetabular preparation. The definitive cup and liner were then inserted into the acetabulum through the main incision and pressed through the cannula. A trial head and neck were placed, and the femoral head was inserted.
mur was pushed by the surgical assistant to insert the neck into the femoral head. C-arm fluoroscopy was used to ensure that the position and angulation of the trial components were correct. The trial components were then removed. The definitive femoral head and neck were placed and reset again (Figure 2). The hip capsule was perfectly closed with a suture followed by closure of the gluteal fascia and skin. Detailed operation procedures can be referred to in a previously published article (8).

**Posterior approach technique**

The artificial joint prostheses were purchased from another commercial company (Zimmer Biomet, Warsaw, IN, USA). The lateral position, with the operative side up, was used, and the fixed bracket was placed at the appropriate position to stabilize the pelvis. The incision was started about 10 cm distal to the posterior superior iliac spine and extended to the posterior part of the greater trochanter (9). The gluteus maximus was bluntly dissected, the external rotators were detached, and the capsule was incised distally to the acetabulum along the femoral neck. The hip was dislocated by flexion and internal rotation. The standard posterior technique was followed to perform femoral neck osteotomy, and the prosthesis was implanted. During closure, the capsule and the external rotators were repaired using absorbable sutures (10).

**Postoperative treatment**

Postoperative pain was treated with multimodal analgesia, including patient-controlled analgesia, nonsteroidal anti-inflammatory drugs, transdermal patch, and central analgesics. Antibiotics were routinely used to prevent infection in the 24-h postoperative period. Lower extremity pneumatic pump and anticoagulant drugs were used to prevent deep venous thrombosis. Routine blood tests and tests for blood coagulation factors, D-dimer level, liver function, renal function, and electrolytes were reviewed on day 2 after the operation. All patients’ rehabilitation exercises were carried out as planned. On day 1 after the operation, the patients were allowed protected, full weight bearing and walking with the aid of a walker. When the Barthel Index (BI) exceeded 70, patients were allowed to be discharged.

**Outcome evaluation**

Age, sex, preoperative diagnosis, preoperative visual analog scale (VAS) for pain, body mass index (BMI), the American Society of Anesthesiologists (ASA) physical status, operation time (skin-to-skin), intraoperative bleeding, incision length (main and auxiliary incisions), postoperative VAS (day 1 after surgery and at the end of patient-controlled analgesia), Harris Hip Score (HHS), BI (11), and length of hospital stay were analyzed. The incidence of postoperative complications, including infection, dislocation, and death during hospitalization, was also recorded. All the patients received cementless THA implants. The positioning of the THA implants was confirmed by radiography.

**Statistical analysis**

Continuous variables are presented as mean±standard derivation, and the Student’s t-test was used to determine intergroup statistical significance. Chi-square test was used for the comparison of categorical variables. All the statistical analyses were performed with the Statistical Package for Social Sciences version 18.0 (IBM SPSS Corp.; Armonk, NY, USA), and the level of significance was set at p<0.05.

**Results**

All 58 patients were successfully operated on using either the SuperPATH (group 1, n=28) or the conventional posterior (group 2, n=30) approach, and the average follow-up time was 45 (45.03±2.44)
Advancements in minimally invasive surgery have led to increased popularity of these techniques, which are often preferred over conventional techniques by both doctors and patients (12, 13). Nowadays, several types of minimally invasive hip arthroplasties are performed, including posterior lateral small incision technique (14), direct anterior approach (15), SuperPATH approach (7), and anterior lateral small incision (16, 17). In this study, we found that the SuperPATH approach for THA had some advantages, such as shorter incision length and length of hospital stay, lower postoperative VAS, and better postoperative HHS and BI at 3 months, over the conventional posterior approach.

In this study, the patients operated on using the SuperPATH approach for THA had shorter length of hospital stay than those operated on using the posterior approach. There are potential advantages of the SuperPATH approach. The pathway is entered through the muscular gap between the gluteus minimus and piriformis. As the upper portion of the capsule is longitudinally opened along the femoral neck, the anterior and posterior capsules are protected. Maximum soft tissue protection optimizes the soft tissue cover of the hip. This is consistent with a report by Della Torre et al. (8). Because the gluteus maximus is cut lengthwise, no other muscle needs to be incised, thereby making it a truly muscle-sparing surgical approach. These advantages make early rehabilitation possible. Early rehabilitation of patients can shorten the hospitalization time and significantly reduce the related expenses (18, 19).

Our study shows that the SuperPATH approach, with a small incision length of about 8.9 cm, also has an esthetically pleasing effect. Furthermore, with light postoperative pain, the patients can resume self-care activities with no specific activity restrictions, including independently turning over on the bed, sitting up, and getting out of the bed. Consistent with the findings of Xie et al., our patients who underwent THA using the SuperPATH approach had better postoperative HHS and BI at 3 months than those who underwent THA using the posterior approach (20). We believe that good joint function and self-care ability have a positive effect on elderly patients by reducing the risk of pneumonia, bedsores, and lower extremity deep venous thrombosis.

Moreover, the SuperPATH approach did not affect prosthesis placement in our study. In the SuperPATH approach group, C-arm fluoroscopy was used to ensure the correct position of the implant components; however, this was somewhat time-consuming. Intraoperative radiography was similarly recommended to ensure implant positioning in the study by Haversath et al. (21). With further technological advancement and increasing number of procedures performed, it is likely that the frequency of intraoperative fluoroscopy will be reduced.

However, in our study, compared with that of the posterior approach, the operation time of the SuperPATH approach for THA was longer. Rasuli et al. reported that the average operation time in the first 50 patients undergoing THA using the SuperPATH approach was 101.7 ± 18.3 min, and the operation time continued to decrease (22). Similarly, in our study, the operation time showed a decreasing trend with increasing number of patients. The SuperPATH approach for hip arthroplasty may require a learning curve, but the process is not very difficult. The patient’s position in the SuperPATH approach is similar to that in the posterior lateral approach and is familiar to many surgeons (23). Moreover, the skin incisions in both the approaches are on the same extension line. This is convenient for those who are less experienced. It is possible that the anatomic structure is not clear in the first surgical attempt or that the operation is challenging given the short surgical inci-

Table 1. Comparison of preoperative patient data between groups 1 and 2

<table>
<thead>
<tr>
<th>Cases</th>
<th>Group 1</th>
<th>Group 2</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>74.95±7.06</td>
<td>75.63±7.89</td>
<td>0.62</td>
</tr>
<tr>
<td>Sex (male/female)</td>
<td>11/17</td>
<td>12/16</td>
<td>0.96</td>
</tr>
<tr>
<td>Preoperative VAS</td>
<td>8.86±0.66</td>
<td>13.26±2.41</td>
<td>0.00</td>
</tr>
<tr>
<td>Preoperative diagnosis (Y/N)</td>
<td>9/19</td>
<td>11/19</td>
<td>0.52</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.91±1.87</td>
<td>23.16±2.03</td>
<td>0.56</td>
</tr>
<tr>
<td>ASA physical status (ASA 2/ASA 3)</td>
<td>10/18</td>
<td>13/17</td>
<td>0.55</td>
</tr>
</tbody>
</table>

VAS: visual analog scale; BMI: body mass index; ASA: American Society of Anesthesiologists

Table 2. Comparison of operative and postoperative data between groups 1 and 2

<table>
<thead>
<tr>
<th>Operation time (min)</th>
<th>Group 1</th>
<th>Group 2</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>113.95±23.36</td>
<td>87.22±25.43</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Intraoperative bleeding (mL)</td>
<td>200.00±166.67</td>
<td>178.63±105.85</td>
<td>0.62</td>
</tr>
<tr>
<td>Incision length (cm)</td>
<td>8.86±0.59</td>
<td>3.13±0.94</td>
<td>0.00</td>
</tr>
<tr>
<td>Postoperative VAS</td>
<td>2.43±0.69</td>
<td>3.13±0.94</td>
<td>0.00</td>
</tr>
<tr>
<td>Postoperative HHS</td>
<td>93.36±1.9</td>
<td>93.14±3.41</td>
<td>0.73</td>
</tr>
</tbody>
</table>

Table 3. Radiologic evaluation of the THA implants

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cup abduction angle</td>
<td>44.3±6.3</td>
<td>43.7±5.9</td>
</tr>
<tr>
<td>Cup anteversion angle</td>
<td>18.7±1.5</td>
<td>18.9±1.9</td>
</tr>
<tr>
<td>Stem alignment neutral</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>Varus or valgus (°±°)</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

THA: total hip arthroplasty

months. There were no significant intergroup differences with respect to age, sex, preoperative VAS, preoperative diagnosis, BMI, and ASA status (p > 0.05, Table 1). There was no nerve damage, fracture, or death during hospitalization in either group.

Patients in group 1 had shorter incision length and length of stay and lower postoperative VAS but longer operation time (p < 0.05) than those in group 2. Group 1 patients had better postoperative HHS and BI than group 2 patients at 3 months; however, this difference ceased to exist at 6 months, 1 year, and 3 years. The amount of intraoperative bleeding was similar in both the groups (p > 0.05, Table 2).

No significant intergroup differences were noted with respect to cup abduction angle, anteversion angle, and stem positioning (p > 0.05, Table 3).

The average follow-up time was 45 (45.03±2.44) months, and no deep venous thrombosis, postoperative infection, or hip dislocation was observed in any patient.

Discussion

Advancements in minimally invasive surgery have led to increased popularity of these techniques, which are often preferred over conventional techniques by both doctors and patients (12, 13). Nowadays, several types of minimally invasive hip arthroplasties are performed, including posterior lateral small incision technique (14), direct anterior approach (15), SuperPATH approach (7), and anterior lateral small incision (16, 17). In this study, we found that the SuperPATH approach for THA had some advantages, such as shorter incision length and length of hospital stay, lower postoperative VAS, and better postoperative HHS and BI at 3 months, over the conventional posterior approach.

In this study, the patients operated on using the SuperPATH approach for THA had shorter length of hospital stay than those operated on using the posterior approach. There are potential advantages of the SuperPATH approach. The pathway is entered through the muscular gap between the gluteus minimus and piriformis. As the upper portion of the capsule is longitudinally opened along the femoral neck, the anterior and posterior capsules are protected. Maximum soft tissue protection optimizes the soft tissue cover of the hip. This is consistent with a report by Della Torre et al. (8). Because the gluteus maximus is cut lengthwise, no other muscle needs to be incised, thereby making it a truly muscle-sparing surgical approach. These advantages make early rehabilitation possible. Early rehabilitation of patients can shorten the hospitalization time and significantly reduce the related expenses (18, 19).

Our study shows that the SuperPATH approach, with a small incision length of about 8.9 cm, also has an esthetically pleasing effect. Furthermore, with light postoperative pain, the patients can resume self-care activities with no specific activity restrictions, including independently turning over on the bed, sitting up, and getting out of the bed. Consistent with the findings of Xie et al., our patients who underwent THA using the SuperPATH approach had better postoperative HHS and BI at 3 months than those who underwent THA using the posterior approach (20). We believe that good joint function and self-care ability have a positive effect on elderly patients by reducing the risk of pneumonia, bedsores, and lower extremity deep venous thrombosis.

Moreover, the SuperPATH approach did not affect prosthesis placement in our study. In the SuperPATH approach group, C-arm fluoroscopy was used to ensure the correct position of the implant components; however, this was somewhat time-consuming. Intraoperative radiography was similarly recommended to ensure implant positioning in the study by Haversath et al. (21). With further technological advancement and increasing number of procedures performed, it is likely that the frequency of intraoperative fluoroscopy will be reduced.

However, in our study, compared with that of the posterior approach, the operation time of the SuperPATH approach for THA was longer. Rasuli et al. reported that the average operation time in the first 50 patients undergoing THA using the SuperPATH approach was 101.7 ± 18.3 min, and the operation time continued to decrease (22). Similarly, in our study, the operation time showed a decreasing trend with increasing number of patients. The SuperPATH approach for hip arthroplasty may require a learning curve, but the process is not very difficult. The patient’s position in the SuperPATH approach is similar to that in the posterior lateral approach and is familiar to many surgeons (23). Moreover, the skin incisions in both the approaches are on the same extension line. This is convenient for those who are less experienced. It is possible that the anatomic structure is not clear in the first surgical attempt or that the operation is challenging given the short surgical inci-
sion and small field of vision. In these patients, the surgeon should lengthen the incision in a timely manner and switch to the familiar posterior lateral approach to complete the operation uneventfully, avoid iatrogenic injuries, and reduce the risk of possible complications [24].

Our study has some limitations. First, this was a retrospective study, and patients were not included based on the principle of randomization. Second, the selected patients were strictly limited because all the operations were performed by the same surgeon and assisting team. We believe that a larger sample size is needed in future studies to validate the advantages and superiority of the SuperPATH approach. Finally, long-term results may require further detailed follow-up.

In conclusion, compared with the posterior approach, the SuperPATH approach for THA had some early functional advantages, such as shorter incision length and length of stay, lower postoperative VAS, and better postoperative HHS and BI at 3 months post-surgery. The longer operation time of the SuperPATH approach for THA was probably related to the learning curve.

Ethics Committee Approval: Ethics committee approval was received for this study from the Internal Review Board of Tianxiang East Hospital (TXDFFH-2017KY001).

Informed Consent: N/A.


Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: This research was supported by the Health Commission of Zhejiang Province, China (2017KY691, awarded to Heng Jiang).

References

1. Tsai SW, Chen CF, Wu PK, Chen TH, Liu CL, Chen WM. Modified anterolateral approach in minimally invasive total hip arthroplasty. Hip Int 2013; 23: 245-50. [Crossref]
3. Paillard P. Hip replacement by a minimal anterior approach. Int Orthop 2016; 40: 481-5. [Crossref]
5. Chow J, Penenberg B, Tjomakaris FP, Freedman KB. Early versus delayed rehabilitation following arthroscopic rotator cuff repair: A systematic review. Phys Sportsmed 2015; 43: 178-87. [Crossref]
15. Chow J, Fitch DA. In-hospital costs for total hip replacement performed using the supercapsular percutaneously-assisted total hip replacement surgical technique. Int Orthop 2017; 41: 119-23. [Crossref]
18. Rasuli KJ, Gofton W. Percutaneously assisted total hip (PATH) and supercapsular percutaneously assisted total hip (SuperPATH) arthroplasty: learning curves and early outcomes. Ann Transl Med 2015; 3: 179. doi: 10.3978/j.issn.2305-5839.2015.08.02. [Crossref]
20. Gülabi D, Yüce Y, Erkal KH, Sağlam N, Çamur S. The combined administration of systemic and topical tranexamic acid for total hip arthroplasty: Is it better than systemic? Acta Orthop Traumatol Turc 2019; 53: 297-300. [Crossref]