Immediate Postoperative Radiographs After Shoulder Arthroplasty Are Often Poor Quality and Do Not Alter Care

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Abstract

Background It is technically difficult to obtain high-quality, postoperative shoulder radiographs immediately after surgery. Further, poor-quality radiographs may be unlikely to change clinical practice or improve patient outcomes. We therefore questioned the value of routine postoperative radiographs after shoulder arthroplasty.

Questions/Purposes We asked whether (1) postanesthesia care unit (PACU) radiographs can reasonably serve as a baseline for future studies; and (2) routine PACU

radiographs change clinical care. (3) We also determined the charges associated with routine PACU radiographs and formal radiographic interpretation of these images.

Methods We retrospectively compared the radiographs of 283 patients who had shoulder arthroplasties (Group 1) who underwent PACU radiographs with those of 241 patients (Group 2) who had their first postoperative radiographs at a later date. Radiographs were compared for quality, ability to serve as a baseline, and their influence on clinical course. Orthopaedic evaluation of each radiograph and the radiographic report were compared and charges were analyzed.

Results All images in Group 1 were single-view radiographs (88% internal rotation), most were underpenetrated (71%); no images changed postoperative management or were considered adequate to serve as a baseline. Group 2 radiographs were multiview radiographs, and 83% were deemed adequate to serve as baseline radiographs. Radiographic interpretation of immediate postoperative radiographs did not change the clinical course or treatment. The charges billed from radiographic evaluation in this study were \$64,524 for Group 1.

Conclusions Routine PACU radiographs, in the absence of a specific indication, may result in poor-quality images. Elimination of these radiographs and radiographic interpretation after shoulder arthroplasty may reduce charges without changing clinical care.

Level of Evidence Level III, diagnostic study. See Guidelines for Authors for a complete description of levels of evidence.

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All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research* editors and board members are on file with the publication and can be viewed on request. Each author certifies that his or her institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research. This work was performed at Penn Presbyterian Medical Center, Philadelphia, PA, USA.

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Introduction

Cost containment and responsible medical spending are major focuses of today's healthcare climate. As a result,

evidence-based medical decisions are increasingly important in dictating proper resource allocation. Multiple methods of cost containment have been implemented, including shortening hospital stays, consolidating implant vendors, and (most pertinent to this study) eliminating duplication of services during the perioperative period. The practice of obtaining routine radiographs immediately after TKA and THA provides no direct patient care or economic benefit [4, 8–10, 12, 15]. Many shoulder surgeons routinely obtain radiographs immediately after shoulder arthroplasty, so the utility of these radiographs should justify the expense. For the shoulder in particular, it is technically difficult to obtain high-quality radiographs immediately postoperatively and the resultant poor-quality radiographs may be unlikely to change clinical practice or measurably improve patient outcomes. Furthermore, the benefit of routine consultation by an attending radiologist regarding these films should be confirmed.

Radiographs are necessary early during the postoperative period to assess alignment, prosthesis position, and to serve as a baseline with which future radiographs are compared (to measure wear or loosening), but we questioned whether obtaining the initial postoperative radiographs before hospital discharge or at a postoperative clinic visit is a more appropriate practice than obtaining portable images in the postanesthesia care unit (PACU).

We therefore asked whether (1) PACU radiographs can reasonably serve as a baseline for future studies; and (2) routine PACU radiographs change clinical care. (3) We also determined the charges after shoulder arthroplasty associated with routine PACU radiographs and formal radiographic interpretation of these images.

Patients and Methods

We retrospectively evaluated postoperative radiographs of all 524 patients who had shoulder arthroplasties performed from February 2004 to May 2008. The patients were identified via the following current procedural terminology (CPT) codes: 23470 for shoulder hemiarthroplasty and 23472 for total shoulder arthroplasty. The series included patients who underwent primary and revision hemiarthroplasties, anatomic total shoulder arthroplasties (TSA), and reverse total shoulder arthroplasties (rTSA). The procedures were performed by five fellowship-trained shoulder surgeons. Based on surgeon preferences during the study period, two groups were created: 283 patients who had shoulder arthroplasties (Group 1), who had PACU radiographs, and 241 patients (Group 2), who had their first postoperative radiographs taken after the day of surgery (Table 1). Two hundred twenty-one Group 2 radiographs were taken on an outpatient basis (range, 2–7 weeks

Table 1. Characteristics of Groups 1 and 2

Variable	Group 1 (n = 283)	% of total	Group 2 (n = 241)	% of total	p value
Hemiarthroplasty	13	5%	14	6%	0.556
TSA	144	51%	157	65%	0.001
rTSA	126	45%	70	29%	< 0.001
Primary surgeries	231	82%	201	83%	0.867
Revision surgeries	52	18%	40	17%	0.867

TSA = total shoulder arthroplasty; rTSA = reverse total shoulder arthroplasty.

postoperative), 20 radiographs were taken during the hospital stay (but not immediately postoperatively) (range, 1–3 days after surgery), and all 241 were multiview radiographs. Intraoperative fluoroscopy was routinely available and often was used in cases of deformity or revision shoulder arthroplasty. Fluoroscopy was used in such cases to ensure proper humeral stem placement in the canal, to rule out intraoperative fractures, and to help determine implant orientation and alignment. Use of fluoroscopy did not influence whether a patient was included in Group 1 or Group 2. The study was approved by our hospital's institutional review board.

All images in Group 1 were single-view radiographs taken in the PACU (Table 2). There were 35 neutral, 248 internal rotation, and 0 external rotation views. In total, the 241 patients in Group 2 included 140 with internal rotation and external rotation AP, scapular Y, and axillary views; 38 patients with neutral AP and scapular Y, and 63 patients with neutral AP and axillary views. Each radiograph was evaluated independently by two of the authors who were blinded to the patient groups (SN, JEH). They were asked to determine (1) the quality of the image (number of views, image orientation with respect to the glenohumeral joint [internal rotation, neutral, external rotation]) (free marginal kappa = 0.95); (2) the exposure (free marginal kappa = 0.93); and (3) whether radiographs could serve as a baseline for future radiographs (answer, yes/no) (free marginal kappa = 1.0). Any discrepancy between evaluators was resolved by consensus. Exposure was judged on a three-category system: adequate, underpenetrated, and overpenetrated. A film was considered underpenetrated if there was not sufficient contrast between the cement-bone interface or if the cortical bone could not be distinguished from the medullary bone [4]. Radiographs were considered suitable to serve as a baseline if they included at minimum an orthogonal AP view, an axillary view, and adequate penetrance of the shoulder to allow for observation of humeral alignment, the bone-implant or bone-cement interface, and glenoid position. This was considered necessary to be able to determine glenoid wear

Table 2. Radiographic comparisons between Groups 1 and 2

Variable	Group 1 (n = 283)	Group 2 (n = 241)	p value
Orientation			
Neutral AP	35	101	< 0.001
Internal rotation AP	248	140*	< 0.003
External rotation AP	0	140*	–
Scapular Y	0	178	–
Axillary	0	203	–
Penetration			
Adequate	45	201	< 0.001
Underpenetrated	201	22	< 0.001
Overpenetrated	37	19	< 0.110
Adequate as baseline	0	200	< 0.001

* The same 140 patients underwent internal rotation and external rotation AP radiographs.

or loosening, humeral implant subsidence or loosening, or proximal humeral migration. Additionally, the surgeons were asked to assess the radiographs for fractures (answer, yes/no) and dislocations (answer, yes/no). Subsequently, the radiology report was evaluated in each case for the same variables. The orthopaedic evaluation of each radiograph was compared with the radiology report for fracture and dislocation. Any patient's return to the operating room that stemmed from the radiographs was noted.

The charges to radiographically evaluate all shoulder arthroplasties immediately postoperative were calculated using the standard billing schedule. This analysis also included an assessment of the charges associated with radiographic consultation.

Pearson's chi-squared test was used to determine differences in Groups 1 and 2 in terms of the type of arthroplasty and the number of primary and revision surgeries. In cases where less than three of an outcome was present for a given category, Fisher's exact test was used. These tests were also used to compare Groups 1 and 2 in terms of radiographic variables.

Results

There were 201 adequate, 22 underpenetrated, and 18 overpenetrated radiographs in Group 2 compared with 45 adequate, 201 underpenetrated, and 37 overpenetrated radiographs in Group 1 ($p < 0.0001$). None of the radiographs in Group 1 were considered adequate to serve as a baseline for future radiographs (Fig. 1). In Group 2, the 200 radiographs that included an AP, an axillary view, and adequate penetrance of the shoulder were considered appropriate to serve as a baseline for future radiographs (Fig. 2).

Fig. 1 This PACU radiograph shows an internally rotated image that is underpenetrated.

No immediate postoperative radiographic finding necessitated a return to the operating room or change in treatment for any of our patients. The official radiology report in Group 1 referred to eight cases of “possible fracture”, none of which was substantiated on followup radiographs or noted on the orthopaedic surgeons' evaluations (SN, JEH) of radiographs. Three separate nondisplaced fractures of the proximal humerus at the proximal aspect of the humeral stem were identified on orthopaedic review (SN, JEH). All of these occurred in revision arthroplasties in which an rTSA prosthesis had been implanted. No cases of implant dislocation were identified. No patient had a postoperative complication (eg, dislocation or fracture) that was identified on an immediate postoperative radiograph in Group 1. Twenty patients in Group 2 had radiographs during the hospital course owing to acute increases in pain or deformity that were believed to be greater than the normal postoperative amount and predicated by an event (fall or unexpected torque to the shoulder). Two of these patients had a dislocated rTSA, and one had anterosuperior escape after hemiarthroplasty for cuff tear arthropathy; all three of these patients had revision surgery during the same hospital admission. One of the two dislocations was not identified by the radiologist's dictated report. Six patients in Group 2 had a dislocated rTSA observed on outpatient radiographs after an acute episode of increased pain or deformity after hospital discharge. These dislocations were identified on orthopaedic review and via the official radiology report. The official

Fig. 2A–C These (A) internal rotation AP, (B) external rotation AP, and (C) axillary views are examples of adequately penetrated radiographs that would be considered suitable to serve as baseline radiographs.

radiology report additionally noted one case of “possible fracture” and two of “possible glenohumeral subluxation” that were not confirmed on orthopaedic review (SN, JEH) or on followup radiographs.

The charges associated with radiographic evaluation were \$64,524 for patients in Group 1 (\$228 per patient). This figure represents the charges for the film, developing, and radiographic interpretation as billed to the patient or insurance company. It does not include the charges associated with transport services, the x-ray technologist’s time, equipment maintenance, and repeat exposures, and so it is likely an underestimation of the total healthcare charges. If radiographic interpretation by the radiologist (\$45 per patient) were eliminated, the charges for radiographic

evaluation in this study would have been \$51,789. Assuming approximately 250 shoulder arthroplasties are performed per year, the elimination of immediate postoperative radiographs would result in a decrease of \$57,000 per year that is billed to the patient or insurance company, and the elimination of radiographic interpretation alone would result in cost savings of \$11,250 per year.

Discussion

In many centers, including ours, a portable radiograph series is obtained in the PACU after shoulder arthroplasty, and another series is obtained at the first or second office

visit. We have questioned the utility of this practice and the practice of obtaining routine radiologic consultation for postoperative shoulder arthroplasty radiographs. It is our belief that many immediate postoperative radiographs are of poor quality, but are obtained to help avoid poor patient outcomes. As there has been no data to indicate a necessity for obtaining immediate postoperative radiographs, this practice may be, in part, an example of defensive medicine used to avoid potential litigation. We therefore asked whether (1) PACU radiographs can reasonably serve as a baseline for future studies; and (2) routine PACU radiographs change clinical care. (3) We also determined the charges associated with routine PACU radiographs and formal radiographic interpretation of these images.

This is a retrospective study and, therefore, has several limitations. First, we were unable to determine the quality and potential benefit of obtaining predischARGE radiographs instead of immediate postoperative radiographs. Second, there were multiple surgeons with preferences for the timing of radiographs after the shoulder arthroplasties that differed during the course of the study period. The groups were different in terms of the number of rTSAs performed, with fewer performed in the group that did not have immediate postoperative radiographs; this skewed the characteristics of Groups 1 and 2 in terms of rTSA and TSA but is likely explained by the known dislocation risk with rTSA [2] and the predilection for surgeons to obtain immediate postoperative radiographs in these cases. Risk of liability is a major surgeon concern if a dislocated rTSA is missed before discharge from the hospital. Despite this, we did not have any case of a dislocated rTSA that was identified on an immediate postoperative radiograph; instead, these were identified on radiographs obtained after a patient noted the new onset of increased pain and/or deformity in the days to weeks after surgery. Finally, five experienced, fellowship-trained shoulder surgeons performed the arthroplasties, and it is unclear whether immediate postoperative radiographs might have been more beneficial for patients undergoing arthroplasties by less experienced surgeons, where there may be greater concern for immediate postoperative complications.

Our review of study quality showed that the radiographs obtained immediately after surgery were not adequate to serve as baselines for future studies. We believe that the ability to obtain high-quality radiographs is limited by postoperative pain, sling position, or the radiology technician's reluctance to manipulate the shoulder, dressings, and patient positioning in the bed. Our findings are consistent with those from the THA and TKA literature; multiple authors [4, 8–10, 12, 15] have reported that postoperative radiographs, taken immediately after TKA or THA, result in poor-quality images that do not serve as adequate baselines for further imaging. We agree that early radiographs are necessary to establish baselines; however, we observed poor-quality radiographs immediately after

shoulder arthroplasty. Studies that show the humeral position relative to the glenoid, glenoid component loosening with time, or the center of rotation of rTSAs generally require high-quality, standardized AP and axillary radiographs at baseline and followup [1, 5–7, 11, 13, 14]. Because the information gleaned from single-view, underpenetrated, internal rotation shoulder radiographs is limited, we recommend using radiographs obtained at the first or second postoperative visit to serve as baselines. Our findings may not be applicable to institutions that have different protocols and are able to obtain adequate radiographs immediately after surgery. To obtain adequate radiographs immediately postoperatively, a physician or a physician-extender may be necessary to help the radiology technician position and hold the patient's limb to safely obtain higher-quality images. Unfortunately, this may result in substantial pain and discomfort for the patient.

We did not find that immediate postoperative radiographs changed treatment or outcome after shoulder arthroplasty. Similar to our study, none of the cases in the TKA series were adversely affected by delaying the initial postoperative radiographs, although some patients did experience complications after surgery [4, 8, 12, 15]. Studies in the THA literature similarly mirror our findings [9, 10, 15]. Mulhall et al. found a 0.1% rate of radiologic diagnosis of dislocation among 2065 consecutive patients who had hip arthroplasties and noted that image quality of PACU radiographs was substantially inferior to that of radiographs taken in the radiology suite [9]. They reported that routine PACU radiographs are not an effective screening procedure, needing 1000 to diagnose one dislocation. They found clinical examination to be equally effective at diagnosing dislocation and recommended that PACU radiographs be obtained only when clinically indicated [9]. Similarly, we recommend acquiring radiographs, regardless of timing, if patients report increased pain or deformity after surgery. In our series, this type of complaint by a patient was especially concerning for dislocation of a rTSA prosthesis after surgery. Postoperative dislocations were diagnosed using radiographs that were obtained after initiation of symptoms, and the dislocations would not have been prevented or diagnosed earlier if immediate postoperative radiographs had been obtained.

It is clear that radiographic charges represent a small percentage of total hospital charges after shoulder arthroplasty. Despite this, with the increasing numbers of shoulder arthroplasties performed each year and the anticipated increases in the future [3], these charges can become substantial. Studies of TKAs and THAs [4, 8, 12, 15] have examined the charges associated with immediate postoperative radiographs and the need for radiographic consultations, and have estimated substantial cost containment with elimination of these practices. It appears that reducing charges by eliminating the routine practice of obtaining immediate

postoperative radiographs after shoulder arthroplasty can be obtained without compromising patient care. Similarly, there did not appear to be a need for radiographic interpretation of shoulder arthroplasty radiographs by an attending radiologist as the reports did not change treatment. This practice also adds to charges and does not appear necessary for radiographs that are obtained the day of surgery or for those obtained days or weeks after surgery.

Postoperative radiographs, taken after shoulder arthroplasty, can be delayed beyond the immediate postoperative period without compromising patient care. As no clear benefit to obtaining PACU radiographs has been shown, experienced shoulder surgeons who do not obtain these images are not placing their patient's at higher risk for a missed complication. Postoperative radiographs that are obtained in the PACU may be underpenetrated, internal rotation views that do not adequately serve as baseline radiographs. Radiographs obtained beyond the immediate postoperative period generally are of adequate penetration and orientation, multiview, and sufficient to serve as baseline radiographs. Selective use of inpatient or outpatient radiographs is essential if a patient reports increased pain, deformity, or change in function after surgery. Unless institutional protocols are in place for high-quality images to be obtained in the PACU, this practice may not be cost effective. Along with decreasing postoperative pain, the elimination of immediate postoperative radiographs can yield substantial savings. Furthermore, radiographic consultation adds additional cost and does not provide substantial benefit over orthopaedic review of radiographs.

References

1. Barwood S, Setter KJ, Blaine TA, Bigliani LU. The incidence of early radiolucencies about a pegged glenoid component using cement pressurization. *J Shoulder Elbow Surg.* 2008;17:703–708.
2. Cheung E, Willis M, Walker M, Clark R, Frankle MA. Complications in reverse total shoulder arthroplasty. *J Am Acad Orthop Surg.* 2011;19:439–449.
3. Day JS, Lau E, Ong KL, Williams GR, Ramsey ML, Kurtz SM. Prevalence and projections of total shoulder and elbow arthroplasty in the United States to 2015. *J Shoulder Elbow Surg.* 2010;19:1115–1120.
4. Glaser D, Lotke P. Cost-effectiveness of immediate postoperative radiographs after uncomplicated total knee arthroplasty: a retrospective and prospective study of 750 patients. *J Arthroplasty.* 2000;15:475–478.
5. Lazarus MD, Jensen KL, Southworth C, Matsen FA 3rd. The radiographic evaluation of keeled and pegged glenoid component insertion. *J Bone Joint Surg Am.* 2002;84:1174–1182.
6. Mercer D, Saltzman MD, Neredilek MB, Gilmer BB, Warne WJ, Matsen FA 3rd. A reproducible and practical method for documenting the position of the humeral head center relative to the scapula on standardized plain radiographs. *J Shoulder Elbow Surg.* 2011;20:363–371.
7. Mercer DM, Gilmer BB, Saltzman MD, Bertelsen A, Warne WJ, Matsen FA 3rd. A quantitative method for determining medial migration of the humeral head after shoulder arthroplasty: preliminary results in assessing glenoid wear at a minimum of two years after hemiarthroplasty with concentric glenoid reaming. *J Shoulder Elbow Surg.* 2011;20:301–307.
8. Moskal JT, Diduch DR. Postoperative radiographs after total knee arthroplasty: a cost-containment strategy. *Am J Knee Surg.* 1998;11:89–93.
9. Mulholland KJ, Masterson E, Burke TE. Routine recovery room radiographs after total hip arthroplasty: ineffective for screening and unsuitable as baseline for longitudinal follow-up evaluation. *J Arthroplasty.* 2004;19:313–317.
10. Ndu A, Jegede K, Bohl DD, Keggi K, Grauer JN. Recovery room radiographs after total hip arthroplasty: tradition vs utility? *J Arthroplasty.* 2012;27:1051–1056.
11. Nho SJ, Frank RM, Verma NN, Romeo AA. Incidence of early development of radiolucent lines in keeled polyethylene glenoid components after total shoulder arthroplasty. *Am J Orthop (Belle Mead NJ).* 2010;39:333–337.
12. Niskanen RO. Early repetitive radiography is unnecessary after an uncomplicated cemented hip or knee arthroplasty for osteoarthritis. *Acta Orthop Belg.* 2005;71:692–695.
13. Saltzman MD, Mercer DM, Warne WJ, Bertelsen AL, Matsen FA 3rd. A method for documenting the change in center of rotation with reverse total shoulder arthroplasty and its application to a consecutive series of 68 shoulders having reconstruction with one of two different reverse prostheses. *J Shoulder Elbow Surg.* 2010;19:1028–1033.
14. Szabo I, Buscayret F, Edwards TB, Nemoz C, Boileau P, Walch G. Radiographic comparison of flat-back and convex-back glenoid components in total shoulder arthroplasty. *J Shoulder Elbow Surg.* 2005;14:636–642.
15. Ververeli PA, Masonis JL, Booth RE, Hozack WJ, Rothman RH. Radiographic cost reduction strategy in total joint arthroplasty: a prospective analysis. *J Arthroplasty.* 1996;11:277–280.