Arthroplasty in the young patient

Shoulder pain and loss of function caused by degenerative joint disease is extremely disabling to young people who have an active lifestyle. If non-operative and minimally invasive treatment fails, shoulder arthroplasty is a reasonable option. This article reviews the options and indications for their use in shoulder disability in the young patient.

Shoulder disability in young patients is often the result of trauma, inflammatory disease or previous surgery. Disruption of the articular surface or irreparable tendon injury often leads to early osteoarthritis. Young patients with degenerative disease of the shoulder present a unique challenge in orthopaedic care because of their increased activity level and duration of use of any treatment. The condition can be extremely debilitating, significantly limiting activities of daily living. The goal of treatment is pain relief and restoration of function to enable pre-injury level of use and activities, which are often quite demanding. Treatment options vary depending on the type of pathology, duration of disability, range of motion and patient expectations. Non-operative or minimally invasive operative treatments should be indicated before glenohumeral arthroplasty.

Early management of shoulder disability

Non-operative treatment of symptomatic shoulder arthritis is always the initial management in young patients and includes activity modification, physical therapy and anti-inflammatory medications. Narcotics are not recommended for this chronic condition. When these options fail, operative intervention may include arthroscopic debridement, resurfacing, hemiarthroplasty, biological resurfacing and total shoulder arthroplasty. It is important to evaluate the glenohumeral joint with both anteroposterior and axillary radiographs, to adequately visualize the joint line. Computed tomography or magnetic resonance imaging may also be helpful. Magnetic resonance imaging will better define soft tissue lesions and the rotator cuff, but computed tomography is more helpful in quantifying bony loss and joint incongruity.

In patients with radiographic evidence of congruent articular surfaces and decreased but preserved joint space, debridement provides pain relief in the majority of patients. Greater severity of disease yields higher rates of dissatisfaction. Only one-third of patients with severe osteoarthritis had good outcomes from arthroscopic debridement (Weinstein et al, 2000). Therefore the authors are reluctant to suggest arthroscopic debridement in patients with osteophyte formation and loss of joint space. For the right indications, the procedure has a low rate of complications and morbidity, does not jeopardize future procedures, and may provide an extended period of pain relief.

Dr Julie M Keller *is Resident in Orthopaedics,* **Dr Katie B Vadasdi** *is Fellow in Shoulder, Elbow and Sports Medicine and* **Dr Louis U Bigliani** *is Chairman in the Department of Orthopaedic Surgery, Columbia University Medical Center, New York Presbyterian Hospital, New York, NY*

Correspondence to: Dr JM Keller

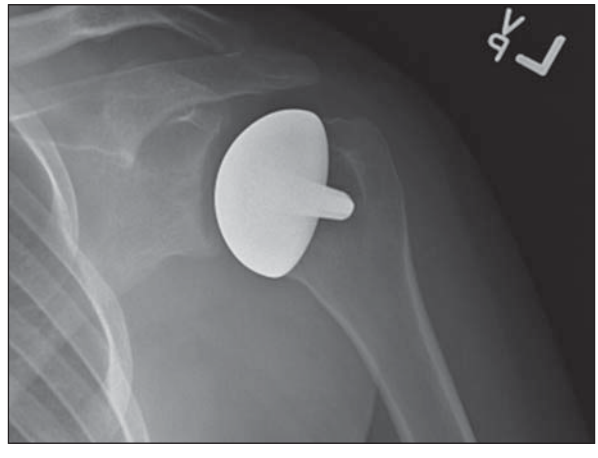
Humeral resurfacing arthroplasty

Humeral resurfacing arthroplasty is an emerging option for young patients with degenerative joint disease of the shoulder. It restores normal surface anatomy while preserving bone, which facilitates future procedures likely to be necessary in young and active individuals. Most modern prostheses are cementless and fit cap-like over the humeral head, restoring a smooth joint surface while sparing the humeral neck and maintaining native inclination, offset, head-shaft angle and version (*Figure 1*).

Resurfacing can be used alone, or in conjunction with glenoid reaming, biological resurfacing or prosthetic replacement. Good results have been achieved at 5 and 10 year follow up with this prosthesis for multiple shoulder pathologies in patients with a mean age of 64 years (Levy and Copeland, 2001). A study of patients undergoing resurfacing for fixed anterior glenohumeral dislocation found significant improvement of the Constant scores, but the authors were unable to achieve stability with bone defects of over 45% of the humeral surface. This study is limited by population number and length of follow up, but suggests that resurfacing may be an option for arthritis with joint incongruity from instability (Raiss et al, 2007).

There are extremely limited data on the use of resurfacing in young patients. Short term follow up by Bailie et al (2008), for patients less than 55 years with end stage glenohumeral arthritis, showed significant improvement in function with low complication rates. Twenty-four of 36

Figure 1. Humeral head resurfacing in a 48-year-old man with osteoarthritis.



had some repair of the glenoid surface, although none had prosthetic replacement. No component loosening was found at a mean of 38.1 months postoperatively and 35 of 36 had returned to their desired level of activity. While encouraging, this study is limited by the number of patients, length of follow up and lack of subjective outcome measurements. While glenoid resurfacing shows promise for relieving pain, restoring function and maintaining bone stock, more data are needed before this can be recommended along with humeral surface replacement.

Hemiarthroplasty

Shoulder hemiarthroplasty provides reliable pain relief and increased range of motion in patients with painful osteoarthritis. However, it gives less pain relief, improvement in external and internal rotation, and patient satisfaction than total shoulder arthroplasty (Cofield et al, 1993; Levine et al, 1997; Gartsman et al, 2000; Edwards et al, 2003; Bryant et al, 2005). Hemiarthoplasty has significantly higher failure rates, significantly higher revision rates, and worse outcomes after revision to total shoulder arthroplasty on long-term follow up than primary total shoulder arthroplasty (Carroll et al, 2004). In long-term follow up, the rate of glenoid revision for total shoulder arthroplasty is lower than the rate of hemiarthroplasty revision in most patients, and when considering only polyethylene glenoids the revision rate is even lower.

A deterioration of functional results ratings at 15 *vs* 5-year follow up has been found with hemiarthroplasty, but not total shoulder arthroplasty; this is especially significant for young patients, as implants will be used for longer than this (Sperling et al, 2004). Hemiarthroplasty is indicated for patients in whom total shoulder arthroplasty is contraindicated, e.g. those with irreparable rotator cuff tears, insufficient soft tissue envelopes, inadequate glenoid bone stock and neuropathy (Bigliani and Flatow, 2005). However, when it is not contraindicated total shoulder arthroplasty gives better long-term motion and pain relief.

In an attempt to improve the long-term success of hemiarthroplasty for pain relief and motion, while avoiding the problems with the glenoid component seen in total shoulder arthroplasty, the procedure has been used in combination with concentric glenoid reaming. In canine shoulder models and in human hip models, reamed, concentric, concave joint surfaces develop a smooth, homogenous, securely attached fibrocartilage regenerative surface for articulation (Coutts et al, 1984; Matsen et al, 2005; Lynch et al, 2007). Data of 38 shoulders at 2–4 years follow up showed significant improvements in range of motion and 10 of 12 individual functions from the Simple Shoulder Test. Two shoulders had worse function at follow up, one shoulder was unchanged; one shoulder had radiographic evidence of humeral loosening, four had progressive medial glenoid erosion, six had recurrent posterior glenoid wear, and one patient required revision reaming for persistent pain and stiffness (Lynch et al, 2007). This suggests that hemiarthroplasty with concentric reaming may provide significant improvement in comfort and function of the shoulder, but caution is needed until further studies and longer outcomes are available.

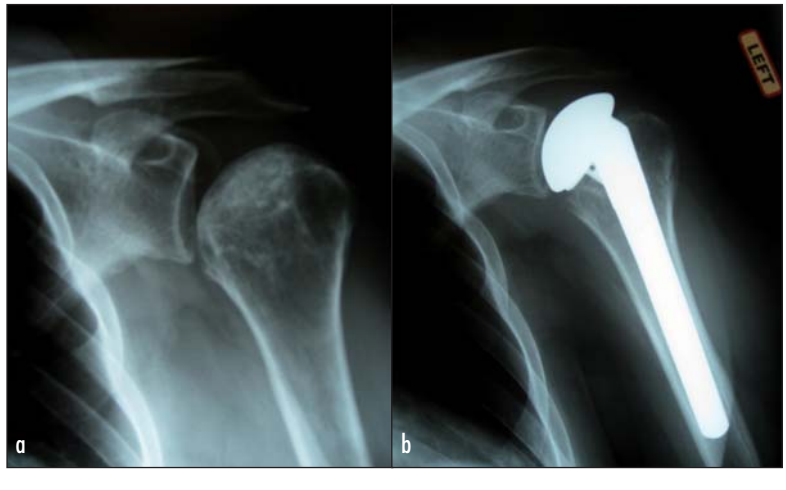
Hemiarthroplasty may be preferred for avascular necrosis of the humeral head without glenoid involvement in young patients (*Figure 2*). The authors have not had to revise a hemiarthroplasty for avascular necrosis when there has been adequate cartilage on the glenoid surface at the time of surgery. Despite severe arthritic changes on the humeral head, the glenoid has not deteriorated with time as occurs in patients with osteoarthritis.

Biological resurfacing

Biological resurfacing has been described as early as 1860, but use along with humeral head replacement is a relatively new technique that may allow glenoid replacement for young, active patients with debilitating shoulder pain. Burkhead and Hutton (1995) reported the use of anterior capsule or autogenous fascia lata with good results with at least 2 years follow up. They noted no glenoid erosion and, based on Neer criteria, had five excellent and one satisfactory result. One patient required revision with biceps tenodesis for persistent pain. Since then, anterior capsule, autogenous fascia lata, Achilles tendon allograft and meniscal allograft have all been used.

Building on Burkhead and Hutton's results, Krishnan et al (2007) studied 2–15-year outcomes for biological resurfacing and found the best results using Achilles allograft, with anterior capsule interposition associated with unsatisfactory results. The mean increase in American Shoulder and Elbow Surgeons score postoperatively was significantly improved, and 86% had good or excellent pain relief. Improvements in active anterior elevation, external and internal rotation were all statistically significant. The average erosion of the glenoid was 7.2 mm, although this seemed to stabilize at 5 years postoperatively. The glenohumeral space also decreased postoperatively in all patients, raising some concern about the viability of the graft, but the decrease stabilized by 5 years as well.

Figure 2. a. Humeral head avascular necrosis in a young patient. b. Humeral hemiarthroplasty in a young patient for avascular necrosis.



Ball et al (2001) pioneered meniscal interposition (*Figure 3*). Their initial results on six patients at 24 months showed little or no pain in four of the six, and maintenance of the joint space, no glenoid erosions and significantly improved range of motion in all patients. Interposition with meniscus decreases forces on the glenoid surface (Creighton et al, 2006) and Themistocleous et al (2006) have developed a modified technique to improve glenoid coverage. There are no long-term follow-up studies of meniscal allograft. Further investigations are required to determine the long-term effect on preservation of joint space, glenoid bone stock, range of motion and pain relief with the interposition grafts currently used. Results seem promising for these techniques, but longevity and success of revision operations remain uncertain.

Total shoulder arthroplasty

Total joint arthroplasty has become increasingly accepted as treatment for severe osteoarthritis in young patients (*Figure 4*). In both total hip and total knee arthroplasty, patients have shown considerable improvement in function (judged by Harrison hip scores and Hospital for Special Surgery Knee scores respectively) and survivorship of 90% or greater at 15–20 years in some studies (Diduch et al, 1997; Sochart and Porter, 1997; Dudkiewicz et al, 2002; Eskelinen et al, 2006; Nilsson et al, 2006; Pollard et al, 2006; Sharkey et al, 2006; Tai and Cross, 2006). Despite the differences between the shoulder and lower extremity joints, which are weight bearing and relatively restricted in motion, it was thought that young patients with severe osteoarthritis would similarly benefit from total shoulder arthroplasty. Osteoarthritis is the most common indication, accounting for over 60% of all total shoulder arthroplasties performed (Hill, 2000).

Outcomes following total shoulder arthroplasty have been excellent for older patients with osteoarthritis; the rate of associated full thickness rotator cuff tears is only 5–10%, the entire soft tissue envelope is usually competent, neurological structures are intact, and adequate bone stock is often present (*Figures 5* and *6*). The superior results of total shoulder arthroplasty over hemiarthroplasty have been well demonstrated (Rodosky and Bigliani, 1996; Smith and Matsen, 1998; Gartsman et al, 2000; Edwards et al, 2003; Bryant et al, 2005), yet surgeons are reluctant to implant total shoulders in young patients with debilitating shoulder osteoarthritis because of concerns for component wear and loosening. In the authors' experience, using modern implants and techniques, the incidence of glenoid loosening is considerably less than in the past and the authors believe total shoulder arthroplasty is an acceptable and successful treatment for debilitating osteoarthritis even in young and active patients (*Figure 7*). Arthroplasty in this group is exceedingly challenging as many have had previous surgery (i.e. for instability) which can create soft tissue scarring and shortening, as well as excessive posterior glenoid wear.

It is important to remove minimal bone from both the surface and glenoid vault, and the authors prefer an inline three peg glenoid component, which removes minimal bone from the glenoid vault. The authors have patients who have had this procedure and been followed for more than 5 years without deterioration of glenoid fixation. Cement pressurization at the time of implantation is essential to achieve excellent fixation with a low incidence of radiographic lucent lines (Barwood et al, 2008).

Use of a dual radius glenoid component preserves glenoid bone stock on the glenoid surface. The outer glenoid bone surface is smaller than the inner articular surface which permits the use of a smaller glenoid bone reamer. This is extremely helpful in cases of posterior glenoid wear where there may be severe bone deformity.

Twenty patients were treated by three fellowship-trained shoulder surgeons, and 80% had excellent or satisfactory Neer scores. There was only one revision for a loose glenoid component. Radiographic evaluation

Figure 3. Meniscal allograft resurfacing of the glenoid.

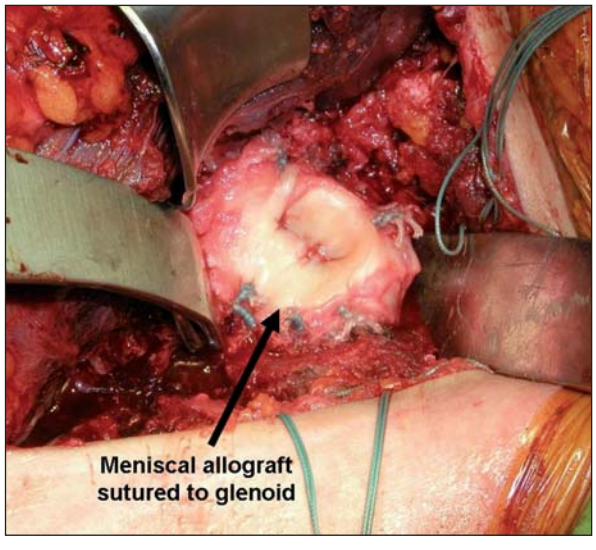


Figure 4. Osteoarthritis in a young patient <50 years old.

showed radiolucent lines around the glenoid of <1 mm in 31% (five patients) of the X-rays and humeral radiolucent lines in 18.75% (three patients) on most recent exam: this means that none of the components currently qualify as being at risk for loosening (Keller et al, 2007).

These results compare favourably with past results. These excellent outcomes could be because all surgeries were done with modern components and surgical technique, including reaming, packing with thrombin-soaked sponges, glenoid bone impaction, and compression of the glenoid component until the cement polymerized. Also, all patients were young, and therefore more likely to have good bone stock, and all had osteoarthritis as an indication. As patients with osteoarthritis have the most favourable outcomes of any indication, limiting the population to these patients likely improved the overall outcomes.

Raiss et al (2008) reported favourable results using third generation total shoulder arthroplasty techniques in patients 37–60 years old, with 95% of 20 patients either satisfied or very satisfied with their results and a significant improvement in pre- and postoperative Constant and Murley scores. The authors found no clinical or radiological signs of loosening of the implants and no patients required revision at a mean of 7 years' follow up. Barwood et al (2008) found a low incidence of early glenoid radiolucencies in patients treated with total shoulder arthroplasty for osteoarthritis, with at least 94% adequate component seating for both concentric glenoids and those with preoperative posterior wear. For a selected population, total shoulder arthroplasty is an effective treatment for eliminating pain and increasing range of motion for young patients with debilitating osteoarthritis of the glenohumeral joint.

Figure 5. Intraoperative view of the humeral head with loss of cartilage and osteophytes consistent with osteoarthritis in a 49-year-old man.

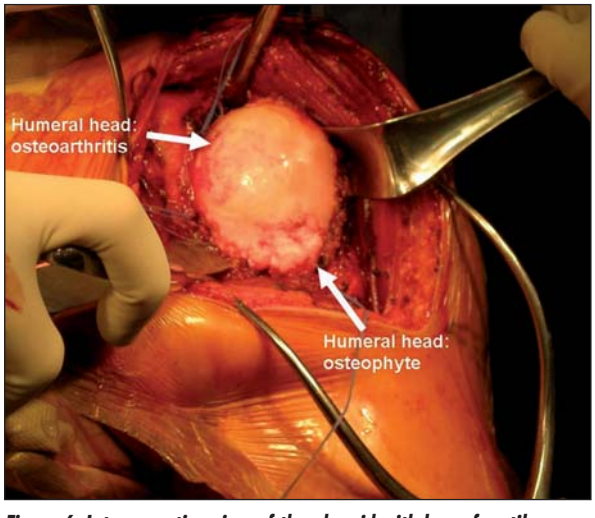
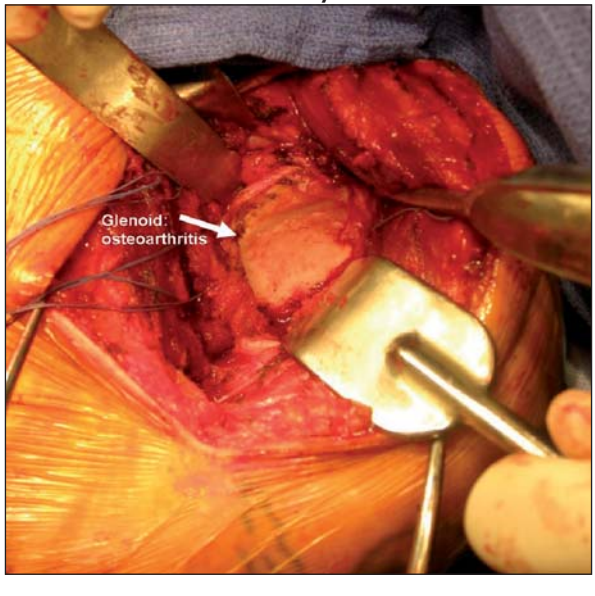


Figure 6. Intraoperative view of the glenoid with loss of cartilage consistent with osteoarthritis in a 49-year-old man.



Conclusions and future directions

Glenohumeral arthritis is a difficult and debilitating problem for which the solution is still being elucidated. When non-operative management and simple debridement have failed to provide relief, arthroplasty is the next option. Current options include hemiarthroplasty, hemiarthroplasty with concentric reaming, biological resurfacing, humeral resurfacing arthroplasty and total shoulder arthroplasty. For glenohumeral arthritis, hemiarthroplasty has inferior long-term results with regard to pain relief and function compared to total shoulder arthroplasty. Studies evaluating short-term results in young patients have shown improvement after hemiarthroplasty with concentric reaming of the glenoid, biological resurfacing and total shoulder arthroplasty. Humeral resurfacing arthroplasty with or without a glenoid procedure also shows promise for long-term pain relief and functional improvement.

Figure 7. Total shoulder arthroplasty in a young patient with osteoarthritis.

The question of which procedure is best has not been answered. Outcome data for both hemiarthroplasty with glenoid resurfacing and humeral resurfacing arthroplasty are limited and short term. There is more evidence for interpositional arthroplasty, although caution is still needed until questions regarding longevity and viability of revision have been answered. There is increasing evidence for the use of total shoulder arthroplasty, with modern techniques and implants, for younger patients with osteoarthritis. Short- and medium-term outcomes are encouraging, but long-term follow up and outcomes for use in expanded indications need further investigation. The use of shoulder arthroplasty in young people is still in its infancy and careful and reproducible measures of functional outcomes should be the focus of further research. **BJHM**

Conflict of interest: Drs Keller and Vadasdi – none; Dr Bigliani has received royalties from Zimmer and Innomed.

Bailie D, Llinas P, Ellenbecker T (2008) Cementless humeral resurfacing arthroplasty in active patients less than fifty-five years of age. *J Bone Joint Surg Am* **90:** 110–17

Ball C, Galatz L, Yamaguchi K (2001) Meniscal allograft interposition arthroplasty for the arthritic shoulder: description of a new surgical technique. *Techniques in Shoulder and Elbow Surgery* **2:** 247–54

Barwood S, Setter K, Blaine T, Bigliani L (2008) The incidence of early radiolucencies about a pegged glenoid component using cement pressurization. *J Shoulder Elbow Surg* **17:** 703–8

Bigliani LU, Flatow EL, eds (2005) *Shoulder Arthroplasty.* Springer, New York

Bryant D, Litchfield R, Sandow M, Gartsman GM, Guyatt G, Kirkley A (2005) 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* **87:** 1947–56

Burkhead W Jr, Hutton K (1995) Biologic resurfacing of the glenoid with hemiarthroplasty of the shoulder. *J Shoulder Elbow Surg* **4:** 263–70

Carroll R, Izquierdo R, Vazquez T, Levine W, Bigliani L (2004) Conversion of painful hemiarthroplasty to total shoulder arthroplasty: long-term results. *J Shoulder Elbow Surg* **13:** 599–603

Cofield RH, Frankel MA, Zuckerman JD (1993) Humeral head replacement for glenohumeral arthritis. *Semin Arthroplasty* **6:** 221

Coutts R, Amiel D, Harwood F, Bradley G, Akeson W (1984) Characterization of arthroplasty tissue after 14 years post-cup arthroplasty: a morphological and biochemical assessment. *J Orthop Research* **2**(4): 425–31

Creighton RA, Cole BJ, Nicholson GP, Romeo AA, Lorenz EP (2006) Effect of lateral meniscus allograft on shoulder articular contact areas and pressures. *J Shoulder Elbow Surg* **16**(3): 367–72

Diduch DR, Insall JN, Scott WN, Scuderi GR, Font-Rodriguez D (1997) Total knee replacement in young, active patients. Long-term follow-up and functional outcome. *J Bone Joint Surg Am* **79:** 575–82

Dudkiewicz I, Salai M, Ganel A, Blankstein A, Chechik A (2002) Total hip arthroplasty in patients younger than 30 years of age following developmental dysplasia of hip (DDH) in infancy. *Arch Orthop Trauma Surg* **122:** 139–42

Edwards TB, Kadakia NR, Boulahia A, Kempf JF, Boileau P, Nemoz C, Walch G (2003) A comparison of hemiarthroplasty and total shoulder arthroplasty in the treatment of primary glenohumeral osteoarthritis: results of a multicenter study. *J Shoulder Elbow Surg* **12:** 207–13

Eskelinen A, Remes V, Helenius I, Pulkkinen P, Nevalainen J, Pavvolainen P (2006) Uncemented total hip arthroplasty for primary osteoarthritis in young patients: a mid-to long-term follow-up study from the Finnish Arthroplasty Register. *Acta Orthop* **77:** 57–70

Gartsman GM, Roddey TS, Hammerman SM (2000) Shoulder arthroplasty with or without resurfacing of the glenoid in patients who have osteoarthritis. *J Bone Joint Surg Am* **82:** 26–34

Hill J (2000) *Total Shoulder Arthroplasty: Indications.* AAOS, Rosemont, IL

Keller JM, Nguyen D, Kippe M, Ahmad CS, Levine WN, Bigliani LU (2007) Total shoulder arthroplasty in patients fifty years and younger for severe arthritis. Poster presented at: Annual Resident Research Symposia. Orthopaedic Research and Education Foundation

Krishnan SG, Nowinski RJ, Harrison D, Burkhead WZ (2007) Humeral hemiarthroplasty with biological resurfacing of the glenoid for glenohumeral arthritis: two fifteen-year outcomes. *J Bone Joint Surg* **89:** 727–34

Levine WN, Djurasovic M, Glasson JM, Pollock RG, Flatow EL, Bigliani LU (1997) Hemiarthroplasty for glenohumeral osteoarthritis: results correlated to degree of glenoid wear. *J Shoulder Elbow Surg* **6:** 449–54

Levy O, Copeland S (2001) Cementless surface replacement arthroplasty of the shoulder. 5- to 10-year results with the Copeland mark-2 prosthesis. *J Bone Joint Surg Br* **83:** 213–21

Lynch J, Franta A, Montgomery WJ, Lenters T, Mounce D, Matsen FI (2007) Self-assessed outcome at two to four years after shoulder hemiarthroplasty with concentric glenoid reaming. *J Bone Joint Surg* **89**(6): 1284–92

Matsen FAI, Clark JM, Titelman RM et al (2005) Healing of reamed glenoid bone articulating with a metal humeral hemiarthroplasty: a canine model. *J Orthop Research* **23**(1): 18–26

Nilsson KG, Henricson A, Norgren B, Dalen T (2006) Uncemented HA-coated implant is the optimum fixation for TKA in the young patient. *Clin Orthop Relat Res* **448:** 129–39

Pollard TC, Baker RP, Eastaugh-Waring SJ, Bannister GC (2006) Treatment of the young active patient with osteoarthritis of the hip. A five- to seven-year comparison of hybrid total hip arthroplasty and metal-on-metal resurfacing. *J Bone Joint Surg Br* **88:** 592–600

Raiss P, Aldinger P, Kasten P, Rickert M, Loew M (2007) Humeral head resurfacing for fixed anterior glenohumeral dislocation. *Int Orthop* **33**(2): 451–6

Raiss P, Aldinger PR, Kasten P, Rickert M, Loew M (2008) Total shoulder replacement in young and middle-aged patients with glenohumeral osteoarthritis. *J Bone Joint Surg* **90**(6): 764–9

Rodosky MW, Bigliani LU (1996) Indications for glenoid resurfacing in shoulder arthroplasty. *J Shoulder Elbow Surg* **5**(3): 231–48

Sharkey PF, Austin MS, Hozack W (2006) Total hip arthroplasty in the young patient. *Instr Course Lect* **55:** 173–6

Smith KL, Matsen FAI (1998) Total shoulder arthroplasty versus hemiarthroplasty. Current trends. *Orthop Clin North Am* **29:** 491–506

Sochart DH, Porter ML (1997) The long-term results of Charnley low-friction arthroplasty in young patients who have congenital dislocation, degenerative osteoarthrosis, or rheumatoid arthritis. *J Bone Joint Surg Am* **79:** 1599–617

Sperling JW, Cofield RH, Rowland CM (2004) Minimum fifteen-year follow-up of Neer hemiarthroplasty and total shoulder arthroplasty in patients aged fifty years or younger. *J Shoulder Elbow Surg* **13:** 604–13

Tai C, Cross M (2006) Five- to 12-year follow-up of a hydroxyapatite-coated, cementless total knee replacement in young, active patients. *J Bone Joint Surg Br* **88:** 1158–63

Themistocleous GS, Zalavras CG, Zachos VC, Itamura JM (2006) Biologic resurfacing of the glenoid using a meniscal allograft. *Tech Hand Up Extrem Surg* **10:** 145–9

Weinstein DM, Bucchieri JS, Pollock RG, Flatow EL, Bigliani LU (2000) Arthroscopic debridement of the shoulder for osteoarthritis. *Arthroscopy* **16:** 471–6

KEY POINTS

- Shoulder osteoarthritis in the young patient is generally a result of a traumatic event and can lead to significant pain and disability.
- Mild to moderate symptoms can be managed with non-operative intervention, pain management or surgical procedures such as arthroscopic debridement.
- Moderate to severe symptoms require more complex surgical intervention including hemiarthroplasty with or without glenoid biological resurfacing and total shoulder replacement.
- Total shoulder arthroplasty has demonstrated a survival rate of 90% or greater at 15–20 years.
- Total shoulder arthroplasty provides reliable pain relief and improvement in function in the young patient with severely disabling osteoarthritis.