CME SAM

Current Concepts of Shoulder Arthroplasty for Radiologists

AJR FOCUS ON:

Current Concepts of Shoulder Arthroplasty for Radiologists: Part 2—Anatomic and Reverse Total Shoulder Replacement and Nonprosthetic Resurfacing

Alice S. Ha[1]
Jonelle M. Petscavage[2]
Felix S. Chew[1]

OBJECTIVE. The purpose of this article is to provide a review of the indications for shoulder arthroplasty, describe preoperative imaging assessment, present new and modified designs of shoulder arthroplasty, illustrate normal and abnormal postoperative imaging findings, and review key radiographic measurements.

CONCLUSION. Knowledge of the physiologic purpose, orthopedic trends, imaging findings, and complications is important in assessing shoulder prostheses.

Reverse total shoulder arthroplasty, anatomic total shoulder arthroplasty, humeral head resurfacing, and hemiarthroplasty are increasingly more common in the orthopedic surgery practice. Successful radiologic evaluation of these different types of shoulder reconstructions requires an understanding of their fundamental hardware design, physiologic objective, normal postoperative imaging appearance, and the appearance of complications. Part 1 of this current concepts review detailed the epidemiology and history of shoulder arthroplasty, preoperative imaging assessment, humeral head resurfacing, and hemiarthroplasty. Part 2 will review anatomic total shoulder arthroplasty, reverse total shoulder arthroplasty, and nonprosthetic glenoid resurfacing in young patients.

Anatomic Total Shoulder Arthroplasty

Indications

Anatomic total shoulder arthroplasty is most commonly performed for degenerative osteoarthritis in patients older than 60 years [1]. Other indications for total shoulder arthroplasty include inflammatory arthritis, humeral head avascular necrosis with secondary glenohumeral arthritis, Charcot arthropathy, and postinfectious arthritis [1, 2]. Total shoulder arthroplasty requires an intact rotator cuff.

Design

The humeral component is a minimally constrained anatomic implant consisting of a spherical metal articular surface and cemented or press-fit metal stem. This articulates with a radiolucent polyethylene glenoid component [2] (Fig. 1). The central peg contains a radiopaque marker.

The first generation of total shoulder arthroplasty was monoblock and limited. The second generation (introduced by Neer) had a modular humeral head and ingrowth coating on the stem. The third generation of total shoulder arthroplasty design allowed anatomic adjustment of the humeral head offset [3].

Early polyethylene glenoid components had a bladelike projection into the native glenoid. These "keeled" glenoid components became less popular with the invention of "pegged" glenoid components (Fig. 1) for proposed benefits of more uniform distribution of stress to the bone and minimal removal of glenoid bone, facilitating future revision surgeries [4]. However, in patients with glenoid bone loss and inadequate space for a pegged component, a keeled component is required [3].

Complications of Total Shoulder Arthroplasty

The most common complication of anatomic total shoulder arthroplasty is loosening of the glenoid component, occurring in up to 39% of patients [5] (Figs. 2 and 3). Radiolucency at the bone-cement interface of the glenoid component is present in 30–96% of cases. Pegged radiolucency is described by the Lazarus et al. [6] classification (Fig. 4A) and keeled radiolucency by Franklin et al. [7] (Fig. 4B). A recent trend is use of a minimally cemented glenoid component with radial fins on the central peg that are packed with bone graft for biologic incorporation [8, 9]. Lower radiolucency scores

Keywords: glenoid resurfacing, humeral head resurfacing, reverse arthroplasty, shoulder arthroplasty

DOI:10.2214/AJR.12.8855

Received March 5, 2012; accepted after revision May 4, 2012.

A. S. Ha has received a grant from GE Healthcare. J. M. Petscavage is a consultant for Medical Metrics, Inc.

[1]Department of Radiology, University of Washington Medical Center, Seattle, WA.

[2]Department of Radiology, Penn State Hershey Medical Center, 500 University Dr, Hershey, PA 17033. Address correspondence to J. M. Petscavage (jpetscavage@hmc.psu.edu).

CME/SAM
This article is available for CME/SAM credit.

AJR 2012; 199:768–776

0361–803X/12/1994–768

© American Roentgen Ray Society

Downloaded from www.ajronline.org by Dartmouth College Library on 06/03/13 from IP address 130.189.10.64. Copyright ARRS. For personal use only; all rights reserved

Downloaded from www.ajronline.org by Dartmouth College Library on 06/03/13 from IP address 130.189.10.64. Copyright ARRS. For personal use only; all rights reserved

have been found. Radiography and CT have shown sclerosis around the central peg as an indication of healing and bone graft incorporation. Complications of the humeral component of a total shoulder arthroplasty have already been detailed in part 1.

Reverse Total Shoulder Arthroplasty

Indications

With full-thickness rotator cuff tears, there is resultant superior humeral head migration, unopposed deltoid contraction, and loss of the glenohumeral fulcrum, leading to inability to raise the arm above the horizontal. This is called “pseudoparalysis” [10]. With a deficient coracoacromial arch (from trauma, arthritis, or surgical acromioplasty), there is “anterosuperior escape” of the humeral head, further complicating the biomechanical problem in a pseudoparalytic patient. Reverse total shoulder arthroplasty is indicated for rotator cuff arthropathy, rotator cuff deficient shoulders with pseudoparalysis, tumor resection reconstruction, prior failed total shoulder arthroplasty with subsequent rotator cuff failure, and acute three- or four-part proximal humerus fracture [5, 11]. Reverse total shoulder arthroplasty requires an intact deltoid muscle.

Design

In 1987, Grammont et al. [12] first designed the reverse total shoulder arthroplasty (Delta Prosthesis, DePuy) that moves the center of rotation more distally and medially [12]. There is resultant lengthening and better contraction of the deltoid muscle for control over humeral motion. Moving the center of rotation more medially was a key step in decreasing pressure on the glenoid and decreasing subsequent loosening rates [13]. Active arm elevation can be restored with reverse total shoulder arthroplasty. However, because of the inherent design of reverse total shoulder arthroplasty, active external and internal rotations are limited [4].

The humeral component consists of a proximal cup-shaped portion and metal stem. A radiolucent polyethylene insert sits in this cup portion and articulates with the glenosphere (Fig. 5). The glenosphere is the rounded metal ball of the prosthesis that attaches to a baseplate (metaglene) secured to the native glenoid by bicortical screws, which may be straight or angled [14].

Imaging

On radiographs, the metaglene should be flush with the glenoid. If feasible, the inferior screw should be completely intraosseous. The anterior, superior, and posterior screws are usually bicortical. The glenosphere should align within the humeral cup, although this space varies on the basis of the polyethylene insert thickness.

Anterior dislocation is the most common early postoperative clinically significant complication, occurring in up to 20% of patients [14] (Fig. 6). The humeral component dislocates in the anterior-superior direction due to pull of the deltoid muscle, a difference from a native shoulder dislocation wherein the humerus lies inferior to the coracoid process [14]. In the immediate postoperative period, hematomas may be seen in up to 21% of patients.

A recent literature search of 261 reverse total shoulder arthroplasties found the most common complications, in descending order of frequency, to be scapular notching; postoperative hematoma; glenosphere dissociation, such as baseplate failure (Fig. 7) or aseptic loosening with or without intraarticular metaglene migration (Fig. 8); glenohumeral dislocation; acromial or scapular fracture (Fig. 9); infection; loosening or dissociation of the humeral component; and nerve injury [5]. Scapular notching occurs because of repetitive contact of the medial aspect of the humeral cup with the inferior border of the scapula [15] (Fig. 10). Scapular notching has been reported in 50–96% of reverse total shoulder arthroplasties [11]. The notching tends to stabilize 1 year after surgery. The presence of scapular notching can be graded according to the classification of Sirveaux et al. [15] as grade 1 if the defect involves only the pillar, grade 2 if the defect contacts the inferior baseplate screw, grade 3 if the notch extends over the inferior screw, and grade 4 if the notch extends under the baseplate [15].

Fractures of the scapular spine and acromion are unique to the reverse total shoulder arthroplasty design, with a reported incidence of 5–6.9% [16]. Type 1 fractures, those of the anterior acromion near or including the footprint of the coracoacromial ligament, tend to occur intraoperatively and often heal without surgical fixation. Fractures of the anterior acromion just posterior to the acromioclavicular joint (type 2) are postulated to occur in patients with preexisting stiff arthritic acromioclavicular joints that receive increased stress over time as the patient regains glenohumeral motion after reverse total shoulder arthroplasty. On radiographs, type 2 fractures may appear initially as subtle periosteal reaction and increased sclerosis, signifying a stress fracture. However, radiographs may be negative and CT or bone scans can be used to detect acromial stress fractures in patients with pain in this location. Without operative treatment, these fractures may become displaced.

Fractures of the posterior acromion or scapular spine (type 3) are postulated to occur because of the superior metaglene screw acting as a stress riser (Fig. 11). An additional type of fracture, the acromial base fracture, appears different from the acromial spine fracture and has worse functional outcomes [17]. This site is the bony support for the entire deltoid, and thus the fracture alters the range of motion of the reverse total shoulder arthroplasty [4]. On imaging, this fracture causes the acromial process to displace inferiorly and typically can be detected on radiographs.

Rates of infection after reverse total shoulder arthroplasty range from 1% to 10%, which is higher than for hemiarthroplasty and anatomic total shoulder arthroplasty [18–20]. Possible reasons include a longer surgical procedure, history of prior surgeries in the shoulder for severe rotator cuff repairs, and a steeper learning curve to perform the procedure. Imaging findings of infection are similar to those of total arthroplasty and hemiarthroplasty. A recent multicenter study of 501 patients showed a statistically significantly lower rate of infection in patients who had antibiotic-impregnated cemented reverse total shoulder arthroplasty compared with those without the antibiotic cement [21].

Nonprosthetic Glenoid Resurfacing for Young Patients

In many studies, total shoulder arthroplasties have shown superior improvement in joint function and pain reduction compared with humeral hemiarthroplasty alone for patients with severe glenohumeral arthritis [22, 23]. However, total shoulder arthroplasty has high rates of prosthetic glenoid component loosening (39% in a meta-analysis of 2540 studies) [5]. For young and active patients, management of glenohumeral arthritis is more challenging because of higher patient expectation, need for more durable reconstruction, and presence of more complex primary disease than ordinary age-related osteoarthritis. Nonprosthetic methods to resurface the glenoid have been explored by orthopedic surgeons. Interpositional allografts using biologic materials have been developed to minimize glenoid erosion and prevent humeral subluxation. So far, autogenous fascia

Downloaded from www.ajronline.org by Dartmouth College Library on 06/03/13 from IP address 130.189.10.64. Copyright ARRS. For personal use only; all rights reserved

lata, Achilles allograft, and lateral meniscus allograft have been used as resurfacing materials for the glenoid, with relatively positive short-term outcomes [24–26]. However, long-term outcomes of these implants remain to be seen.

The most commonly used nonprosthetic glenoid resurfacing method is called the "ream and run" glenoid arthroplasty. Often in glenohumeral arthritis, the glenoid shows posterior wear or "biconcave" shape (Fig. 12). The glenoid bone is contoured to a concavity 2 mm larger in diameter than the humeral component [27]. This method was first developed after it was noted that patients functioned well after removal of the glenoid component after total shoulder arthroplasty and replacement of only the humeral component. The glenoid labrum and remaining soft tissues are preserved, and the resurfaced glenoid allows a more even distribution of humeral weight onto the glenoid, similar to a normal joint (Fig. 12). In a canine model, by 6 months a recontoured glenoid heals with smooth overlying fibrocartilaginous tissue securely attached to the underlying bone [28].

Requirements for the ream and run include no evidence of infection, functioning rotator cuff and deltoid, sufficient glenoid bone stock to create a stabilizing concavity, and robust bone quality without osteopenia to withstand the reaming. The procedure is not offered to patients with inflammatory arthropathy, with smoking history, or taking medications that interfere with bone healing. In a series of 189 patients with ream and run surgery, there was a 3% revision rate to total shoulder arthroplasty and a 5% complication rate, including infection, lysis, and subscapularis failure [27]. Patient selection seems to play an important role in ream and run surgery because a longer and more painful recovery is required.

Conclusion

Knowledge of indications, component construction, normal postoperative imaging assessment and measurements, and findings of complications is important for providing a meaningful radiologic evaluation of shoulder arthroplasty.

References

1. Wiater JM, Fabing MH. Shoulder arthroplasty: prosthetic options and indications. *J Am Acad Orthop Surg* 2009; 17:415–425
2. Merolla G, Di Pietto F, Romano S, et al. Radiographic analysis of shoulder anatomical arthroplasty. *Eur J Radiol* 2008; 68:159–169
3. Sanchez-Sotelo J. Total shoulder arthroplasty. *Open Orthop J* 2011; 5:106–114
4. Boileau P, Sinnerton RJ, Chuinard C, Walch G. Arthroplasty of the shoulder. *J Bone Joint Surg Br* 2006; 88:562–575
5. Bohsali KI, Wirth MA, Rockwood CA Jr. Complications of total shoulder arthroplasty. *J Bone Joint Surg Am* 2006; 88:2279–2292
6. 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
7. Franklin JL, Barrett WP, Jackins SE, Matsen FA 3rd. Glenoid loosening in total shoulder arthroplasty: association with rotator cuff deficiency. *J Arthroplasty* 1988; 3:39–46
8. Arnold RM, High RR, Grosshans KT, Walker CW, Fehringer EV. Bone presence between the central peg's radial fins of a partially cemented pegged all poly glenoid component suggest few radiolucencies. *J Shoulder Elbow Surg* 2011; 20:315–321
9. Churchill RS, Zellmer C, Zimmers HJ, Ruggero R. Clinical and radiographic analysis of a partially cemented glenoid implant: five-year minimum follow-up. *J Shoulder Elbow Surg* 2010; 19:1091–1097
10. Matsen FA 3rd, Boileau P, Walch G, Gerber C, Bicknell RT. The reverse total shoulder arthroplasty. *J Bone Joint Surg Am* 2007; 89:660–667
11. Alfonso J, Nicholson GM, Frankle MA, et al. Complications of the reverse prosthesis: prevention and treatment. *Instr Course Lect* 2012; 61:157–168
12. Grammont P, Trouilloud P, Laffay JP, Deries X. Concept study and realization of a new total shoulder prosthesis [in French]. *Rhumatologie* 1987; 39:407–418
13. Jazayeri R, Kwon YW. Evolution of the reverse total shoulder prosthesis. *Bull NYU Hosp Jt Dis* 2011; 69:50–55
14. Roberts CC, Ekelund AL, Renfree KJ, Liu PT, Chew FS. Radiologic assessment of reverse shoulder arthroplasty. *RadioGraphics* 2007; 27:223–235
15. Sirveaux F, Favard L, Oudet D, Huquet D, Walch G, Mole D. Grammont inverted total shoulder arthroplasty in the treatment of glenohumeral osteoarthritis with massive rupture of the cuff: results of a multicentre study of 80 shoulders. *J Bone Joint Surg Br* 2004; 86:388–395
16. Boileau P, Watkinson DJ, Jatzidakis AM, Balq F. Grammont reverse prosthesis: design, rationale, and biomechanics. *J Shoulder Elbow Surg* 2005; 14[suppl S]:147S–161S
17. Wahlquist TC, Hunt AF, Braman JP. Acromial base fractures after reverse total shoulder arthroplasty: report of five cases. *J Shoulder Elbow Surg* 2011; 20:1178–1183
18. Farshad M, Gerber C. Reverse total shoulder arthroplasty-from the most to the least common complication. *Int Orthop* 2010; 34:1075–1082
19. Favard L, Levigne C, Nerot C, Gerber C, De Wilde L, Mole D. Reverse prostheses in arthropathies with cuff tear: are survivorship and function maintained over time? *Clin Orthop Relat Res* 2011; 469:2469–2475
20. Frankle M, Siegal S, Pupello D, Saleem A, Mighell M, Vasey M. The reverse shoulder prosthesis for glenohumeral arthritis associated with severe rotator cuff deficiency: a minimum two-year follow-up study of sixty patients. *J Bone Joint Surg Am* 2005; 87:1697–1705
21. Nowinski RJ, Gillespie RJ, Shishani Y, et al. Antibiotic-loaded bone cement reduces deep infection rates for primary reverse total shoulder arthroplasty: a retrospective cohort study of 501 shoulders. *J Shoulder Elbow Surg* 2012; 21:324–328
22. Sperling JW, Cofield RH, Rowland CM. Minimum fifteen-year follow-up of Neer hemiarthroplasty and total shoulder arthroplasty in patients aged fifty years or younger. *J Shoulder Elbow Surg* 2004; 13:604–613
23. Bryant D, Litchfield R, Sandow M, et al. A comparison of pain, strength, range of motion, and functional outcomes after hemiarthroplasty and total shoulder arthroplasty in patients with osteoarthritis of the shoulder: a systematic review and meta-analysis. *J Bone Joint Surg Am* 2005; 87:1947–1956
24. Elhassan B, Ozbaydar M, Diller D, Higgins LD, Warner JJ. Soft-tissue resurfacing of the glenoid in the treatment of glenohumeral arthritis in active patients less than fifty years old. *J Bone Joint Surg Am* 2009; 91:419–424
25. Krishnan SG, Nowinski RJ, Harrison D, Burkhead WZ. Humeral hemiarthroplasty with biologic resurfacing of the glenoid for glenohumeral arthritis: two to fifteen year outcomes. *J Bone Joint Surg Am* 2007; 89:727–734
26. Wirth MA. Humeral head arthroplasty and meniscal allograft resurfacing of the glenoid. *J Bone Joint Surg Am* 2009; 91:1109–1119
27. Clinton J, Warme W, Lynch J, Lippitt S, Matsen FA 3rd. Shoulder hemiarthroplasty with nonprosthetic glenoid arthroplasty: the ream and run. *Tech Should Elbow Surg* 2009; 10:43–52
28. Matsen FA 3rd, Clark JM, Titelman RM, et al. Healing of reamed glenoid bone articulating with a metal humeral hemiarthroplasty: a canine model. *J Orthop Res* 2005; 23:18–26

Downloaded from www.ajronline.org by Dartmouth College Library on 06/03/13 from IP address 130.189.10.64. Copyright ARRS. For personal use only; all rights reserved

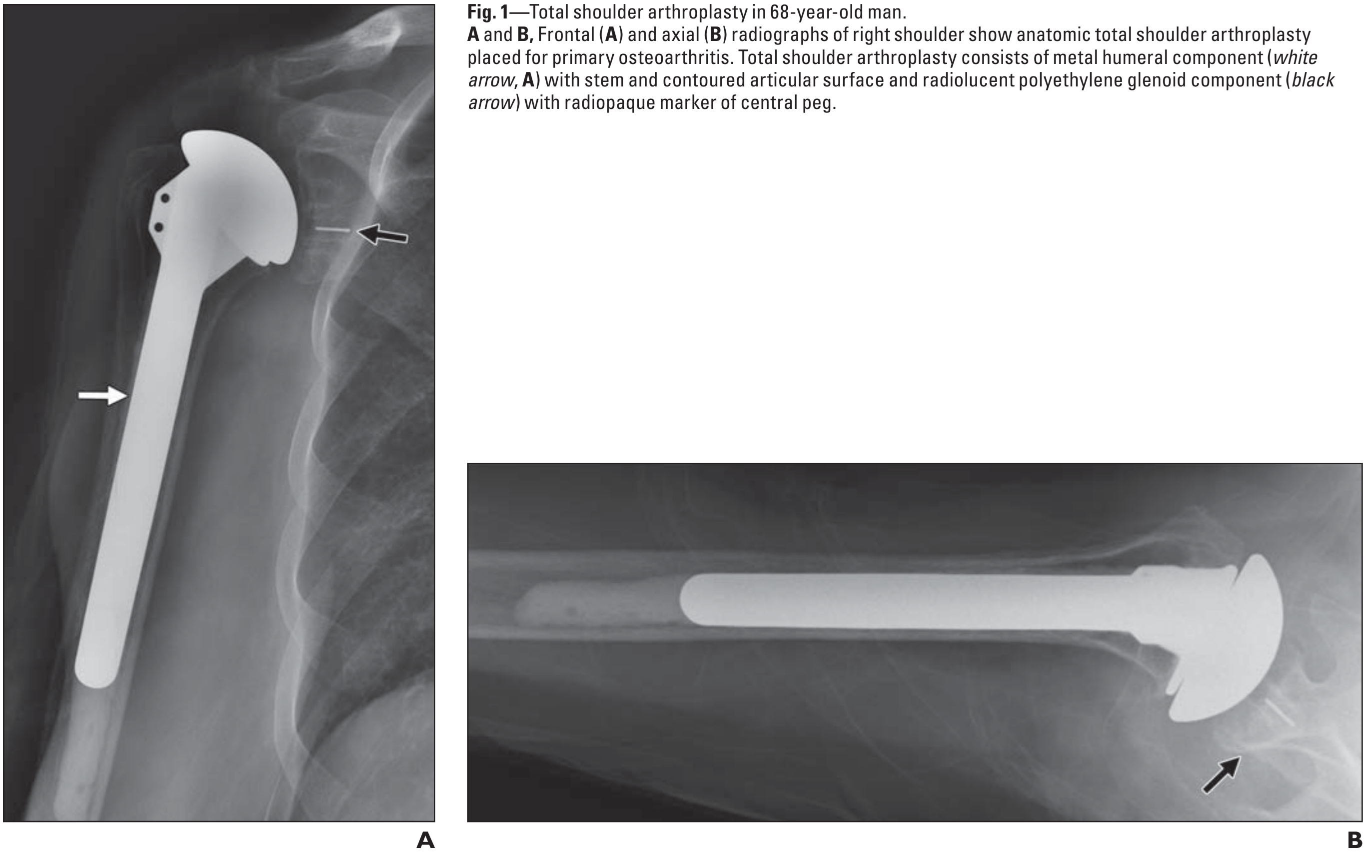


Fig. 1—Total shoulder arthroplasty in 68-year-old man.
A and **B,** Frontal (**A**) and axial (**B**) radiographs of right shoulder show anatomic total shoulder arthroplasty placed for primary osteoarthritis. Total shoulder arthroplasty consists of metal humeral component (*white arrow*, **A**) with stem and contoured articular surface and radiolucent polyethylene glenoid component (*black arrow*) with radiopaque marker of central peg.

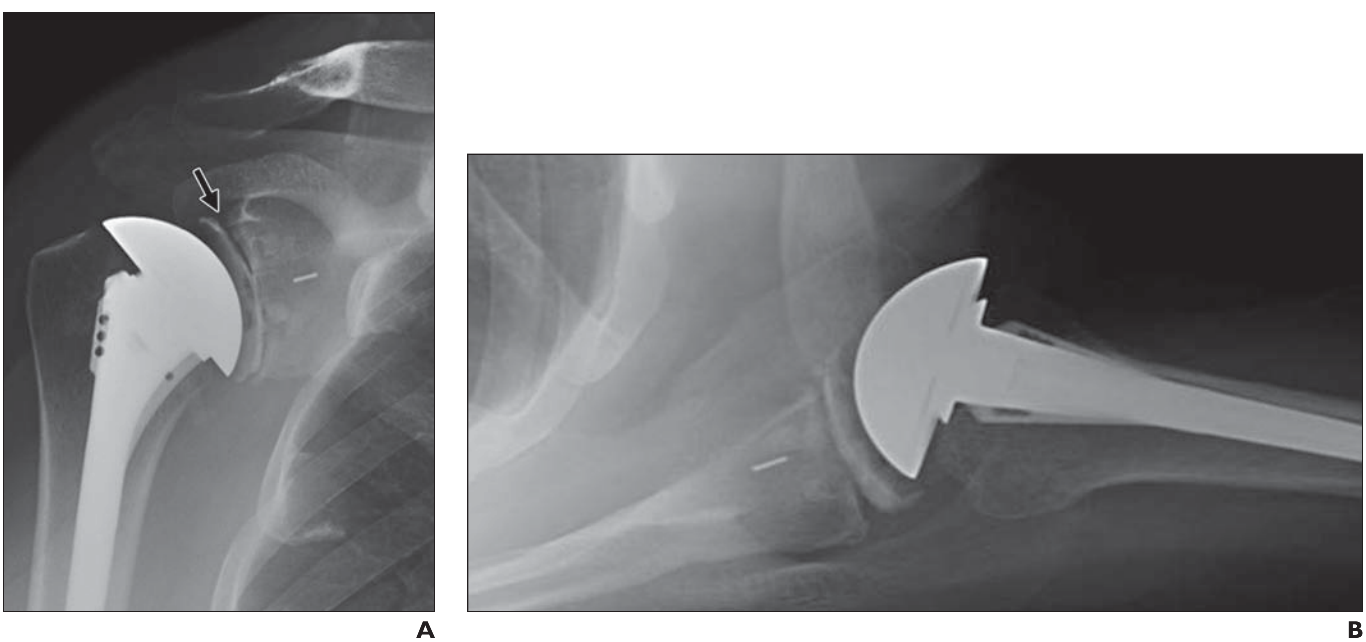
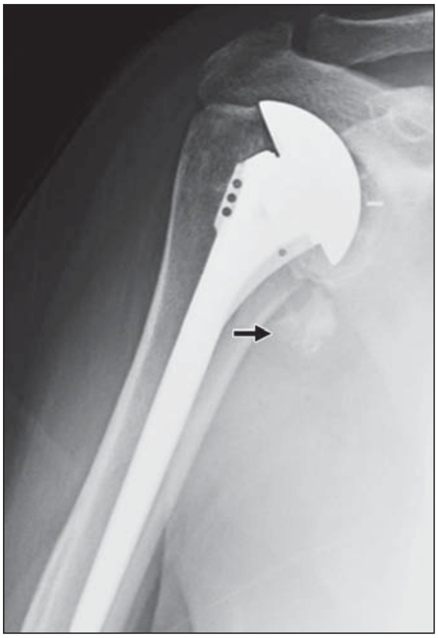
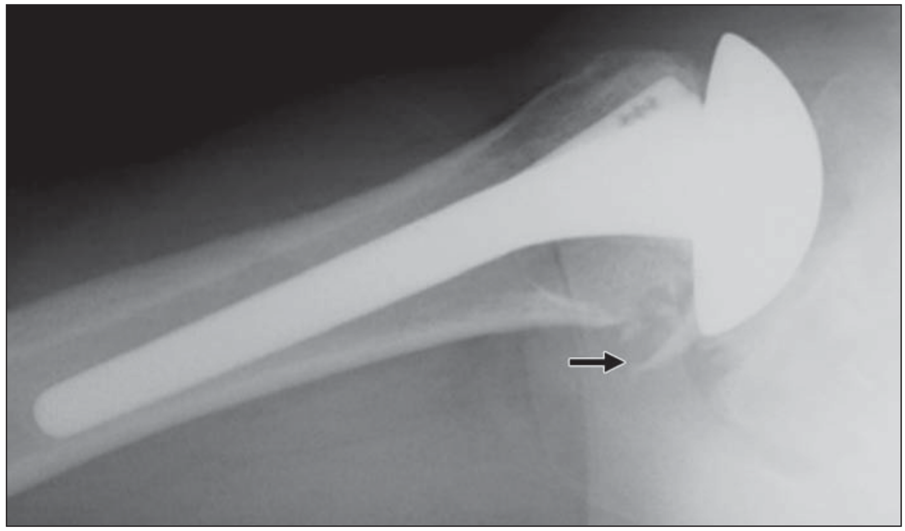


Fig. 2—Glenoid component loosening in 72-year-old woman with anatomic total shoulder arthroplasty.
A and **B,** Grashey (**A**) and axial (**B**) radiographs show frank loosening of glenoid component, with several millimeters of space between bone and polyethylene face (*arrow,* **A**).
(Fig. 2 continues on next page)

Downloaded from www.ajronline.org by Dartmouth College Library on 06/03/13 from IP address 130.189.10.64. Copyright ARRS. For personal use only; all rights reserved



C



D

Fig. 2 (continued)—Glenoid component loosening in 72-year-old woman with anatomic total shoulder arthroplasty.
C and **D,** Anteroposterior (**C**) and axial (**D**) radiograph obtained several months later show fracture of inferior glenoid and inferior and posterior loosening of fracture fragments and glenoid component (*arrow*).

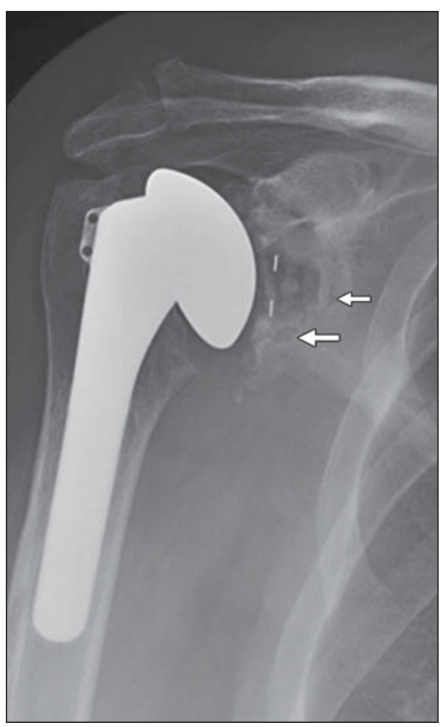
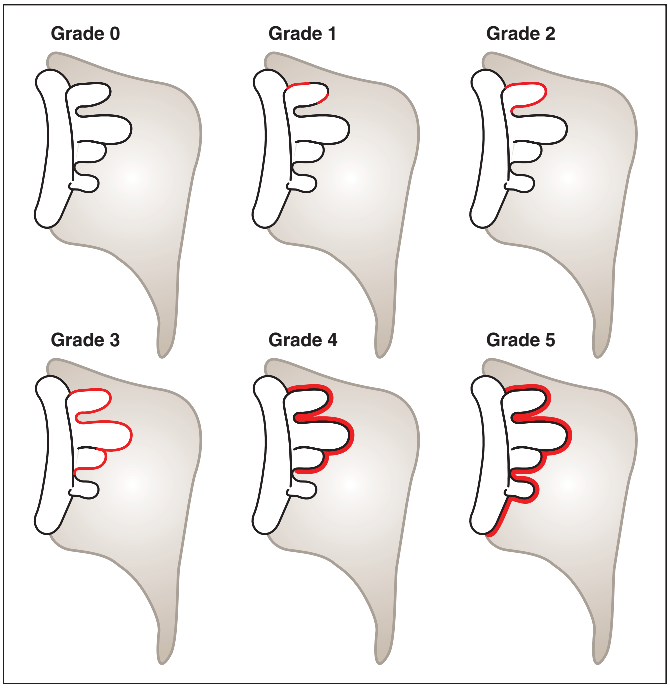
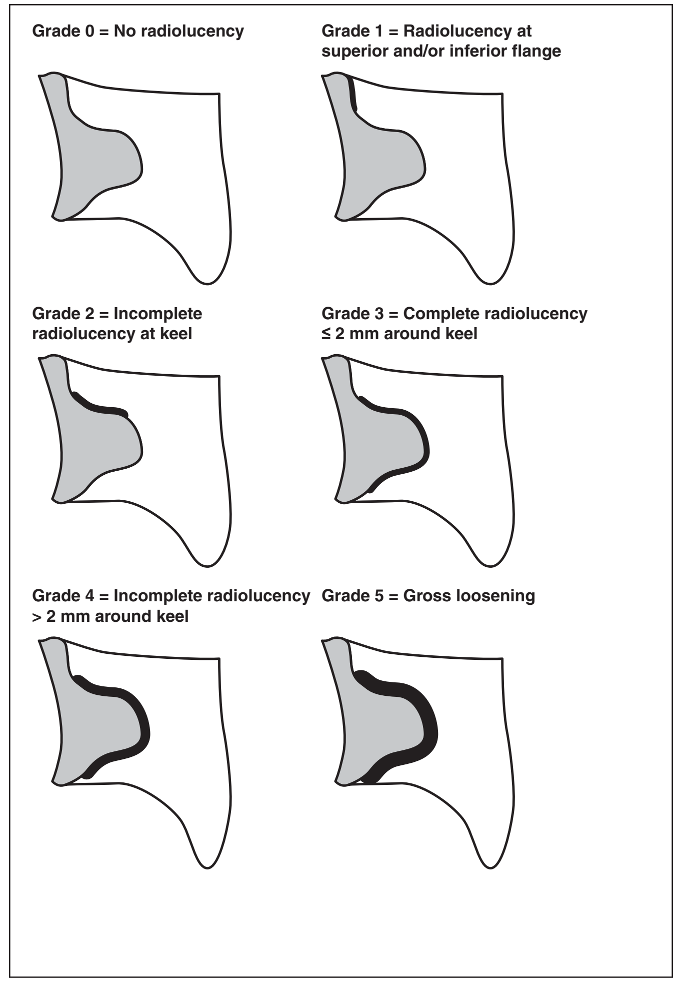


Fig. 3—Glenoid radiolucency due to infection in 64-year-old man with total shoulder arthroplasty. Frontal radiograph shows areas of radiolucency (*arrows*) surrounding keeled glenoid component. This was due to infection in this patient.

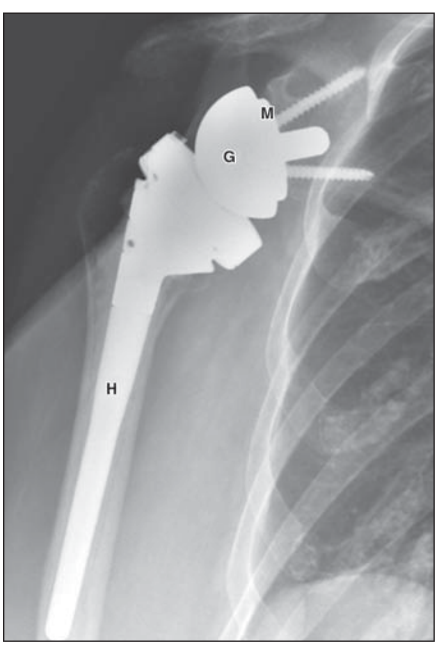
Fig. 4—Classification of loosening of glenoid component.
A, Illustrations show Lazarus classification scheme [6] used to characterize radiolucency surrounding pegged glenoid components. Grade 0 = absent, grade 1 = incomplete radiolucency around one or two pegs, grade 2 = complete radiolucency (< 2 mm wide) around one peg only with or without incomplete radiolucency around one other peg, grade 3 = complete radiolucency (< 2 mm wide) around two or more pegs, grade 4 = complete radiolucency (> 2 mm wide) around two or more pegs, grade 5 = gross loosening.
B, Illustrations show Franklin classification scheme (7) to characterize radiolucency surrounding keeled glenoid components.



A



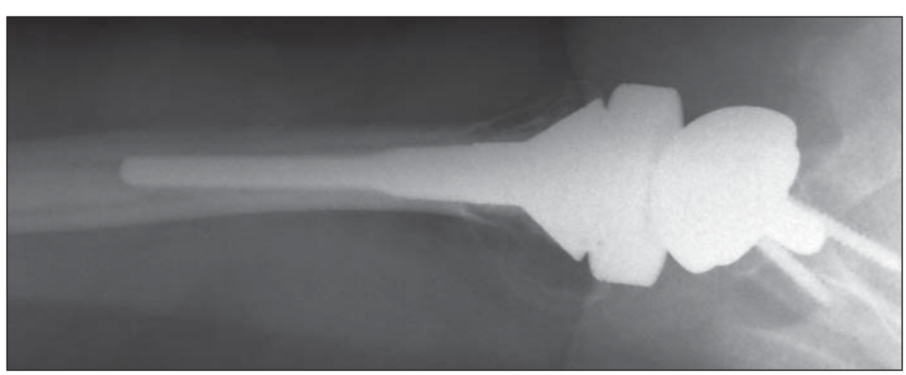
B



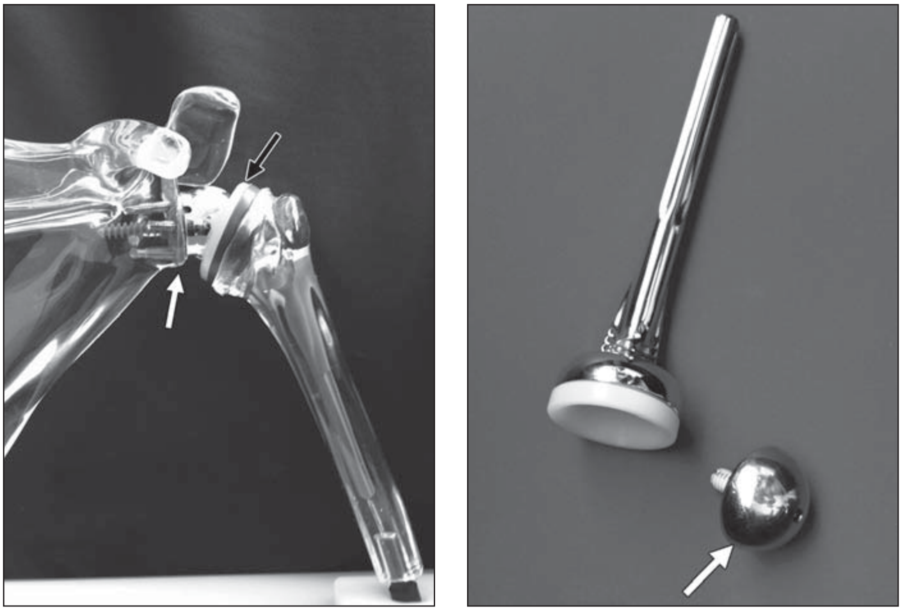
A

Fig. 5—Reverse total shoulder arthroplasty in 76-year-old woman.
A and **B,** Anteroposterior (**A**) and axial (**B**) radiographs of right shoulder show normal reverse total shoulder arthroplasty. Humeral component (H) consists of stem and cup-shaped proximal portion. Glenosphere (G) is round metal component that articulates with humeral cup via radiolucent polyethylene insert. Glenosphere is attached to baseplate that screws into native glenoid. Baseplate-screw complex is termed “metaglene” (M) and should be flush with glenoid with inferior screw intraosseous if possible.

(Fig. 5 continues on next page)


B

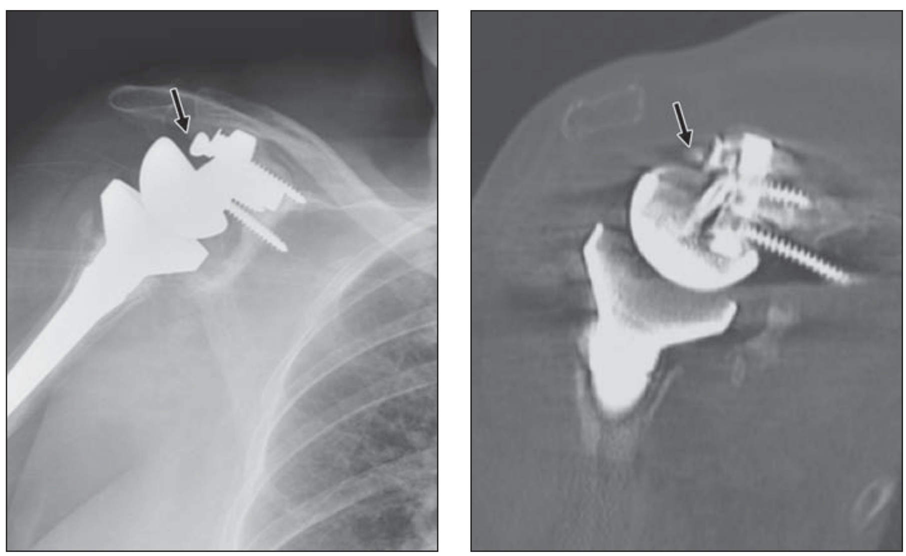
Downloaded from www.ajronline.org by Dartmouth College Library on 06/03/13 from IP address 130.189.10.64. Copyright ARRS. For personal use only; all rights reserved



C D

Fig. 5 (continued)—Reverse total shoulder arthroplasty in 76-year-old woman.
C, Photograph of reverse total shoulder arthroplasty model shows metaglene (*white arrow*) that inserts into glenoid. Polyethylene liner (*black arrow*) is seen between humeral stem and glenosphere ball.
D, Photograph of separated components of reverse total shoulder arthroplasty shows metal humeral stem and white polyethylene liner that articulates with round glenosphere (*arrow*).

Fig. 6—Reverse total shoulder arthroplasty dislocation in 74-year-old woman. Anteroposterior radiograph shows anterior dislocation of humeral component of reverse total shoulder arthroplasty with humerus anterosuperior rather than anteroinferior. This is due to pull of deltoid muscle. This is most common immediate complication, with incidence of 20%.



A B

Fig. 7—Dissociation in 68-year-old man.
A and **B,** Anteroposterior radiograph (**A**) and coronal CT image in bone algorithm (**B**) show dissociation-disengagement between glenosphere ball and metaglene (*arrow*), with glenosphere more horizontally oriented than expected.

Downloaded from www.ajronline.org by Dartmouth College Library on 06/03/13 from IP address 130.189.10.64. Copyright ARRS. For personal use only; all rights reserved

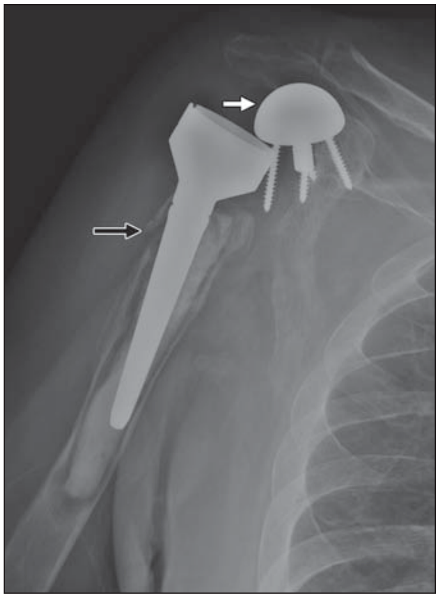


Fig. 8—Intraarticular migration of metaglene in 87-year-old woman. Anteroposterior radiograph shows metaglene-glenosphere construct of reverse total shoulder arthroplasty has loosened from glenoid and migrated superiorly within joint (*white arrow*). Also present is periprosthetic fracture about proximal humerus (*black arrow*) and several areas of osteolysis around humeral stem and cement.

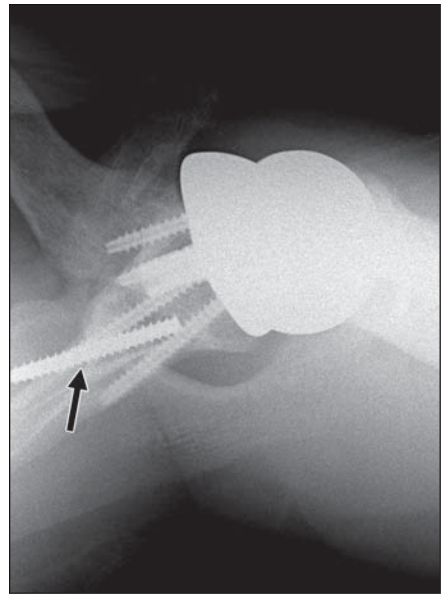
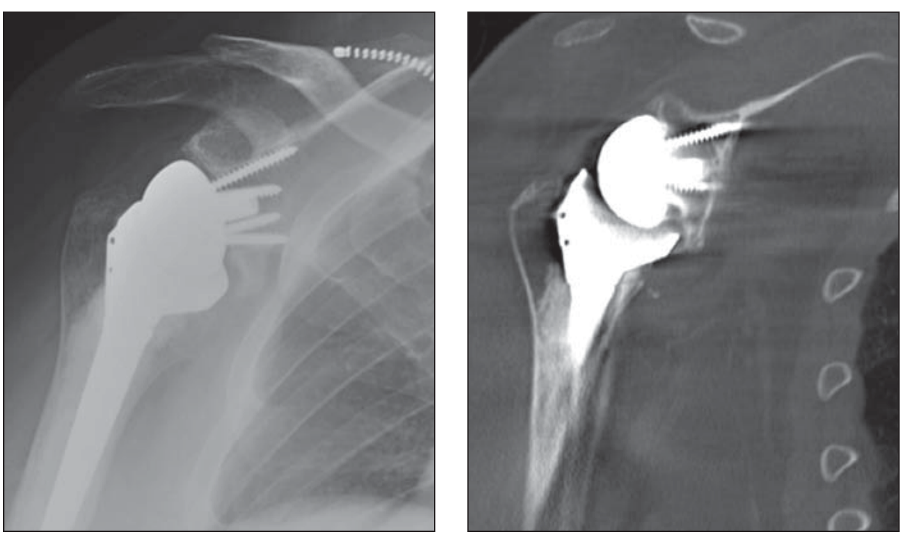


Fig. 9—Fracture of metaglene screws in 66-year-old woman. Axial radiograph shows fracture of one of metaglene screws (*arrow*), which places patient at risk of loosening and backing out of metaglene-glenosphere complex.



A B

Fig. 10—Reverse total shoulder arthroplasty scapular notching in 68-year-old man with reverse total shoulder arthroplasty.
A, Frontal radiograph shows scapular notching inferior to metaglene.
B, On coronal reformatted CT image, medial portion of humeral cup is engaging scapular notching, explaining how it was originally formed.

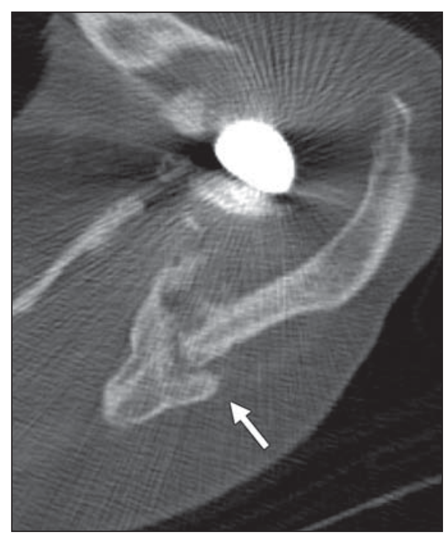


Fig. 11—Reverse total shoulder arthroplasty scapula stress fracture in 79-year-old man with reverse total shoulder arthroplasty that had been placed 22 months prior. Axial CT image of left scapula shows fracture of scapular spine (*arrow*) with areas of sclerosis indicating more chronic finding. With reverse arthroplasty, deltoid becomes more important in controlling humeral motion, increasing stress on scapular spine.

Downloaded from www.ajronline.org by Dartmouth College Library on 06/03/13 from IP address 130.189.10.64. Copyright ARRS. For personal use only; all rights reserved

Downloaded from www.ajronline.org by Dartmouth College Library on 06/03/13 from IP address 130.189.10.64. Copyright ARRS. For personal use only; all rights reserved

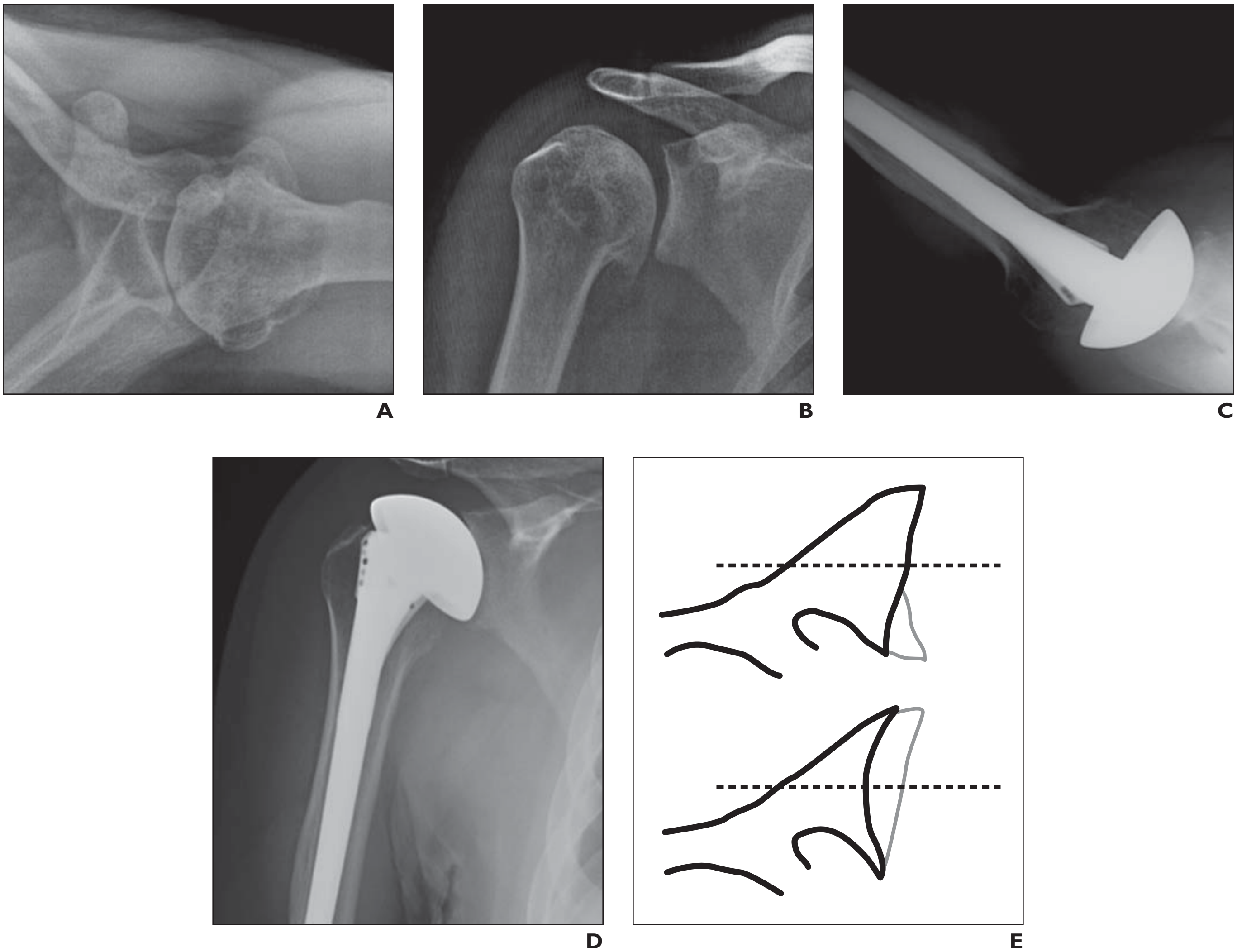


Fig. 12—Ream and run glenoid arthroplasty in 38-year-old man with severe glenohumeral osteoarthritis.
A and **B,** Axial (**A**) and Grashey (**B**) radiographs show biconcave shape of glenoid with posterior subluxation of humeral head, best seen on axial view.
C and **D,** Axial (**C**) and Grashey (**D**) radiographs show humeral hemiarthroplasty and ream and run glenoid resurfacing.
E, Diagram shows glenoid morphology before (*top*) and after (*bottom*) reaming to increase glenoid concavity.

FOR YOUR INFORMATION

This article is part of a self-assessment module (SAM). Please also refer to "Current Concepts of Shoulder Arthroplasty for Radiologists: Part 1—Epidemiology, History, Preoperative Imaging, and Hemiarthroplasty," which can be found on page 757.

Each SAM is composed of two journal articles along with questions, solutions, and references, which can be found online. You can access the two articles at www.ajronline.org, and the questions and solutions that comprise the Self-Assessment Module by logging on to www.arrs.org, clicking on *AJR* (in the blue Publications box), clicking on the article name, and adding the article to the cart and proceeding through the checkout process.

The American Roentgen Ray Society is pleased to present these SAMs as part of its commitment to lifelong learning for radiologists. Continuing medical education (CME) and SAM credits are available in each issue of the *AJR* and are ***free to ARRS members. Not a member?*** Call 1-866-940-2777 (from the U.S. or Canada) or 703-729-3353 to speak to an ARRS membership specialist and begin enjoying the benefits of ARRS membership today!