Common and uncommon complications after total hip replacement arthroplasty or open reduction and internal fixation of the femur: Evaluation with 3D-Multidetector computed tomography of the hip

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Learning objectives

1. To introduce the indication and surgical techniques of total hip replacement arthroplasty (THRA) and open reduction and internal fixation (ORIF).

2. To understand the types and incidence rate of complication after THRA or ORIF of the femur with 3D-multidetector computed tomography (MDCT) of the hip.

3. To correlate complications on MDCT with other radiologic modalities, such as plain radiography or magnetic resonance imaging.

Background

1. Introduction

Despite advances in surgical technique and prosthetic design, a small but significant numbers of patients (1-5%) develop complications, many of which require revision (1).

Plain radiography is the initial imaging method of choice for evaluation of hip arthroplasty or open reduction internal fixation (ORIF) for fracture of the femur, but is limited in evaluation of complications due to its inability to delineate complex three-dimensional (3D) structures (2).

Furthermore, recognizing and diagnosing these complications are often challenging because the presentation and findings are often nonspecific and redundant subtle (1).

CT is now also a useful imaging tool for assessing orthopaedic implants, as recent advances in technology and imaging techniques have largely overcome the problems arising from beam hardening artifact in CT (3-4).

Multidetector CT is an excellent supplemental imaging tool for evaluating hip prostheses; CT can detect periprosthetic fluid collections, evaluate osteolysis due to small-particle disease, more clearly define the periprosthetic soft tissues than plain radiography, and demonstrate hardware loosening that is frequently missed on plain radiography (5).

2. Surgical Techniques
2.1. **Hemiarthroplasty** refers to replacement of only the femoral side of the hip joint and is usually done for cases of hip fracture or avascular necrosis in which the acetabular cartilage is preserved and there is no degenerative arthritis.

- **Unipolar Endoprosthesis** Unipolar implants consist of either a femoral stem with fixed head or modular head with no acetabular component.
- **Bipolar Endoprosthesis** Bipolar prostheses have a metallic cup with the size of the resected femoral head, filled with polyethylene that contains an articular cavity for the metallic femoral head attached to the stem. The femoral head is locked into the larger cup.

2.2. **Total Arthroplasty** in which both the femoral head and the acetabulum are replaced by fixed prosthetic devices, is most often performed for disease processes that have affected both sides of the native joint, such as degenerative and rheumatoid arthritis.

*(Radiology Pearls)* Hemiarthroplasty Vs. Total hip arthroplasty (Fig. 1)

2.3. **Resurfacing Arthroplasty** is primarily designed for bone preservation in younger patients. The femoral head (hemiresurfacing) and acetabulum (total resurfacing) may be resurfaced.

- Femoral Head Resurfacing
- Total Joint Resurfacing

3. **Postoperative Prosthesis Evaluations**

3.1. **Type of Prosthesis**

- **Hemiarthroplasty** preserved subchondral bone plate of the acetabulum
- **Total Hip Arthroplasty or Total Resurfacing Arthroplasty** showed metal cup directly abuts the trabecular bone

3.2. **Component of Hip Prostesis** consist of acetabular cup, the femoral head, and the femoral stem. Component materials can be recognized by relative opacity and attenuation differences.

- **Metal Alloy** (cobalt-chrome, stainless steel, titanium, tantalum)
- **Plastic** (ultra-high-molecular-weight polyethylene)
- **Ceramic** (aluminum oxide, zirconium oxide)

3.3. **Bearing Surfaces** (Fig. 2) are materials in contact at articulations, provide durability and smooth range of motion. The most common one is metal-on-polyethylene (51%), followed by metal-on-metal (35%) and ceramic-on-ceramic (14%) in the United States in 2005-2006.
3.4. Components Fixed to Bone (Fig. 3)

- Cemented
- Cementless
- Hybrid

4. Detection of Complications

Modern hip arthroplasty is a relatively safe procedure.

But, potentially devastating complications can occur as follows; Infection, neurovascular injury, leg length discrepancy, periprosthetic fracture, dislocation or subluxation, osteolysis, loosening, heterotopic ossification, pseudobursa formation, metal sensitivity or toxicity, and wear or breakage of hardware.

We can systematically evaluate the prosthesis and detect numerous potential complications by asking the following concerns.

4.1. Evaluation of Prosthesis (Fig. 4)

- Implant Breakage
- Subluxation or Dislocation
- Component Wear

4.2. Component Fixation (Fig. 5)

- Solid Fixation
- Normal or Not Probable Loosening
- Possible or Probable Loosening
- Definite Loosening

4.3. Abnormality of Bones or Soft Tissues (Fig. 6)

- Periprosthetic Fracture
- Heterotopic Ossifications
- Periprosthetic Cement Leakage
- Periprosthetic Abscess
- Periprosthetic Metallosis

Images for this section:
**Fig. 1:** Note the normal lucent hyaline cartilage between the acetabulum and the femoral head (arrow in A) in hemiarthroplasty (A), as compared with total hip replacement arthroplasty.

**Fig. 2:** The metal-on-polyethylene bearing surface (A) is less dense than metal-on-metal (B) (arrow in A).
Fig. 3: A. Cemented THA (arrows). B. Cementless THA with acetabular screws (arrow). C. Hybrid THA [cementless (arrow) acetabular and cemented (arrowhead) femoral components]. D. Reverse hybrid THA [cemented (arrows) acetabular and cementless femoral components].

Fig. 4: A. Implant Breakage; Breakage of ceramic femur head implant with displacement to inferolateral aspect. B. Subluxation; Cup disintegration (arrow) and incidental cup loosening (arrowhead). C. Dislocation; Dislocated femur head (arrows). D. Component
Wear; Loss of gap (arrow) between the head and acetabular shell resulting from component wear at left side. Note the intact right side.

**Fig. 5:**

A. Solid Fixation; trabecular pattern bone in-growth called "Spot welds" (arrows).

B. Normal or Not Probable Loosening; normal air bubble in the cement mantle (arrows).

C. Possible or Probable Loosening; periprosthetic lucency more than 2 mm wide in femoral zone, endosteal scalloping at the cement-bone interface (arrows), incidental periprosthetic fracture (arrowhead).

D. Definite Loosening; globular periprosthetic lucency in acetabular zones (arrows).
Fig. 6: A. Periprosthetic Fracture (Stem). B. Heterotopic Ossifications. C. Periprosthetic Cement Leakage. D. Periprosthetic Abscess. E. Periprosthetic Metallosis.
Imaging findings OR Procedure details

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**Cases in Seoul National University Bundang Hospital**

- **115 cases**, postoperative CT for hip arthroplasty or ORIF following fracture of the femur
- **44 cases** without complication
- **71 cases** with complications

<table>
<thead>
<tr>
<th>No.</th>
<th>Complications</th>
<th>Cases</th>
<th>Fig.</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Periprosthetic Fracture</td>
<td>35 (49.3%)</td>
<td>7, 8</td>
</tr>
<tr>
<td>2</td>
<td>Device Wearing or Breakage</td>
<td>13 (18.3%)</td>
<td>9, 10, 11, 12</td>
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<tr>
<td>3</td>
<td>Loosening and/or Saponification</td>
<td>7 (9.9%)</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>Postoperative Avascular Necrosis</td>
<td>5 (7.0%)</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>Infection</td>
<td>4 (5.6%)</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>Prosthesis Migration or Dislocation</td>
<td>3 (4.2%)</td>
<td>16, 17</td>
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<tr>
<td>7</td>
<td>Organizing Hematoma</td>
<td>2 (2.8%)</td>
<td>18</td>
</tr>
<tr>
<td>8</td>
<td>Metallosis</td>
<td>2 (2.8%)</td>
<td>19, 20</td>
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**Periprosthetic Fractures**

Periprosthetic fractures are bone breaks that occur around the implant. These fractures typically occur because the bone around the implant has been weakened by osteoporosis, medications, pressure from the implant or stress placed on the implant (Fig. 7, 8).
Device Wearing or Breakage

Breakage of the implant itself can occur as a result of wear and tear of the prosthesis, often over the course of years. Breakage of the femoral component of a total hip replacement prosthesis is an uncommon occurrence with modern protheses. This is a rare occurrence, with less than 0.5 percent of people experiencing breakage (Fig. 9, 10, 11, 12).

Loosening

Loosening is the loss of bone around the hip replacement. When implants loosen, the hip replacement can begin to move small amounts. Usually this is associated with increasing pain and loss of motion experienced by the patient (Fig. 13).

Saponification

Saponification is calcific fat necrosis of dead fat with salt precipitates and fragments of dead bone. The debris may resemble dystrophic calcification (Fig. 13).

Postoperative Avascular Necrosis

Avascular necrosis of the hip is an uncommon and often unexpected postoperative complication in patients with persistent pain and disability postprocedure. Artifacts from metallic implants may obscure characteristic imaging signs of AVN, and plain radiography and CT are the mainstay imaging modalities of the postoperative hip (Fig. 14).

Infection

With an incidence rate of about 1 percent, infections following hip surgery are not common (Fig. 15).

Prosthesis Migration or Dislocation

Although migration or dislocation is not very common, it occurs following 1 percent to 5 percent of initial surgeries. Following revision surgery, the risk for dislocation rises as high as 20 percent (Fig. 16, 17).

Organizing Hematoma

Periprosthetic fluid collections including hematoma can occur both in the perioperative period and in the chronic setting, and they can be detected with CT (Fig. 18).
Metallosis

Metallosis is a rare condition that is caused by the buildup of metallic debris in the soft tissue of the body (Fig. 19, 20).

Images for this section:

Fig. 7: Periprosthetic Fracture. 79-year-old woman with right hip pain, after right bipolar hemiarthroplasty following femur neck fracture. A. Hip AP shows no remarkable finding. B. Coronal CT image shows fracture at right greater trochanter (red arrow), suggestive of periprosthetic fracture and wearing at superior portion of cup (yellow arrow).

Fig. 8: Periprosthetic Fracture with Cement leakage. 89-year-old woman with left hip pain, after left THRA following intertrochanteric fracture. A. Hip AP shows left femur shaft fracture and ill-defined radio-opacity along the inferomedial aspect of the left femoral neck (red arrows). B. Coronal CT image shows periprosthetic fracture at left femur shaft near distal stem (yellow arrow). C. Axial CT image shows amorphous high attenuation lesions around underlying intertrochanteric fracture, suggestive of callus formation and periprosthetic cement leakage (blue arrow).
**Fig. 9:** Device Wearing. 43-year-old man with left hip pain, after right THRA following LCP sequelae. A. Hip AP shows acetabular and stem sides of both THRA loosening (red arrows). B. Coronal, C, Sagittal CT images show loosening left acetabular component (yellow arrow) and left polyethylene wearing (blue arrow).

**Fig. 10:** Ceramic Head Breakage. 61-year-old man with right hip pain, after both THRA following AVN. A. Hip AP shows acetabular and stem sides of both THRA loosening (red arrows). B. Coronal CT image shows loosening at stem sides of both THRA (yellow arrows) and fracture of right femoral head ball portion with fragmentation (blue arrow).
**Fig. 11:** Ceramic Head Breakage. 38-year-old man with right hip pain, after both THRA following AVN. A. Hip AP shows two semicircular densities just below the normal head ball portion at right hip (red arrows). B. Coronal CT image shows fracture of right femoral head ball portion with fragmentation (yellow arrow).

**Fig. 12:** Wire Breakage. 68-year-old man with right hip pain, after both THRA following AVN. A. Hip AP shows no remarkable. B. About 2 years later, hip AP shows a displaced portion of the broken wire (red arrow). C. Coronal, D. axial CT images show the broken wire at the vastus medialis muscle (yellow arrows).
Fig. 13: Loosening with Saponification. 66-year-old man with left hip pain, after left THRA following intertrochanteric fracture. A. Hip AP shows ill-defined multifocal radio-opacities (red arrows) around left hip. B. Coronal, C. Sagittal CT image shows wearing and loosening (yellow arrow) of left hip joint with extensive osteolysis and massive granulation tissue formation (blue arrows) causing posterior displacement of the acetabular cup.

Fig. 14: Postoperative Avascular Necrosis. 79-year-old woman with right hip pain, after ORIF with multiple pinning, right. A. Hip AP shows right femoral head collapse with deformity (red arrows). B. Coronal, C. Axial CT image shows collapse of the right femoral head with deformity (yellow arrows), suggestive of postoperative AVN with collapse.
Fig. 15: Cold Abscess (Tuberculous Infection). 39-year-old man with right hip pain, after right THRA following AVN. A. Hip AP, B. frog leg views show low density areas (red arrows) around the right THRA prosthesis. C. Axial, D. Coronal CT images show multifocal low attenuation lesions with rim enhancement (yellow arrows), suggestive of multiple abscesses around right THRA prosthesis. E. Coronal T1 weighted MR image with contrast enhancement shows multiple abscesses (blue arrows) at the right gluteus minimus, iliacus, iliopsoas, and obturator externus muscles. The patient was confirmed to have tuberculous infection.
**Fig. 16:** Prosthesis Migration. 62-year-old woman with right hip pain, after proximal femoral nailing and internal fixation at right proximal femur. A. Hip AP shows superior migration (red arrow) of intramedullary nail and internal fixators. B. Coronal CT image shows bone destruction and suggested osteolysis (yellow arrows) at the right femoral head, neck, and intertrochanteric portion.

**Fig. 17:** Dislocation of the Prosthesis. 87-year-old woman with right hip pain, after both THRA following AVN. A. Hip AP shows superolateral dislocation (red arrows) of the right femur. B. Coronal CT image shows superolateral dislocation of the right femur with greater trochanteric fracture (yellow arrow).
Fig. 18: Organizing Hematoma. 45-year-old man with right mass, after both THRA following AVN. A. Hip AP shows a huge soft tissue mass around the right hip (red arrows). B. Coronal CT image shows a huge soft tissue density mass (yellow arrows) around the right hip joint with solid and cystic components causing bony erosion of the right sacral ala (not shown). C. T1 weighted, D. T2 weighted, E. T1 weighted with contrast enhancement, coronal MR images show an organizing hematoma (blue arrows) with heterogeneous high signal intensity on T1 WI, heterogeneous low to intermediate signal intensity on T2WI including heterogeneously enhancing portion. The patient was confirmed to have an organizing hematoma following revision surgery.
**Fig. 19:** Metallosis. 61-year-old woman with left hip pain, after left THRA following comminuted fracture. A. Hip AP shows penetration of the left acetabular cup raising suspicion of acetabular loosening (red arrow) and ill-defined increased opacity (yellow arrows) around the left hip. B. Coronal, C. Sagittal CT images show multi-lobulated or multiple complicated cysts around the left hip joint, and complicated synovial cysts with small metallic particles (blue arrows).

**Fig. 20:** Bursitis with Metallosis. 52-year-old woman with left hip pain, after left THRA following AVN. A. Hip AP shows a few radiopacities around left acetabulum (red arrow). B. C. Coronal CT image shows complicated iliopsoas bursitis (yellow arrows) with internal granulation tissue from metallosis calcification (blue arrows).
Conclusion

In summary, the complication after hip arthroplasty or open reduction and internal fixation for fracture remains a common problem, for both clinicians and radiologists.

Series of follow-up radiographs are often useful in addressing this issue.

However, improvements in metal artifact reduction protocols mean that diagnostic CT examinations can be the technique of choice for evaluating the volume and extent of operation bed while planning revision surgery.

3D-MDCT imaging may be useful in evaluating for complications after hip arthroplasty or ORIF, especially in cases, where postoperative radiographs do not reveal sufficient diagnostic information in patients suspected of postoperative complications.

References


Personal Information