Shoulder Osteoarthritis: Diagnosis and Management

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Osteoarthritis of the shoulder is a gradual wearing of the articular cartilage that leads to pain and stiffness. As the joint surface degenerates, the subchondral bone remodels, losing its sphericity and congruity. The joint capsule also becomes thickened, leading to further loss of shoulder rotation. This painful condition is a growing problem in the aging population. In most cases, diagnosis of degenerative joint disease of the shoulder can be made with careful history, physical examination, and radiography. The symptoms and degree of shoulder arthritis visible on radiography determine the best treatment option. Mild degenerative joint disease can be treated with physical therapy and over-the-counter anti-inflammatory medications such as acetaminophen or nonsteroidal anti-inflammatory drugs. More advanced cases of osteoarthritis that are refractory to nonoperative management can be managed with corticosteroid injections. In severe cases, surgery is indicated. Surgical options include arthroscopic debridement, arthroscopic capsular release, and, in the most severe instances, hemiarthroplasty or total shoulder arthroplasty. (*Am Fam Physician.* 2008;78(5):605-611, 612. Copyright © 2008 American Academy of Family Physicians.)

▶ **Patient information:** A handout on shoulder osteoarthritis, written by Uma Jayaraman, MD, *AFP* Editing Fellow, is provided on page 612.

Shoulder osteoarthritis, also known as degenerative joint disease of the shoulder, is a gradual, progressive, mechanical, and biochemical breakdown of the articular cartilage and other joint tissues, including bone and joint capsule. As the articular surface wears, friction within the joint increases, causing progressive loss of the normal load-bearing surfaces with pain and disability. There are many risk factors for shoulder osteoarthritis, including age, genetics, sex, weight, joint infection, history of shoulder dislocation, and previous injury. Certain occupations, such as heavy construction or overhead sports, are also risk factors. The prevalence of shoulder osteoarthritis is increasing as the population ages. Primary care physicians will be confronted with this disease at various levels of severity. This review highlights epidemiology, evaluation, current treatment options, and treatment results for osteoarthritis of the shoulder.

Epidemiology

Musculoskeletal disorders have had a significant impact on the world's population. The current decade (2000–2010) has been named the "Bone and Joint Decade."[1] In the United States alone, musculoskeletal conditions account for 131 million patient visits per year, costing society about $215 billion.[1] Arthritis and chronic joint symptoms affect one out of three adults, making it the most widespread disease in America.[2] The prevalence of arthritis for all joints is higher in whites, men older than 45 years, women older than 55 years, overweight and inactive persons, and persons with less than eight years of education.[2] Nearly 60 percent of those affected by osteoarthritis are older than 65 years, and the incidence is increasing.[2]

Osteoarthritis affects many joints throughout the body.[3] Although not as common as other locations, shoulder osteoarthritis is just as debilitating. The loss of shoulder function can lead to depression, anxiety, activity limitations, and job-performance problems.[4] The causes of shoulder osteoarthritis are divided into primary and secondary categories. Primary osteoarthritis has no specific cause, but is more prevalent and not isolated to older persons.[5] Secondary osteoarthritis has a

SORT: KEY RECOMMENDATIONS FOR PRACTICE

Clinical recommendation	*Evidence rating*	*References*
Axillary radiography should be performed because it provides the best images of joint-space narrowing to diagnose degenerative joint disease of the shoulder. This view also helps rule out dislocation. Anteroposterior radiography with the arm actively held at 45 degrees of abduction may reveal joint-space narrowing in patients with otherwise normal neutral anteroposterior radiography.	C	10
The initial approach to early osteoarthritis should begin with activity modification, rest, and ice. Physical therapy, strength training, and aerobic exercise alleviate symptoms in certain cases; in other patients, over-the-counter medications may be sufficient for pain relief.	C	12, 23, 24
Acetaminophen should be the first pharmacologic agent used to manage pain. Therapeutic effects are achieved at dosages of 3 to 4 g per day.	C	13
The most common indications for shoulder arthroplasty are pain from shoulder arthritis with a loss of function that is unresponsive to conservative treatment; end-stage rotator cuff tear arthropathy; osteonecrosis; and a previously failed joint-sparing surgery or total shoulder arthroplasty.	C	16

A = consistent, good-quality patient-oriented evidence; B = inconsistent or limited-quality patient-oriented evidence; C = consensus, disease-oriented evidence, usual practice, expert opinion, or case series. For information about the SORT evidence rating system, go to http://www.aafp.org/afpsort.xml.

Table 1. Classification of Degenerative Arthritis of the Glenohumeral Joint

Type	*Etiology*
Primary	Unknown
Secondary	
Atraumatic osteonecrosis	Alcohol induced
	Corticosteroid therapy
	Cytotoxic drugs
	Gaucher's disease
	Lipid metabolism disorders
	Obesity
	Radiation
	Sickle cell disease
Postinflammatory	Crystal arthropathies
	Postinfection arthritis
	Rheumatoid arthritis
	Rotator cuff arthropathy
Postsurgical	Capsulorrhaphy arthropathy
	Intra-articular hardware (e.g., screws, staples)
	Overtightened anterior joint capsule (prior Putti-Platt repair)
Posttraumatic	Dislocation
	Malunion of the proximal humerus
	Posttraumatic avascular necrosis
	Subluxation

Adapted with permission from Gerber A, Lehtinen JT, Warner JJ. Glenohumeral osteoarthritis in active patients: diagnostic tips and complete management options. Phys Sportsmed. *2003;4(31). http://www.physsportsmed.com/issues/2003/0403/gerber.htm. Accessed April 21, 2008.*

known cause or predisposing factor, such as major shoulder trauma, chronic dislocations, infection, congenital malformations, or chronic rotator cuff tear *(Table 1*[6]*)*.[5]

Evaluation

The diagnosis of shoulder osteoarthritis involves a specific set of symptoms, physical examination findings, and changes to the bone, which are visible on radiography. The typical presenting symptom is progressive, activity-related pain that is deep in the joint and often localized posteriorly. As the disease progresses, night pain becomes more common. For many patients, the pain is present at rest and interferes with sleep. In advanced cases, the stiffness creates significant functional limitations. In younger patients, prior trauma, dislocation, or previous surgery for shoulder instability are factors associated with the development of osteoarthritis.

Patients in the early stages of degenerative joint disease may complain of mild pain and may have unremarkable examinations. Radiography may show only subtle changes to the bone until there is more advanced destruction. The only objective evidence of the disease is articular cartilage wear, which may be shown on magnetic resonance imaging (MRI). In advanced cases, there is a loss of active and passive range of motion, in addition to pain. Physical examination will reveal painful crepitus, joint enlargement, and swelling. In severe cases, audible and palpable grinding may occur when a mechanical stress is placed on the shoulder.

During the examination, it is important to exclude other shoulder pathologies that cause pain besides osteoarthritis *(Table 2)*. Pain that is not induced by joint palpation or passive range of motion suggests bursitis, rotator cuff disease, or biceps tendinitis.[7] Loss of passive

and active range of motion may also occur with calcific tendinitis or idiopathic adhesive capsulitis. Radiography will show calcific tendinitis as radiodense calcium in the rotator cuff. In patients with adhesive capsulitis, shoulder joint radiography is typically normal. Morning stiffness may suggest rheumatoid arthritis. Intense inflammation, swelling, and erythema can be caused by gout, pseudogout, or a septic joint. A blood panel can help identify infection (i.e., white blood cell count greater than 11,000 per mm^3 [11 x 10^9 per L] and white blood cell count in the joint fluid greater than 50,000 per mm^3 [50 x 10^9 per L]). An erythrocyte sedimentation rate greater than 45 mm per hour may indicate rheumatoid arthritis, an underlying malignancy, or chronic infection. These blood tests are sensitive, but not specific in determining causes of shoulder pain.[8]

Imaging studies are essential to diagnosing degenerative joint disease. In most cases, conventional radiography demonstrates shoulder osteoarthritis[9] *(Table 2)*. Early in the disease process, radiographic evidence of degenerative joint disease may include joint-space narrowing (mild), osteophytes (small), subchondral sclerosis, cysts, and eburnation or advanced articular cartilage loss *(Figure 1)*. The axillary view provides the best image to look for joint-space narrowing and helps rule out dislocations. Anteroposterior radiography, with the arm held at 45 degrees of abduction, may also show early joint-space narrowing.[10] Computed tomography arthrograms can localize articular defects, whereas MRI reveals soft-tissue pathologies and subtle changes in articular cartilage. Subchondral edema visible on MRI suggests advanced articular cartilage involvement.[11]

Current Treatment Options

MEDICAL MANAGEMENT

Presently, there are no known interventions that alter the natural history of early osteoarthritis; therefore, the main objectives in treatment are to control pain and restore function. The initial approach to osteoarthritis treatment begins with activity modification, rest, and ice. Physical therapy, strength training, and aerobic exercise help alleviate symptoms.[12] Acetaminophen should be the first pharmacologic agent used to manage pain, with therapeutic effects achieved at dosages of 3 to 4 g per day.[13] Nutritional supplements, such as glucosamine and chondroitin, are pharmacologic alternatives to acetaminophen, although only anecdotal evidence supports their use for shoulder osteoarthritis.

The mainstay of pharmacotherapy for degenerative joint disease has been the nonselective and selective cyclooxygenase-2 (COX-2) inhibitors, or nonsteroidal

Table 2. Diagnosis of Shoulder Pathologies

Finding	*Probable diagnosis*
History	
Joint effusion	Osteoarthritis
	Rheumatoid arthritis
	Septic arthritis
Morning stiffness improved with activity	Rheumatoid arthritis
Night time shoulder pain	Impingement
	Rotator cuff disease (partial or complete cuff tears)
Pain or "clunking" sound with overhead motion	Labral disorder
Pain radiating down arm	Disk disease (cervical)
Stiffness worse with activity, improves with rest	Osteoarthritis
Physical examination	
Cervical range of motion decreased	Disk disease (cervical)
Crepitus	Osteoarthritis
	Rheumatoid arthritis
Decreased range of motion, specifically external rotation and abduction	Osteoarthritis
	Soft tissue injury (frozen shoulder)
Erythema, warmth	Septic arthritis
	Rheumatoid arthritis
Shoulder joint line tenderness	Osteoarthritis
Radiography	
Joint space narrowing (central, posterior, and superior erosion)	Cuff-tear arthropathy
	Osteoarthritis
	Rheumatoid arthritis
Marginal joint erosions	Rheumatoid arthritis
Normal joint	Frozen shoulder
	Septic arthritis
Osteophytes	Osteoarthritis
Subchondral sclerosis	Osteoarthritis

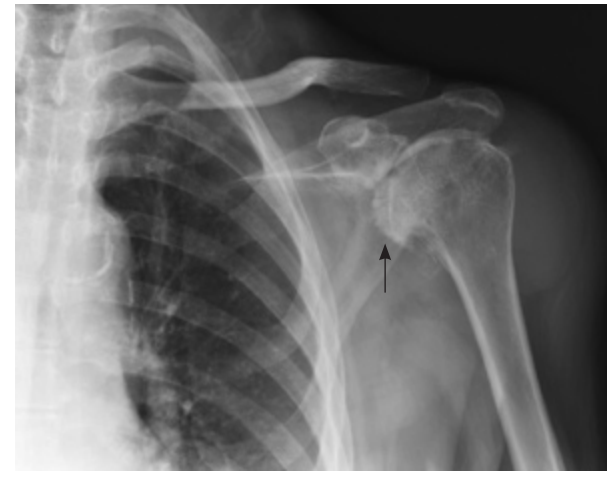

Figure 1. Preoperative anteroposterior radiograph illustrating degenerative changes.

anti-inflammatory drugs (NSAIDs) *(Table 3[14])*. Nonselective COX-2 inhibitors (e.g., ibuprofen [Motrin], diclofenac [Voltaren], naproxen [Naprosyn]) and selective COX-2 inhibitors (e.g., celecoxib [Celebrex]) have been effective in alleviating osteoarthritis symptoms, but have varying side effects. Side effects can include gastrointestinal irritation, stomach ulcerations, bleeding, or renal failure from long-term use. In advanced osteoarthritis cases with inflammation, an injection of a corticosteroid, such as triamcinolone acetonide (Kenalog; 1 to 2 mL of 40 mg per mL) with lidocaine 1% (Xylocaine), into the affected joint can help relieve pain and swelling.

SURGICAL MANAGEMENT

If conservative therapies fail, there are many surgical options available. Joint preservation surgery is preferable for patients younger than 55 to 60 years or those with early stage degenerative joint disease of the shoulder. The operative procedure should match the patient's symptoms or functional limitations. Arthroscopic debridement, capsular release, corrective osteotomies, and interposition arthroplasty are surgical options that attempt to reduce symptoms while preserving the native joint.[15] Arthroscopic debridement with capsular release is the most common surgical treatment. It is most effective in patients younger than 55 to 60 years with moderate pain and significant passive motion restrictions. Debridement removes mechanical irritants, unstable cartilage flaps, or loose bodies. Inflamed synovium can be treated via synovectomy, and the stiff contracted joint capsule can be released to restore passive joint mobility and unload articular surfaces. Arthrodesis (shoulder fusion) is an option for patients younger than 45 to 50 years with severe arthritis or for those who are not suitable candidates for total shoulder replacement. This procedure eliminates pain by fusing the humeral head to the glenoid, thus eliminating painful motion interface.

Shoulder arthroplasty is recommended for patients with severe shoulder osteoarthritis. The most common indications for shoulder arthroplasty are pain from shoulder arthritis with a loss of function that is unresponsive to conservative treatment; end-stage rotator cuff tear arthropathy; osteonecrosis; and a previously failed joint-sparing surgery or total shoulder arthroplasty.[16] Most recent studies support the use of a total shoulder arthroplasty, which involves replacing the glenoid and humerus [17,18] *(Figure 2)*. In certain instances, a hemiarthroplasty (humerus only) may be an acceptable option. Major contraindications to shoulder replacement are: active or recent infection, neuropathic joint, complete paralysis of deltoid or rotator cuff muscles, debilitating medical status, or uncorrectable shoulder instability.

Shoulder arthroplasty is typically done under general anesthesia. A regional nerve anesthetic (interscalene block) can supplement general anesthesia and provide perioperative pain control. After careful surgical exposure, the glenoid fossa is resurfaced with a solid polyethylene component, and the humeral head is resected along the anatomic neck and replaced with a metal prosthesis. Newer prostheses, called reverse or inverse shoulder replacements, have been designed specifically for use in rotator-cuff–deficient shoulders. The procedure lasts one

Table 3. Guide to NSAID Therapy

	No or low NSAID gastrointestinal risk	*NSAID gastrointestinal risk*
No cardiovascular risk (no aspirin)	Traditional NSAID	Consider non-NSAID therapy Traditional NSAID plus PPI *or* COX-2 inhibitor plus PPI* (if necessary)
Cardiovascular risk (consider aspirin)	Consider non-NSAID therapy Traditional NSAID† plus PPI if gastrointestinal risk warrants gastroprotection	Consider non-NSAID therapy A gastroprotective agent must be added if a traditional NSAID† is prescribed

COX-2 = cyclooxygenase-2; NSAIDs = nonsteroidal anti-inflammatory drugs; PPI = proton pump inhibitor.

**—The U.S. Food and Drug Administration has determined that over-the-counter and prescription NSAIDs (including selective COX-2 agents), when used as monotherapy, may be linked to potentially life-threatening gastrointestinal bleeding.*

†*—NSAIDS should be used cautiously in patients taking aspirin.*

Adapted with permission from Fendrick AM. COX-2 inhibitor use after Vioxx: careful balance or end of the rope? [editorial]. Am J Manag Care. *2004;10(11):741.*

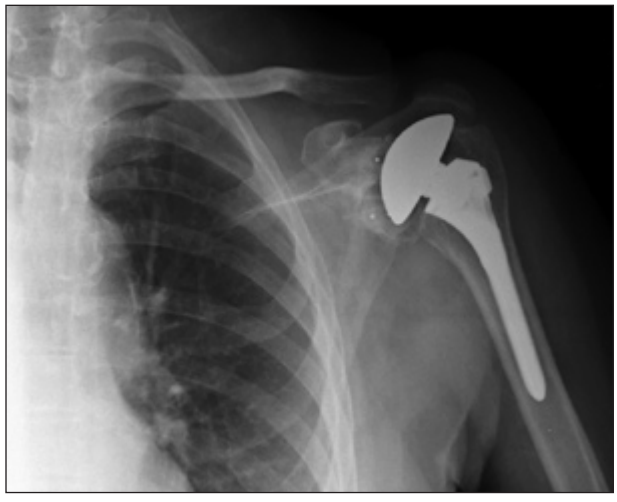

Figure 2. Postoperative radiograph following total shoulder arthroplasty.

to three hours, followed by a two- to four-day postoperative hospitalization. Blood loss is minimal, and patients who start with a preoperative hemoglobin above 11 g per dL (110 g per L) should not need transfusions. Donating blood before surgery is not recommended.[19] Pain is controlled in the hospital with opioids via intravenous patient-controlled analgesia. A sling should be used for three to six weeks to protect the repair. Patients usually require some assistance with normal daily activities for approximately four to six weeks after surgery.

Postoperative rehabilitation begins immediately with joint motion, in-home exercises, and a therapist-supervised program *(Table 4)*.[20] The initial six weeks of rehabilitation focus on stretching exercises to optimize the flexibility of the joint. When flexibility and range-of-motion goals have been achieved (usually at six to eight weeks), the strengthening can begin. Normal activities of daily living can be resumed within six weeks of surgery, and patients can often return to athletic activities within four months. After shoulder arthroplasty, patients can expect alleviation of pain and a significant improvement in range of motion.[18] Improvement in function may continue up to two years after surgery.[21]

Table 4. Postoperative Rehabilitation Sequencing

Exercise	*Postoperative day*
Active hand, forearm, elbow motion	1
Passive shoulder motion	1
Pulley	21
Wand or cane	35
Isometrics	35

Information from reference 20.

Treatment Results

NONSURGICAL TREATMENT

Nonsurgical osteoarthritis treatments can temporize symptoms; however, they do not alter natural history and have had unsatisfactory results. Nonpharmacologic measures, such as aerobic exercise and strengthening, are unproven in the shoulder.[22] One study has shown that acetaminophen was more effective than placebo at pain reduction, but less effective than NSAIDs.[23] NSAIDs were also associated with more frequent gastrointestinal events than acetaminophen.[23] Two randomized placebo-controlled studies have been published since 2003. One found no significant difference between placebo and acetaminophen, and the other found acetaminophen to be more effective than placebo, and celecoxib to be more effective than acetaminophen.[13,24]

Pharmacologic results show that newer COX-2 selective inhibitors are not more effective than nonselective NSAIDs for treating knee and hip osteoarthritis.[25,26] However, the Celecoxib Long Term Arthritis Safety Study (CLASS) illustrated that the COX-2 inhibitor celecoxib was associated with significantly less gastrointestinal events than traditional NSAIDs.[27] In recent years, studies have shown certain COX-2 inhibitors to be associated with an increased cardiovascular risk, resulting in the removal of rofecoxib (Vioxx) from the market. Additional data suggest that the nonselective NSAIDs may also cause an increase in adverse cardiovascular events.[28,29] More studies are needed to demonstrate effectiveness and serious cardiovascular side effects of NSAIDs and COX-2 selective inhibitors.

Nutritional supplements are widely used for osteoarthritis treatment, although the U.S. Food and Drug Administration has not approved them for this use. The most common supplements are glucosamine and chondroitin. Glucosamine has been shown to provide moderate symptomatic relief over placebo, but the overall effectiveness of these supplements remains uncertain.[30] At this time, there is a paucity of evidence to support the use of these supplements in shoulder degenerative joint disease.

SURGICAL TREATMENT

Few studies exist on joint-preservation surgery for the shoulder. There are several case reports and small series that present cartilage resurfacing procedures for young patients with focal chondral defects.[31,32] The largest series

on arthroscopic treatment consists of 25 patients with early to moderate osteoarthritis, treated with lavage, partial synovectomy, and subacromial decompression.[15] The mean follow-up was 34 months, and the authors demonstrated good or excellent outcomes in 80 percent of patients. The authors concluded that arthroscopic debridement was reasonable for early shoulder osteoarthritis treatment. Surgical prerequisites included concentric humeral head and glenoid with visible joint space on axillary radiography.

Prosthetic total shoulder arthroplasty is the treatment of choice for severe degenerative joint disease. Studies show that total shoulder arthroplasty provides excellent clinical results with good durability. The results of total shoulder arthroplasty have been shown to be superior to hemiarthroplasty, in which only the humerus is resurfaced.[33] As early as 1982, one study reported that 90 percent of patients who underwent total shoulder arthroplasty had satisfactory results at minimum two-year follow-up.[34] As of 1988, only two of the 615 patients who had undergone total shoulder arthroplasty required further surgery. Another paper with 12-year mean follow-up demonstrated satisfactory pain relief in 83 percent of shoulders, with an average improvement of 40-degree active abduction, and yielding an overall average range of motion of 117 degrees.[18] Despite concerns about glenoid loosening, long-term studies have shown high rates of survivorship. Another study of patients younger than 50 years, with minimum five-year and mean 12-year follow-up, found a prosthesis survival rate of 97 percent at five years, 97 percent at 10 years, and 84 percent at 15 years.[16] This study illustrates that total shoulder arthroplasty improves functional range of motion with good long-term pain relief.

The average orthopedic surgeon performs only two total shoulder arthroplasties per year, and recent data has shown that surgeon and hospital volume significantly influence surgical outcomes.[32,35] Surgeons with higher volumes of arthroplasties have better patient outcomes and fewer complications. When total shoulder arthroplasty is performed under appropriate clinical indication, complete pain relief and normal or near-normal restoration of function is often the result. Experts predict that surgical outcomes following total shoulder arthroplasty will continue to improve with newer implant designs and fixation methods.

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REFERENCES

1. United States Bone and Joint Decade Homepage. About the decade. http://www.usbjd.org/about/index.cfm. Accessed April 21, 2008.
2. National Center for Chronic Disease Prevention and Health Promotion, Division of Adult and Community Health. Arthritis. http://www.cdc.gov/arthritis/. Accessed April 21, 2008.
3. National Institutes of Health, National Institute of Arthritis and Musculoskeletal and Skin Diseases. Osteoarthritis. http://www.niams.nih.gov/Health_Info/Osteoarthritis/osteoarthritis_hoh.pdf. Accessed April 21, 2008.
4. Memel DS, Kirwan JR, Sharp DJ, Hehir M. General practitioners miss disability and anxiety as well as depression in their patients with osteoarthritis. *Br J Gen Pract*. 2000;50(457):645-648.
5. Kerr R, Resnick D, Pineda C, Haghighi P. Osteoarthritis of the glenohumeral joint: a radiologic-pathologic study. *AJR Am J Roentgenol*. 1985;144(5):967-972.
6. Gerber A, Lehtinen JT, Warner JJ. Glenohumeral osteoarthritis in active patients: diagnostic tips and complete management options. *Phys Sportsmed*. 2003;4(31). http://www.physsportsmed.com/issues/2003/0403/gerber.htm. Accessed April 21, 2008.
7. Gomoll AH, Katz JN, Warner JJ, Millett PJ. Rotator cuff disorders: recognition and management among patients with shoulder pain. *Arthritis Rheum*. 2004;50(12):3751-3761.
8. Li SF, Henderson J, Dickman E, Darzynkiewicz R. Laboratory tests in adults with monoarticular arthritis: can they rule out a septic joint? *Acad Emerg Med*. 2004;11(3):276-280.
9. Rockwood CA, Matsen FA, Wirth MA, Harryman DT. *The Shoulder*. 2nd ed. Philadelphia, Pa.: Saunders;1998:840-964.
10. Warner JJ, Iannotti JP, Gerber C, eds. *Complex and Revision Problems in Shoulder Surgery*. Philadelphia, Pa.: Lippincott-Raven;1997:289-302.
11. Radiological Society of North America. 90th Scientific Assembly and Annual Meeting. November 30, 2004. Chicago, Ill. Muskuloskeletal (cartilage imaging). Articular cartilage in the shoulder: correlation of MR arthrography and surgical arthroscopy [Abstract]. http://rsna2004.rsna.org/rsna2004/V2004/conference/event_display.cfm?em_id=4409527. Accessed May 6, 2008.
12. O'Reilly SC, Muir KR, Doherty M. Effectiveness of home exercise on pain and disability from osteoarthritis of the knee: a randomised controlled trial. *Ann Rheum Dis*. 1999;58(1):15-19.
13. Miceli-Richard C, Le Bars M, Schmidely N, Dougados M. Paracetamol in osteoarthritis of the knee. *Ann Rheum Dis*. 2004;63(8):923-930.
14. Fendrick AM. COX-2 inhibitor use after Vioxx: careful balance or end of the rope? [editorial]. *Am J Manag Care*. 2004;10(11 pt 1):740-741.

15. Weinstein DM, Bucchieri JS, Pollock RG, Flatow EL, Bigliani LU. Arthroscopic debridement of the shoulder for osteoarthritis. *Arthroscopy*. 2000;16(5):471-476.
16. Sperling JW, Cofield RH, Rowland CM. Neer hemiarthroplasty and Neer total shoulder arthroplasty in patients fifty years old or less. Long-term results. *J Bone Joint Surg Am*. 1998;80(4):464-473.
17. Edwards TB, Kadakia NR, Boulahia A, et al. A comparison of hemiarthroplasty and total shoulder arthroplasty in the treatment of primary glenohumeral osteoarthritis: results of a multicenter study. *J Shoulder Elbow Surg*. 2003;12(3):207-213.
18. Torchia ME, Cofield RH, Settergren CR. Total shoulder arthroplasty with the Neer prosthesis: long-term results. *J Shoulder Elbow Surg*. 1997;6(6):495-505.
19. Millett PJ, Porramatikul M, Chen N, Zurakowski D, Warner JJ. Analysis of transfusion predictors in shoulder arthroplasty. *J Bone Joint Surg Am*. 2006;88(6):1223-1230.
20. Millett PJ, Wilcox RB III, O'Holleran JD, Warner JJ. Rehabilitation of the rotator cuff: an evaluation-based approach. *J Am Acad Orthop Surg*. 2006;14(11):599-609.
21. Matsen FA III, Antoniou J, Rozencwaig R, Campbell B, Smith KL. Correlates with comfort and function after total shoulder arthroplasty for degenerative joint disease. *J Shoulder Elbow Surg*. 2000;9(6):465-469.
22. van Baar ME, Dekker J, Oostendorp RA, Bijl D, Voorn TB, Bijlsma JW. Effectiveness of exercise in patients with osteoarthritis of hip or knee: nine months' follow up. *Ann Rheum Dis*. 2001;60(12):1123-1130.
23. Zhang W, Jones A, Doherty M. Does paracetamol (acetaminophen) reduce the pain of osteoarthritis? A meta-analysis of randomised controlled trials. *Ann Rheum Dis*. 2004;63(8):901-907.
24. Pincus T, Koch G, Lei H, et al. Patient Preference for Placebo, Acetaminophen (paracetamol) or Celecoxib Efficacy Studies (PACES): two randomised, double blind, placebo controlled, crossover clinical trials in patients with knee or hip osteoarthritis. *Ann Rheum Dis*. 2004;63(8):931-939.
25. American College of Rheumatology 62nd National Scientific Meeting and Association of Rheumatology Health Professionals 33rd National Scientific Meeting. San Diego, Calif., USA. November 8-12, 1998. Abstracts [published correction appears in *Arthritis Rheum*. 1998;41(12):2195]. *Arthritis Rheum*. 1998;41(9 suppl):S33-S426.
26. Lisse JR, Perlman M, Johansson G, et al., for the ADVANTAGE Study Group. Gastrointestinal tolerability and effectiveness of rofecoxib versus naproxen in the treatment of osteoarthritis: a randomized, controlled trial. *Ann Intern Med*. 2003;139(7):539-546.
27. Silverstein FE, Faich G, Goldstein JL, et al. Gastrointestinal toxicity with celecoxib vs nonsteroidal anti-inflammatory drugs for osteoarthritis and rheumatoid arthritis: the CLASS study: a randomized controlled trial. *JAMA*. 2000;284(10):1247-1255.
28. Kearney PM, Baigent C, Godwin J, Halls H, Emberson JR, Patrono C. Do selective cyclo-oxygenase-2 inhibitors and traditional non-steroidal anti-inflammatory drugs increase the risk of atherothrombosis? Meta-analysis of randomised trials. *BMJ*. 2006;332(7553):1302-1308.
29. Spalding WM, Reeves MJ, Whelton A. Thromboembolic cardiovascular risk among arthritis patients using cyclooxygenase-2-selective inhibitor or nonselective cyclooxygenase inhibitor nonsteroidal anti-inflammatory drugs. *Am J Ther*. 2007;14(1):3-12.
30. McAlindon TE, LaValley MP, Gulin JP, Felson DT. Glucosamine and chondroitin for treatment of osteoarthritis: a systematic quality assessment and meta-analysis. *JAMA*. 2000;283(11):1469-1475.
31. Romeo AA, Cole BJ, Mazzocca AD, Fox JA, Freeman KB, Joy E. Autologous chondrocyte repair of an articular defect in the humeral head. *Arthroscopy*. 2002;18(8):925-929.
32. Scheibel M, Bartl C, Magosch P, Lichtenberg S, Habermeyer P. Osteochondral autologous transplantation for the treatment of full-thickness articular cartilage defects of the shoulder. *J Bone Joint Surg Br*. 2004;86(7):991-997.
33. Gartsman GM, Roddey TS, Hammerman SM. Shoulder arthroplasty with or without resurfacing of the glenoid in patients who have osteoarthritis. *J Bone Joint Surg Am*. 2000;82(1):26-34.
34. Neer CS II, Watson KC, Stanton FJ. Recent experience in total shoulder replacement. *J Bone Joint Surg Am*. 1982;64(3):319-337.
35. Jain N, Pietrobon R, Hocker S, Guller U, Shankar A, Higgins LD. The relationship between surgeon and hospital volume and outcomes for shoulder arthroplasty. *J Bone Joint Surg Am*. 2004;86-A(3):496-505.