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Radiologic Assessment of the Failed Total Hip Arthroplasty

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Abstract: The objective of this study was to assess the accuracy in evaluating radiographs of a failed total hip arthroplasty. Pre-revision radiographs from fifty consecutive hip revisions (49 patients) performed by a single surgeon between 1994 and 1996 were reviewed retrospectively by the operating surgeon (surgeon 1), a second experienced hip surgeon who was not involved in the surgery (surgeon 2), and a bone radiologist. The three reviewers performed a detailed analysis focusing on loosening, wear, component position and bone loss. Their responses were then compared to the operative findings as documented on the operative notes by a third, uninvolved orthopedic surgeon.

There were 19 men, 30 women with an average age of 68 (range 37–86) at the time of revision. The reason for revision arthroplasty was symptomatic aseptic loosening of one or both components with varying amounts of bone loss in 42 hips, instability in three hips, periprosthetic fracture with loosening in three hips, component fracture and polyethylene failure in one each. No infected arthroplasties were included.

Twenty-seven femoral components were loose at the time of revision arthroplasty. During radiographic review surgeon 1 identified 21 (78%) of these as loose or possibly loose, surgeon 2 identified 18 (67%), and the bone radiologist identified 24 (89%). The routine preoperative radiology report identified 15 (56%) of loose components. The false positive rate (identifying implants as loose or possibly loose when at surgery they were determined to be secure) was 10% for surgeon 1, 8% for surgeon 2, 18% for the bone radiologist, and 2% for the initial radiology report.

Thirty-four acetabular components were loose at revision. At radiographic review surgeon 1 identified 100% of those as loose or possibly loose, surgeon 2 identified 100%, and the radiologist identified 91%. The initial radiology report documented 59% of the loose components. The false positive rate (identifying implants as loose or possibly loose when at surgery it was determined to be secure) was 11% for surgeon 1, 4% for surgeon 2, 11% for the bone radiologist, and 6% for the initial radiology report.

Eighty-nine percent of the 38 hips with moderate or severe bone loss (as documented on the operative notes) were identified as such by surgeon 1, 71% by surgeon 2, 63% by the radiologists, and 16% on the initial radiology report. The false positive rate was 8% for surgeon 1, 6% for surgeon 2, 0% for the radiologist, and 2% for the radiology report.

Surgeons assessing radiographs of failed total hip arthroplasties for possible revision surgery should pay particular attention to the fixation status of the femoral component and should always examine both components intraoperatively for stable fixation. Surgeons should not rely exclusively on conventional radiologic assessment by themselves or a radiologist in patients who are to undergo revision total hip surgery.

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Introduction

Although primary total hip arthroplasty (THA) is a very successful and durable procedure, it is estimated that revision total hip arthroplasty will be necessary at a rate of approximately 1% per year of follow-up. Certainly the frequency of revision will increase as the number of hips that have been in place for 15 to 25 years increases. Preoperative planning prior to revision THA allows the surgeon to develop an appropriate surgical plan and obtain the necessary instruments, prostheses, and any bone grafts that may be needed to carry out the procedure. One of the initial steps in preoperative planning is critical evaluation of the radiographs for component fixation, component position, wear, and bone loss. Questions also persist whether in the current medical environment it is imperative for a radiologist to review all preoperative x-rays prior to revision THA. This study is a retrospective examination of the accuracy of two experienced hip surgeons and a musculoskeletal radiologist in evaluating preoperative radiographs for component fixation, wear, component position, and bone loss prior to revision THA. The objective was to assess the reliability of hip surgeons in assessing their intraoperative needs preoperatively.

Methods

Pre-revision radiographs from 50 consecutive hip revisions performed by a single surgeon between 1994 and 1996 were reviewed retrospectively by the operating surgeon (surgeon 1), a second experienced hip surgeon who was not involved in the surgery (surgeon 2), and a bone radiologist. All patients had three "views" of their hip including an anterior-posterior pelvis, anterior-posterior hip view, which includes the proximal 50% of the femur, and a true surgical lateral view. The three reviewers filled out a questionnaire focusing on component loosening, wear, component position, and bone loss based on the last radiographs taken at our institution prior to the revision surgery (Figure 1). Additionally, all x-rays had been evaluated preoperatively by a radiologist who was not part of the study as part of the standard practice at our institution (five of the films had been read by radiology residents, 45 by staff radiologists). The four evaluations (three reviewers and the preoperative radiologist interpretation) were then compared to the operative findings as documented on the operative notes by a third, uninvolved orthopedic surgeon (surgeon 3).

Surgeon 1 had evaluated the radiographs prior to surgery (and had examined the patient) but reviewed them for this study no less than three months following the surgical procedure. Surgeon 2 had not seen the radiographs or the patient prior to this study. The bone radiologist had reviewed five of the radiographs prior to revision as part of the routine practice at our institution but was blinded to the reason for the revision and did not have access to the prior reading when reviewing the radiographs for this study.

The study included 50 revision hip arthroplasties in 19 men and 30 women with an average age of 68 (range 37–86) at the time of surgery. One patient underwent bilateral revision surgery. The failed index arthroplasties were cemented in twenty-seven hips, uncemented in eight hips, hybrid (cementless socket and cemented femoral components) in seven hips, "reverse" hybrid (cemented socket and uncemented femoral components) in three, uncemented bipolar in two, and cemented bipolar in three. Overall, 37 of the 50 femoral components were cemented and 13 were uncemented. Thirty of the acetabular components were cemented and fifteen were uncemented.

The reason for revision arthroplasty was symptomatic aseptic loosening of one or both components with varying amounts of bone loss in 42 hips, instability in three hips, periprosthetic fracture with loosening in three hips, component fracture and polyethylene wear in one each.

Thirty-one femoral components were revised, and 41 acetabular components were revised. Both the femoral and the acetabular components were revised in 23 hips, the acetabular component only in 18 hips, the femoral component only in six hips, the polyethylene only in one hip, and the femoral component and the polyethylene liner in two hips.

Results

Twenty-seven femoral components (54%) were loose at the time of revision arthroplasty. During radiographic review surgeon 1 identified 21 (78%) of these as loose or possibly loose, surgeon 2 identified 18 (67%), and the bone radiologist identified 24 (89%). Sixteen (59%) were correctly identified by all three reviewers (Figure 2). The initial radiology report identified 15 (56%) of the loose components (Figure 3). The false positive rate (identifying implants as loose or possibly loose when at surgery they were determined to be secure) was 10% for surgeon 1, 8% for surgeon 2, 18% for the musculoskeletal radiologist, and 2% for the radiology report (Figure 4). Twenty-one of the 27 loose femoral stems were cemented, and six were uncemented. Surgeon 1 identified 71% of the loose cemented femoral stems as loose, surgeon 2 identified 62%, the radiologist identified 90%, and the radiology report identified 52% (Figure 5). The results for the uncemented stems were better as surgeon 1 identified 100% of the loose stems, surgeon 2 identified 83%, the radiologist identified 83%, and the radiology report identified 67%. Overall, the sensi-

Questionnaire

For questions 1-4: 0 = no, 1 = yes, 2 = not sure

1) Is the femoral component loose? ___

2) Is the acetabular component loose? ___

3) Is there significant polyethylene wear? ___

4) Are the components malpositioned, dislocated or dissociated? ___

5) Categorize bone loss: ___

(0 = none or mild; 1 = moderate or severe)

Fig. 1. Questionnaire filled out by the three reviewers.

Fig. 2. Radiograph interpreted correctly by all three reviewers and the radiologist report. Both components were confirmed to be loose at surgery.

tivity and specificity for surgeon 1 in identifying loose femoral components were 0.78 and 0.78; for surgeon 2, 0.67 and 0.83; for the radiologist, 0.88 and 0.61; and for the radiology report 0.56 and 0.96 (Table 1).

Thirty-four of the 45 acetabular components (76%) were loose at revision surgery. During radiographic review surgeon 1 identified 100% of these as loose or possibly loose, surgeon 2 identified 100%, and the musculoskeletal radiologist identified 91% (Figure 2). Ninety-one percent were identified correctly by all three reviewers however the initial radiology report identified only 59% of the loose components. The false positive rate (identifying implants as loose or possibly loose when at surgery it was determined to be secure) was 11% for surgeon 1, 4% for surgeon 2, 11% for the radiologist, and 6% for the radiology report. Twenty-nine of the 34 loose acetabular components were cemented and five were uncemented. Surgeon 1 identified 100% of the loose cemented acetabular components as loose, surgeon 2 identified 100%, the radiologist identified 90%, and the radiology report identified 60%. The results for the uncemented acetabular components were similar. Surgeon 1 identified 100% of the loose uncemented components, surgeon 2 identified 100%, the musculoskeletal radiologist identified 100%, and the radiology report identified 60%. Overall, the sensitivity and specificity for surgeon 1 in identifying loose acetabular components were 1.0 and 0.54; for surgeon 2, 1.0 and 0.81; for the radiologist, 0.91 and 0.54; and for the radiology report, 0.59 and 1.0 (Table 2).

Polyethylene wear could not be reliably determined from the operative report thus it was defined by the uninvolved orthopedic surgeon (surgeon 3) as wear of greater than one millimeter on the anterior-posterior radiograph. Twenty-two of the 50 hips were identified as having significant polyethylene wear. Five hips could not be adequately evaluated for polyethylene wear from the x-rays present. Seventeen of the 22 (77%) were identified by reviewer 1 as having significant poly wear, twenty of the 22 (91%) by reviewer 2, and eighteen of 22 (82%) by the musculoskeletal radiologist. Two of 22 (9%) were identified on the radiology report. Sixteen of the 22 (73%) were identified by all three reviewers as showing wear or possibly showing wear. Only two of these 16 were identified by the radiology report.

Fig. 3. Radiograph interpreted correctly by all three reviewers. Report from radiology department stated "doubt loosening has occurred."

Fig. 4. Radiograph interpreted by all three reviewers as a loose cup and loose stem. At surgery cup was grossly loose, stem was well fixed.

Table 1. Loose femoral components

	Surgeon one	Surgeon two	Bone radiologist	Radiology report
Percent of loose cemented femoral stems identified	71%	62%	90%	52%
Percent of loose uncemented femoral stems identified	100%	83%	83%	67%
Sensitivity/specificity in identifying loose femoral components	0.78/0.78	0.67/0.83	0.88/0.61	0.56/0.96

Moderate or severe bone loss was defined by the uninvolved surgeon (surgeon 3) as those hips that required allograft reconstruction of cavitary or segmental defects. Thirty-eight hips were identified as having moderate or severe bone loss. Eighty-nine percent of the 38 hips were identified as having moderate or severe bone loss by surgeon 1, 71% by surgeon 2, 63% by the musculoskeletal radiologist, and 16% on the routine radiology report (Figure 6). The false positive rate (hips which were identified as having moderate or severe bone loss on review but did not have moderate or severe bone loss at the time of surgery) was 8% for surgeon 1, 6% for surgeon 2, 0% for the radiologist, and 2% for the radiology report.

Malposition was more difficult to evaluate as evidenced by the wider variation in the frequency with which the different reviewers identified the components as dislocated, fractured, or malpositioned. This likely relates to the absence of specific criteria for malposition in this study (as well as in the literature) and variation in what each reviewer considered acceptable. Surgeon 3 reviewed all of the x-rays for malpositioning using criteria of greater than 2° of femoral component varus or valgus or <25° or >65° acetabular component abduction as malposition (measured on the anterior-posterior hip radiograph). Additionally cups with <0% or >35° of anteversion were considered malpositioned (measured on the true lateral hip radiograph). By these criteria 31 hips were identified as having malpositioned com-

Fig. 5. Radiograph interpreted by all three reviewers as a loose cup and well fixed stem. At surgery both components were found to be grossly loose.

Fig. 6. Radiograph with marked bone loss in both the acetabulum and proximal femur. No mention made concerning bone stock on radiologist report.

Table 2. Loose acetabular components

	Surgeon one	Surgeon two	Bone radiologist	Radiology report
Percent of loose cemented acetabular components identified	100%	100%	90%	60%
Percent loose uncemented acetabular components identified	100%	100%	100%	60%
Sensitivity/specificity in identifying loose acetabular components	1.0/0.54	1.0/0.81	0.91/0.54	0.59/1.0

ponents. Some of these components had changed position due to loosening. Twenty-one femoral components were malpositioned and fourteen acetabular components were malpositioned. Reviewer 1 identified 28 (90%) of these as malpositioned, reviewer 2 identified 19 (61%), the musculoskeletal radiologist identified 23 (74%), and the radiology report identified 8 (26%). Fifteen of the 31 (48%) were identified by all three reviewers as malpositioned. The radiology report identified only 7 of these 15 (47%) as malpositioned. The false positive rates varied from 6 to 20% reflecting differences in the reviewers' definition of what constituted malposition.

Discussion

Overall all three reviewers successfully identified >90° of loose acetabular components but had more difficulty identifying loose femoral components (average 78%). The success rate was better for uncemented components than for cemented components. Wear, bone loss, and component malposition were harder to precisely define preoperatively and intraoperatively. Identification of bone loss was variable ranging from 63% for the radiologist to 89% for surgeon 1. Overall, 44% of the hips demonstrated polyethylene wear greater than one millimeter as determined by surgeon 3. The various other reviewers identified between 77% and 91% of these as demonstrating polyethylene wear. There was a high rate of agreement between the reviewers with regard to which hips demonstrated wear. Seventy-three percent of the hips which demonstrated wear were identified by all three reviewers. The false negative rate was also low for this analysis as well.

The original radiology reports frequently did not provide specific information regarding identifying component loosening, bone loss, polyethylene wear, and component malposition. The reports documented only 56% of loose femoral components and 60% of loose acetabular components. In addition, only 10% of the hips recognized by all three reviewers as demonstrating polyethylene wear were identified in the radiology reports as demonstrating wear. It should be noted that the initial radiologist reading the film did not have the questionnaire prompting their opinion on loosening, wear, bone loss, and malposition. Furthermore, radiologists did not have any clinical information and often don't comment on component position, wear, and bone loss.

This data seems to support subspecialization in radiology as the bone radiologist performed similar to the hip surgeons and markedly better than the initial radiologist report. The findings in this study also confirm those in previous reports that in many routine cases interpretation of orthopedic x-rays by a radiologist does not alter the management of a patient who undergoes a joint replacement [1]. There are occasions when the radiologist detects abnormalities unrelated to the joint arthroplasty which provide an explanation for the patient's symptoms. For example, diagnoses such as insufficiency type stress fractures, primary or metastatic skeletal neoplasms, and gastrointestinal/genitourinary pathology could go undetected by an orthopedist focusing on the components of a joint arthroplasty.

Surgeons must address multiple potential concerns when evaluating failed THAs for possible revision including component fixation, bone loss, polyethylene wear, and component position. They should pay particular attention to the fixation status of the femoral component and should always examine both components intra-operatively for stable fixation as the reliability of identifying loose femoral components from preoperative x-rays is considerably less than for loose acetabular components. Surgeons should be prepared to revise a femoral component, even if it is felt to be secure preoperatively as even high volume hip arthroplasty surgeons may be wrong in their preoperative assessment in up to 22% of cases.

Orthopedic surgeons should not rely exclusively on conventional radiologic assessment by themselves or a radiologist in patients who are to undergo revision total hip surgery.

Reference

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