Radiologic evaluation of hip endoprostheses - What the orthopaedic surgeon wants to know.

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Learning objectives

What different types of hip replacements are there?
What's important and how to describe in f/u after hip arthroplasty?

Background

Resurfacing of the hip is one of the most successful procedures in orthopedic surgery. Despite the rather small number of producers the number of models seems confusing.

The incidence for total hip arthroplasty (THA) is not only age and gender dependent, but also increases over the past decades, and ranges from about 15 (+/-5)/100,000 in the 5th decade to 500/100,000 in the 8th decade [1]. More than 90% of the implants are intact in elderly patients after ten years [2]. For younger patients (< 55 years) the survival rate is due to a greater activity about 80% after ten years.

While the planning of the surgical procedures is usually done by the orthopedic surgeon himself, the radiologists' duties are the follow-ups (f/u). On one hand to validate the surgeons work, on the other hand reveal potential postoperative complications. It should be mentioned, that it's very important for a radiologist, to be very diplomatic in case of an apparent failure committed by a surgical colleague. Incrimination has nothing whatsoever to do in a professional report.

The first thing a radiologist should describe is the kind of prosthesis. Usually the type gives a lot of information about the underlying conditions, e.g. traumatic or degenerative. Don't forget to mention the side and the f/u time. At last you should always exclude loosening, fractures or implant failure.

The following paragraphs are ment as a clipping of Total Hip Arthroplasty (THA) with the radiological important parts. You'll find nothing about e.g. preoperative planning or therapy in case of complications. The focus is set on what's normal and what's pathological.

Findings and procedure details

Type
Younger patients are usually treated with surface replacement to "save" bone for later revisions. The surface replacements normally use Metal/Metal pairing, a cementless cup, and a cemented femoral cap [3]. An alternative are thrust plate prosthesis which transfer the force on the medial and lateral compacta without using a stem.

The particularity in doing revision prosthesis is the bone defect. To compensate the defect or bone loss, the surgeon can use either bigger stems or more cement. Another possibility is to use autologous or homologous bone transplantation to refill the defects. It's often necessary to use additional screws for primary fixation especially after acetabular instabilities or reconstruction of the acetabular roof.

Dual Head prostheses are used after femoral neck fractures in old, multimorbide patients. It's very important to know how this kind of prosthesis acts and looks like in plain views. The cup is always loose to the acetabulum. In case of a mobile patient, the cup stands horizontal (head in the neck sign).

Stems are available in many sizes. The commonly used stem is a short, square in profile, anatomic bended stem with a modular "plug-on" head. The Long stems are used for revision or after tumor excision. The cup comes usually with an exchangeable inlay. To grab the force on the resection area at the Calcar femoris, many prostheses have collars.

The carrier material is normally titan, coated with alloyage such as Aluminum, Niobium, Vanadium or even proteins to support the bone ingrowth for the secondary stability. The pairing is either metal/metal, ceramic/metal or metal/polyethylene.

The fixation of the stem is either cemented or uncemented (also called press fit). The nowadays used model is the uncemented stem which is normally coated in the proximal third. Cups usually are implanted press fit or screwed by the surrounding winding.

The Follow-ups

Correct view

To assess the correctness of a hip prosthesis, an AP-view of the pelvis and a axial view are necessary. Quality characteristics are the complete display of the components as well as the correct justification. In some cases e.g. tumor prosthesis, it is necessary to conduct a second pair of images to picture the distal part of the prosthesis.

Implant positioning

Cup version: 15°+/-10° anteversio in axial-view [3-6].

Cup inclination: 40°+/-10° in AP-view [4].

Stem antetorsio: norm 5-15° [7]. Angle between a horizontal line and cup diameter.
Offset: Center of Hip to stem axis compared to the healthy side.

Interval

Postoperative AP-view: The first f/u should be conducted immediately after surgery, at the latest before discharge. No axial views for the first the months to avoid luxation. The first f/u should be three to six moths after surgery (AP and axial) to exclude early complications as infections, dislocations or luxation and should be followed by a final examination one year after surgery. If necessary, the intervals can be shortening. Subsequent it's advisable to f/u every three to five years.

Complications

Fractures

Incidence: intraoperative acetabular periprosthetic fractures for cemented cups 0.2% [8], for uncemented higher [9]. Intraoperative femoral fractures for cemented stems 0.3%, for uncemented 5.4% [10]. Periprosthetic fractures during revision surgery as high as 30% [11].

Classification: Acetabular fractures are classified by Letournel [12, 13] (Tab. 1) or Peterson [14] (Tab. 2), the Vancouver Classification is used for femoral fractures [15] (Tab. 3).

| Simple Fractures (20%) | Posterior wall fractures |
| Anterior wall fractures |
| Anterior column fractures |
| Transverse fractures |
| Combined Fractures (80%) | posterior wall & column fractures |
| posterior wall & transverse fractures |
| T-shaped fractures |
| Anterior & posterior hemitransverse fractures |
| Both column fractures |

Tab 1: Classification of acetabular fractures by Letournel.
Type 1  Stable acetabular component
Type 2  Unstable cup

Tab 2: Classification of acetabular fractures by Peterson

<table>
<thead>
<tr>
<th>Fracture type and subtype</th>
<th>Location of fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td>A_G</td>
<td>Greater trochanteric area</td>
</tr>
<tr>
<td>A_L</td>
<td>Lesser trochanteric area</td>
</tr>
<tr>
<td>B_1</td>
<td>Around or just distal to the prosthesis but implant stable</td>
</tr>
<tr>
<td>B_2</td>
<td>Around or just distal to the prosthesis but implant unstable with good bone stock</td>
</tr>
<tr>
<td>B_3</td>
<td>Around or just distal to the prosthesis but implant unstable with poor bone stock</td>
</tr>
<tr>
<td>C</td>
<td>Below the implant</td>
</tr>
</tbody>
</table>

Tab 3: Vancouver classification of periprosthetic femoral fractures

Dislocation/Luxation

*Incidence:* After primary THA 1 to 10% [16-20], up to 27% after revision [21]. Most dislocations occur within the first 4 to 6 weeks [16, 22] Fig. 2 on page 8.

*Definition:* Cup dislocation of at least 4 mm and/or 4°, and/or subsidence of the stem of at least 4 mm after the first postoperative f/u.

Infection

*Incidence:* Within two years after primary THA (age > 65) 1.63%. Between 2 to 10 years 0.59% [23].

*Radiographic evaluation:* Rapid osteolysis, periostitis, endosteal scalloping, early component loosening [24].

Implant Failure, Loosening

*Classification:* Gruen (1979) [25] (Tab. 4).

*Wear:* Migration of the femoral head to cranio-dorsal inside the cup.
Osteolysis: Shape ovoid, globular or longish. Located somewhere around the prosthesis between metal and cement, metal and bone and/or cement and bone due to a hypersensitive reaction. Normal findings: 1 to 2 focal osteolysis, < 1cm, w/o expansion, nearby margin, dislocation or clinical evidence > f/u in 3 to 6 months recommended.

Margin: X-ray transparent fissure usually with a thin sclerosing front between bone, cement and/or prosthesis. Two planes are necessary to distinguish complete from incomplete circumferential margins. Don’t forget to describe the margin length. Progressive margins need f/u in three to six months intervals. Normal findings: margins < 2 mm.

### AP view

1. Greater trochanteric area
2. Lateral middle third of the stem
3. Lateral lower third of the stem
4. Below the stem
5. Medial lower third of the stem
6. Medial middle third of the stem
7. Lesser trochanteric area

### Axial view

8. Greater trochanteric area
9. Lateral middle third of the stem
10. Lateral lower third of the stem
11. Below the stem
12. Medial lower third of the stem
13. Medial middle third of the stem
14. Lesser trochanteric area

Tab 4: Classification of loosening zones by Gruen

### Heterotopic Ossification

Incidence: 1 to 2% after THA in the general population and up to 90% in patients with multiple risk factors [26-32] Fig. 3 on page 9.

Classification: Brooker (1973) [33] (Tab. 5) or Mayo Clinic (1984) [34].
**Clinics:** Common but often irrelevant. Symptoms are restricted motion, impingement and pain.

<table>
<thead>
<tr>
<th>Stage 0</th>
<th>No heterotopic bone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>Islands of bone within soft tissue</td>
</tr>
<tr>
<td>Stage 2</td>
<td>Bone spurs from pelvis to femur leaving at least 1 cm space b/w bones</td>
</tr>
<tr>
<td>Stage 3</td>
<td>Bone spurs from pelvis to femur leaving at less than 1 cm space b/w bones</td>
</tr>
<tr>
<td>Stage 4</td>
<td>Bony ankylosis of hip</td>
</tr>
</tbody>
</table>

**Tab 5: Classification of heterotopic ossification by Brooker**

**Stress Shielding**

Definition: Bone loss in the area of the trochanter major and minor (Gruen zones 1 and 7) due to a more distal effecting force [Fig. 4](#) on page 10.

**Images for this section:**
Fig. 1: Periprosthetic fracture below the implant (Vancouver type C)
Fig. 2: THA dislocation
Fig. 3: Heterotopic ossification on the left with bony ankylosis of the hip (Brooker Stage 4).
Fig. 4: Stress shielding at the area of the trochanter major and hypertrophy of the cortiocalis due to distal effecting force after three years (lower image)
Conclusion

To do a valuable report for a THA f/u two things are very important. On one hand it is helpful to use a pattern, similar to an x-ray chest which avoids missing pathologies. On the other it is necessary to compare the examination at hand with the postoperative pictures. It is always important to look for changes, even if they are below the critical value.

A good system is to go from the inside to the outside or otherwise, as you prefer. First assess the image quality as described above. The second step is to look for position changes of the complete prosthesis (stem and cup) to the body in comparison to the older f/u. The third step should look for position changes of the components to each other to exclude dislocation and greater wear. The forth step recons periprosthetic changes as osteolysis, margins or cement fractures. The fifths step assesses the bone. Keep an eye not only on fractures but also on bone structural changes like sclerosis or osteopenia.

If you stick to a scheme, it is unlikely to overlook something.

You can start your report by describing the type of the prosthesis and kind of fixation as mentioned above. Even if there are no visible complications, you should state the proper seat of the components, e.g. uncemented short stem total hip prosthesis with a screwed cup in correct and same position as in the preliminary assessment. No periprosthetic fractures, no signs of loosening, no implant failure.

Personal information

References


