



Experience of Complications of Hip Arthroplasty

Sung Kwan Hwang, MD, PhD

Department of Orthopaedic Surgery, Yonsei University Wonju College of Medicine, Seoul, Korea

Multiple complications can occur after hip arthroplasty. Some of them may be unavoidable despite surgeon's attention and care to prevent complications. However, many complications are preventable with surgeon's careful attention and efforts. The author of this study has reviewed complications following hip arthroplasty over 30 years of experience in surgery. In some cases, complications stemmed from carelessness, for example lack of careful postoperative follow-up. The author had some regrets for being concerned only with surgical procedures and not eliminating complications, such as sciatic nerve injury that may have resulted from surgical assistant's careless use of retractors. This review intends to mainly address complications that the author has experienced instead of discussing complications described in textbooks.

Death

Death is a rare complication of hip arthroplasty. The in-hospital mortality rate following this surgery ranges from 0.16% to 0.52% in the United States. The 90-day postoperative mortality rate is ~1% after primary total hip arthroplasty (THA) and ~2.5% after revision surgery. The mortality rate is higher in patients with

cardiovascular diseases aged over 70 years¹⁻⁴). When the author first started performing hip arthroplasties in 1984, THA-related deaths were rare over about a decade. One of the reasons for low mortality was that patients were younger than in the following decades (20-65 years of age), had no multiple medical problems, and mostly received hip arthroplasties due to secondary osteoarthritis such as avascular necrosis of the femoral head, sequelae of Legg-Perthes disease, developmental hip dysplasia, or sequelae of hip fracture or dislocation. As rapid population aging has started since mid-1990s, the percentage of elderly patients with fractures visiting our hospital has gradually increased. Consequently, the postoperative death rate has been steadily increasing. Pulmonary complications were the most common cause of death (10 cases); these patients died after being referred to our pulmonology department for further management due to postoperative development or deterioration of symptoms. Since their conditions were no longer surgically treatable, no conflicts had arisen with family members after patients' death.

Pulmonary embolism

The second most common cause of death was pulmonary embolism. Until 2011, combined therapy with antithrombotic agents, pre- and postoperative ankle exercise, and an intermittent pneumatic compression apparatus were not appropriately used in hip arthroplasties. Nevertheless, a relatively low mortality rate caused by pulmonary embolism following hip arthroplasty was reported (4 or 5 deaths) from mid-1990s to 2011. Since 2012, ankle exercise has been performed and an intermittent pneumatic compression apparatus has been used pre- and postoperatively to prevent thromboembolism. In addition, antithrombotic agents have been administered to patients at high risk

Submitted: October 20, 2014 **1st revision:** November 10, 2014

Final acceptance: December 10, 2014

Address reprint request to

Sung Kwan Hwang, MD, PhD

Department of Orthopaedic Surgery, Yonsei University Wonju College of Medicine, 20 Ilsan-ro, Wonju 220-701, Korea

TEL: +82-33-741-1360 **FAX:** +82-33-746-7326

E-mail: hwtonlka@yonsei.ac.kr

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

for thromboembolism. Patients rarely died of pulmonary embolism between 2011 and August 2014. Of these, a dementia patient in his 80s underwent hip arthroplasty due to a femur neck fracture and died at an elderly care facility after being discharged from the hospital. Since the patient was in bed confinement without any exercise or rehabilitation, pulmonary embolism occurred on the third postoperative week. Thus, a transfer note with a detailed description of required rehabilitation and thromboembolism prevention measures is recommended when a patient is transferred to a non-orthopaedic facility.

In the author's hospital, cemented hip arthroplasty had been conducted until 2000 in older patients with hip fractures. A female patient in her 70s, who had a hip fracture, died in our hospital during cemented hip arthroplasty on June 2000. Even though the patient had normal cardiac findings on pre-op tests, she died of heart failure immediately after injection of bone cement into the femoral canal and femoral stem insertion, despite cardiopulmonary resuscitation (CPR). The cause of her death is thought to be related to bone cement. Bone cement implantation syndrome is described as one of cardiovascular complications caused by intramedullary canal pressure. This syndrome may lead to hypotension caused by the cardiovascular toxic effect of methyl methacrylate monomer or bone cement additives, or pulmonary embolism due to fat or bone marrow release into the circulation following increased intramedullary pressure after intramedullary insertion of hot acrylic cement. After the death of this patient, cementless hip arthroplasty was performed in elderly patients because of the risks of cardiovascular toxicity of the bone cement monomer or additives, pulmonary embolism and other complications. Cemented hip arthroplasty is performed in primary hip arthroplasty but not in revision hip arthroplasty regardless of age, osteoporosis, fracture type, and the form of the medullary canal, and favourable clinical outcomes comparable to those of cemented hip arthroplasty have been achieved.

Hematoma formation

The third most common complication is hematoma formation. Termination or suspension of preoperative drugs and complete intraoperative haemostasis are required for patients at high risk for intraoperative bleeding, especially those undergoing antiplatelet, anti-inflammatory or anticoagulant drug therapy, those with

blood dyscrasia, coagulopathy or a family history of these conditions, and those with a history of excessive bleeding during previous surgical procedures. Potential vascular injuries that may occur during hip surgery are as follows. First, branches of the obturator vessels may be injured during ligamentum teres and transverse ligament resection or removal at the inferior aspect of the acetabulum. Second, the first perforating branch of the profunda femoris may be injured because of an incision made to the tendinous insertion of the gluteus maximus. Third, injury of the iliac vessels may occur when drilling the medial acetabular wall or removing a medially displaced cup. In addition, late bleeding (≤ 1 week postoperatively) may occur due to intraoperative rupture of a false aneurysm. Embolization was performed for a patient with a ruptured pseudoaneurysm by identifying injured vessels by arteriography. The author experienced intraoperative bleeding in a 50-year old male patient with osteoarthritis. While THA was performed, haemorrhage occurred at the medial aspect of the acetabulum during osteophyte removal and transverse ligament resection due to the large size of the osteophyte at the inferior aspect of the acetabulum and attenuation of the transverse ligament. Because haemostasis of the inferior medial aspect of the acetabulum was difficult to achieve, epinephrine-soaked Gelfoam packed into this area was used for this purpose to continue surgery. Another experience was a female patient with THA who had sequelae of acetabular dysplasia; loose posterolateral screw fixation of the acetabular cup was corrected by firmly fixing the anterosuperior screw by drilling the medial acetabulum to complete THA. This patient had postoperative abdominal distension and hypotension. Angiography revealed iliac vessel injury; ligation of blood vessels and hematoma removal were performed by a general surgeon through the abdomen. In screw fixation, the anterior and medial sites need to be avoided while drilling the acetabular medial wall. In unavoidable cases, careful attention is crucial in drilling the medial wall to prevent iliac vessel injury.

Heterotopic ossification

The fourth most common complication is heterotopic ossification that frequently occurs after THA is performed to manage hypertrophic osteoarthritis, ankylosing spondylitis, or fused hip conversion.

Heterotopic ossification often results from injury of the gluteus minimus muscle, one of the hip abductor muscles attached closely to the hip capsule surface. Nevertheless, in our experience, no patients had heterotopic ossification severely disturbing hip joint exercise. Considering this fact in the author's opinion, heterotopic ossification is a rather common but not serious complication.

Thromboembolism

The fifth most common complication following THA is thromboembolism. It occurs at substantially lower rates in Korea and other Asian countries than in Western countries. However, the incidence of this condition tends to gradually increase with population aging and westernized lifestyle patterns in Korea. Over the past two decades, thromboembolism has been prevented in our hospital by applying physical exercise therapy or graduated compression stockings (GCSs). Thromboembolism and pulmonary embolism have been very rare. However, since the mean age of patients undergoing THA and the hip fracture rate have increased dramatically, thromboembolism and pulmonary embolism became more frequent than in the past. In recent years, to prevent this complication, the author has prescribed appropriate management based on the clinical practice guidelines for thromboembolism of the Korean Hip Society: pre- and postoperative ankle exercise, wearing GCSs on the lower limbs, the use of an intermittent pneumatic compression apparatus, and antithrombotic agents (aspirin, low-molecular-weight heparin or rivaroxaban). However, sciatic nerve compression symptoms that had developed because of severe hematomas caused by late bleeding were detected in two patients administered antithrombotic agents. One patient recovered completely from nerve injury after hematoma removal; however, another patient recovered incompletely. Thus, careful follow-up is crucial when using antithrombotic agents⁵⁻⁷.

Nerve injury

The sixth most common complication is nerve injury, which frequently occurs in patients undergoing THA. Injuries to the femoral nerve, sciatic nerve, and superior gluteal nerves are most common⁸. We did not use an anterior approach and I do not have any THA cases with

anterior approach. We used a direct lateral approach in the past (1984-1990s); several studies reported the risk of superior gluteal nerve injury when separating the gluteus medius muscle, leads to weakness of the gluteus medius muscle and limping. For these reasons, a posterior approach has been used in all THAs since the 1990s. Nevertheless, of ~3,000 patients who underwent posterior-approach hip arthroplasty, sciatic nerve injury (peroneal component injury) occurred in 7 cases. Only 4 out of these 7 patients recovered from nerve injury within 2 years. Nerve injury is a complication that many surgeons want to avoid the most due to long-lasting psychological trauma and conflicts with patients. None of the 7 patients had sciatic nerve transection injuries; sciatic nerve injuries may have been traction injuries caused by retractors or compression injuries caused by Hohmann's retractor intraoperatively, but the exact cause has not been identified in some cases. Thus, surgeons must fully inform the patients about the high probability of postoperative sciatic nerve injury; this is particularly important for patients likely to have pre- or postoperative nerve injury, especially those with sciatica due to lumbosacral plexus compression, partial sciatic nerve injuries as sequelae of cerebrovascular accidents, or diabetic peripheral neuropathy. We experienced a female patient, in her 50s, who underwent bilateral THA after being diagnosed with avascular necrosis involving bilateral femoral heads. She had postoperative bilateral sciatic nerve injury and did not recover from nerve injury even after 2 postoperative years. She had preoperative paraplegia caused by brain lesions. Although she recovered from it after a year, bilateral leg weakness and ankle dorsiflexion weakness remained as well as bilateral sciatic nerve pain due to lumbar spinal stenosis. She was the only our patient to have nerve injury among those who received bilateral THA. This was the most difficult and serious case of ~4,000 hip arthroplasties performed over the past 30 years. The author regretted not emphasizing to the patients preoperatively the possibility of nerve injury or ankle dorsiflexion weakness^{9,10}.

In our experience, the most important considerations in preventing sciatic nerve injury are incision sufficient enough to avoid nerve traction, compression and twisting, and incision of the gluteus maximus tendon insertion to provide free gliding of the sciatic nerve during lower limb twisting in the posterior approach in hip arthroplasty. In the past, the author attempted

minimal incision and did not perform gluteus maximus tendon release. Since a minimal incision leads to the risk of muscle and nerve injury because of excessive retraction and compression of muscles and soft tissues underneath the incision in the skin, this surgical procedure is no longer used in our hospital. We use the traditional posterior approach and minimize the length of the incision as much as possible.

Hurd et al.¹¹⁾ stated in their study, *Sciatic Nerve Palsy after Primary Total Hip Arthroplasty*, that intraoperative identification of sciatic nerve compression underneath the gluteus maximus tendon on magnetic resonance imaging during limb rotation and incision of the gluteus maximus insertion are critical in preventing sciatic nerve injury. Even though an incision is small, the release of the gluteus maximus tendon insertion is anticipated to be helpful in avoiding sciatic nerve injury. Moreover, excessive limb lengthening may increase the risk of sciatic nerve injury in patients with severe limb discrepancy. Therefore, limb lengthening must be attempted to the degree that the sciatic nerve is not stretched (which can be ensured through sciatic nerve palpation) or compressed by the acetabular posterior wall or posterior edge of the acetabular component.

Fractures

THA-related fractures are the seventh most common complication. We did not experience any cases of acetabular fracture among patients who underwent THA due to arthritis or avascular necrosis of the femoral head. We experienced widening of an existing fracture gap in a case of early primary hip arthroplasty in a patient with an acute acetabular fracture. On the other hand, femoral fractures were very common (50-100 cases). The most common femoral fracture type was a 1-2 cm crack starting longitudinally from the femoral neck cutting surfaces of femur neck prepared for femoral stem insertion. Wiring was not performed, and rehabilitation exercise was conducted postoperatively and was successful in all cases. When the femoral neck fracture was long and stability was not ensured, cables were used for fixation. We experienced 3-5 cases of subtrochanter or distal femoral fractures caused by excessive twisting force during hip dislocation in elderly or osteoporotic patients. These fractures were fixed with plates, wires, or both. In such cases, surgeons have to notify patients of complications and ask patients and

their family for understanding. To prevent fractures in patients at high risk for fractures, surgeon's assistants must be thoroughly instructed not to flex, twist, or pull legs forcefully, the incision must be sufficiently long (including gluteus maximus tendon release), resection of the osteophytes needs to be performed around the acetabulum, and the femoral head needs to be removed from the acetabulum in case of acetabular protrusion. Sometimes a femoral stem one size larger than the size already decided on preoperative templating was required in older patients because they had almost no cancellous bone in the femur and the stem needed to be in direct contact with the cortical bone due to a loose structure cancellous bone. In such cases, excessive hammering in of the femoral stem to the isthmus area for firm fixation may result in templating-related subtrochanter fracture on the medial side. Completing the surgery without detecting this fracture can eventually lead to a serious situation when the fracture is found on postoperative follow-up. The author performs radiography intraoperatively in elderly patients with the possibility of fractures and cable fixation in patients with a suspected fracture. No additional explanations need to be provided to the patient and family.

In contrast, a stem one size smaller than the size measured on preoperative templating was often used in younger patients, presumably because they have dense cancellous bone in the proximal femur and solid fixation is achieved by press-fitting despite using a smaller stem. Of course, a large stem can be inserted into the femoral neck by reaming the femur, but this results in unnecessary bone destruction. In templating, the most important factor is whether the prepared prosthesis of a particular size fits into the place. Deciding the right size intraoperatively is most important in comparison with other criteria, such as preoperative templating.

Postoperative dislocation

The eighth most common complication is postoperative dislocation. In our experience, the use of a posterior approach has been the main cause of posterior dislocation. Abductor muscle injury or neurological problems need to be examined in patients preoperatively. The prevalence of postoperative dislocation is high in elderly patients, especially in those with hip fractures, due to frequent muscle injuries around the hip and abductor muscle weakness. In such cases, the author maintains

appropriate abductor muscle tension by regulating the lateral offset length to improve the abductor lever arm, and checks hip joint laxity by performing the “shuck test” to examine stability after hip reduction and insertion of the acetabular cup and stem. In case of minimum laxity, a femoral stem with a smaller neck-shaft angle (127°) or long neck-head can be used with a femoral neck cutting of ~ 5 mm larger to lengthen the abductor lever arm. Sometimes, I use the longer-limb method to prevent postoperative dislocation; hip stability can be improved by lengthening the lower limbs by 2-3 mm when it is not achieved by any other means in older patients with hip muscle weakness. Achieving hip stability without postoperative dislocation is more satisfactory despite lengthening of the lower limbs. Movements such as hyperflexion or medial rotation should be limited for ~ 3 postoperative months in elderly patients who underwent THA. A slightly higher frequency of dislocation in older patients is attributable to lower compliance and weaker muscle strength than in younger patients. Accurate insertion of the femoral stem and acetabular components is crucial to prevent postoperative dislocation. The ideal position of the acetabular cup to be inserted during hip arthroplasty is at an abduction angle of 40° and anteversion angle of 20° . However, the acetabular cup is inserted at a 40° abduction angle and 30° anteversion angle in patients with high risk of postoperative dislocation. Postoperative anterior dislocation may develop in case of excessive anteversion of the cup and stem, since the optimal combined anteversion angle should be $30\text{--}40^\circ$. Anterior hip dislocation occurred postoperatively in a female patient who received hip arthroplasty with a posterior approach after acetabular cup insertion at a 35° anteversion angle during THA. Her dislocation was managed with an abduction brace after reduction. Anterior dislocation has a relatively favourable prognosis in comparison with posterior dislocation.

Postoperative deep infection

The ninth most common complication is postoperative deep infection, which is quite distressful not only to a surgeon but also to patients and their families and requires long-term (a minimum of 3 months) treatment. Recently, Gram-positive methicillin-resistant *Staphylococcus aureus* (MRSA) and Gram-negative bacillus have emerged as predominant pathogens responsible for

difficult-to-treat infections. Complete remission is hardly achieved in postoperative deep infections caused by these bacteria despite administration of vancomycin-type antibiotics to which these pathogens are sensitive. To manage these infections, removal of the implant and primary or secondary revision are performed when wound becomes clean and the level of C-reactive protein (CRP) is normalized after daily wound irrigation and curettage. Over the past 3 decades, the author has experienced 30 patients with deep infection following THA. Of these, 5 patients were referred to another hospital. I appreciate the efforts of orthopaedic surgeons who treated those transferred patients. The other 25 patients were treated in our hospital. In 15 patients, wound irrigation and curettage were carried out on a daily basis and vancomycin was administered for 6 weeks. Since their CRP levels were nearly normalized and wounds became clean, oral medication (rifampin, cravit, septrin, or other antibiotics) was administered for ~ 3 months after the patients were discharged without removal of the implant and revision surgery. Subsequently, deep infection was completely cured. In the remaining 10 patients, although wound irrigation and curettage were performed daily and vancomycin was administered for 2-4 weeks, infection was only partially cured and CRP levels remained the same. For these reasons, acetabular and femoral components used in primary hip arthroplasty were removed and primary revision arthroplasty was performed by inserting a cemented stem into the femur and bipolar cup or inserting a cemented acetabular cup into the acetabulum with vancomycin-impregnated cement. Even though MRSA was cultured from these 10 patients preoperatively, infection did not recur during follow-up (from a minimum of 1 year to a maximum of 17 years).

Arthroplasty-related complications

The tenth most common complications are arthroplasty (cementless)-related. Until the 1980s, femoral stem fractures, polyethylene liner wear, osteolysis around the acetabular component and femoral stem, and component loosening occurred due to shortcomings of the prosthetic materials. Since then, failures of the surrounding bone and bone fixation (bone ingrowth or ongrowth) have occasionally occurred after cementless arthroplasty using the femoral stem and metal cup; polyethylene liner wear and osteolysis may also occur. These

complications require revision surgery after primary THA. Hence, a high revision rate is observed between 5 and 20 years after THA. Revision surgery is a satisfactory treatment option; it does not have the difficulty of component removal and its outcome is comparable to that of primary THA in patients with periprosthetic loosening following cemented THA. However, uncemented THA has the risk of periprosthetic osteolysis developing as a late complication. Bone grafting or other procedures are required in many cases because bone destruction is much more severe than predicted preoperatively. Moreover, the outcome of revision THA may be poorer than that of primary hip arthroplasty. In revision THA, surgical approaches to ensure sufficient incision are essential to prevent injuries of nerves and blood vessels. When replacing only the head and worn-out liner without removing old acetabular components, the availability of the implant units used in primary hip surgery must be checked with manufacturers prior to surgery by confirming their serial numbers and others. Despite all preparations for revision surgery, on several occasions the author experienced a mismatch of the metal cup and liner when inserting a new liner after removing the damaged acetabular liner from the metal acetabular shell. In such cases, the problem was resolved by fixing a smaller polyethylene or ceramic liner inside the metal cup with bone cement. Our hospital always prepares polyethylene or ceramic liners that can be fixed inside the metal cup with bone cement for revisions in case of mismatch.

Since the 1990's, the revision rate has decreased along with recent advances in designs and materials of hip components, which now have good biocompatibility. However, commonly used alternative bearing surfaces also have problems. Early failures due to metal hypersensitivity reactions, pseudotumor formation, and other complications have been reported in patients with metal-on-metal articulation. Purchasing failed components from the same manufacturer must be avoided. Large metal heads must also be avoided. Although metal-metal articulation was used in some patients in our hospital, the author used only 28-mm metal heads in all cases. The above complications were not detected during long-term follow-up. Damage of ceramic components has been occasionally reported as ceramic-on-ceramic articulation with the ceramic ball and insert has been commonly used as an alternative bearing instead of the polyethylene liner and metal head. Even though the incidence of ceramic

fractures has been lowered with the improvement of materials (delta ceramic), consistent follow-up is warranted because the use of delta ceramic cannot completely prevent ceramic fractures¹²⁻¹⁴.

Hip squeaking

The eleventh most common complication is hip squeaking following THA. The number of patients (in particular those with ceramic articulation) who hear or feel squeaking noises after 2-3 postoperative years is gradually increasing. Squeaking hips may cause problems in social or daily living activities, or in severe cases lead to depression. Even though several causes of squeaking have been identified, the solutions to tackle this problem are insufficient. According to an extensive meta-analysis performed in 2014, the incidence of squeaking in ceramic-on-ceramic bearings was 4.2%. Of these patients, 0.2% underwent revision surgery. A domestic study reported that the incidence of squeaking in Asian countries was 2.7%. These findings suggest that squeaking still remains a challenge to be tackled. Moreover, the patients with ceramic bearings must be fully informed preoperatively of the possibility of squeaking, and the risk factors need to be minimized. After experiencing postoperative squeaking in about 10 patients (3-4%) with ceramic heads and liners, the author started using cross-linked polyethylene liners with ceramic femoral heads in cementless THA since 2014, and plans to follow-up these cases for further investigation^{15,16}.

REFERENCES

1. Dearborn JT, Harris WH. *Postoperative mortality after total hip arthroplasty. An analysis of deaths after two thousand seven hundred and thirty-six procedures.* *J Bone Joint Surg Am.* 1998;80:1291-4.
2. Dunsmuir RA, Allan DB, Davidson LA. *Early post-operative mortality following primary total hip replacement.* *J R Coll Surg Edinb.* 1996;41:185-7.
3. Paavolainen P, Pukkala E, Pulkkinen P, Visuri T. *Causes of death after total hip arthroplasty: a nationwide cohort study with 24,638 patients.* *J Arthroplasty.* 2002;17:274-81.
4. Skinner HB, Schulz MM. *Clinical implications of thromboprophylaxis in the management of total hip and knee arthroplasty.* *Am J Orthop (Belle Mead NJ).* 2002;31 (9 Suppl):20-30.
5. Pellegrini VD Jr, Clement D, Lush-Ehmann C, Keller GS, Everts CM. *The John Charnley Award. Natural history of thromboembolic disease after total hip arthroplasty.* *Clin Orthop Relat Res.* 1996;333:27-40.
6. Jang MJ, Bang SM, Oh D. *Incidence of venous*

- thromboembolism in Korea: from the Health Insurance Review and Assessment Service database. J Thromb Haemost. 2011;9:85-91.*
7. Park YS, Lim SJ, Lee TH. *Prevention of venous thromboembolism in hip surgery patients. Hip Pelvis. 2014;26:1-6.*
 8. Schmalzried TP, Amstutz HC, Dorey FJ. *Nerve palsy associated with total hip replacement. Risk factors and prognosis. J Bone Joint Surg Am. 1991;73:1074-80.*
 9. Edwards BN, Tullos HS, Noble PC. *Contributory factors and etiology of sciatic nerve palsy in total hip arthroplasty. Clin Orthop Relat Res. 1987;218:136-41.*
 10. Cohen B, Bhamra M, Ferris BD. *Delayed sciatic nerve palsy following total hip arthroplasty. Br J Clin Pract. 1991;45:292-3.*
 11. Hurd JL, Potter HG, Dua V, Ranawat CS. *Sciatic nerve palsy after primary total hip arthroplasty: a new perspective. J Arthroplasty. 2006;21:796-802.*
 12. Hannouche D, Nich C, Bizot P, Meunier A, Nizard R, Sedel L. *Fractures of ceramic bearings: history and present status. Clin Orthop Relat Res. 2003;417:19-26.*
 13. Park YS, Hwang SK, Choy WS, Kim YS, Moon YW, Lim SJ. *Ceramic failure after total hip arthroplasty with an alumina-on-alumina bearing. J Bone Joint Surg Am. 2006;88:780-7.*
 14. Smith AJ, Dieppe P, Vernon K, Porter M, Blom AW; National Joint Registry of England and Wales. *Failure rates of stemmed metal-on-metal hip replacements: analysis of data from the National Joint Registry of England and Wales. Lancet. 2012;379:1199-204.*
 15. Owen DH, Russell NC, Smith PN, Walter WL. *An estimation of the incidence of squeaking and revision surgery for squeaking in ceramic-on-ceramic total hip replacement: a meta-analysis and report from the Australian Orthopaedic Association National Joint Registry. Bone Joint J. 2014;96-B:181-7.*
 16. Lee TH, Moon YW, Lim SJ, Park YS. *Meta-analysis of the incidence and risk factors for squeaking after primary ceramic-on-ceramic total hip arthroplasty in asian patients. Hip Pelvis. 2014;26:92-8.*