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" Shoulder Arthroplasty in Young "

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Abstract

Background: Prosthetic shoulder replacement provides excellent pain relief and functional improvement for patients with shoulder arthritis. Total shoulder arthroplasty for osteoarthritis and reverse shoulder arthroplasty for cuff tear arthropathy remains the gold standard for the geriatric patient population. Poor long-term survivorship, implant failure (glenoid component loosening, and glenoid arthrosis), and functional deterioration requiring early revision surgery are major concerns of similar management in younger patients. Young patients prove as a major challenge to shoulder surgeons due to expected longer life expectancy, desire to pursue sports, and active lifestyle thereby placing excessive demands on their shoulder arthroplasty components. Alternative strategies for arthroplasty in young have been developed; however, there is presently no clear consensus, recommendations to guide clinicians toward management. This manuscript reviews the current concepts of shoulder arthroplasty in young patients.
Keywords: Shoulder, arthritis, arthroplasty, glenoid, total shoulder arthroplasty.

Introduction

Total shoulder arthroplasty (TSA) has been a reliable treatment with predictable pain relief and functional improvement for glenohumeral osteoarthritis (GHOA) in the absence of rotator cuff deficiency [1].

Young, in terms of shoulder arthroplasty, has been arbitrarily defined as younger than 55 years in most studies [2]. Instead of arbitrarily placing a chronological age definition for "young" it is better to define this after detailed discussion with patients about their comorbidities, activity levels, and expectations from the surgery. Younger patients in addition to getting pain relief, functional restoration from the procedure have higher expectations regard sports participation and ability to perform physically demanding recreational activity [3]. In their study Henn et al. [3], multivariate analysis showed that younger age was the only independent predictor of greater expectations.

Zarkadas et al. [4] found that 89% of TSA and 77% of humeral head replacement patients participated in medium-to high-demand activities McCarty et al. [5] reported that 64% patients who had a shoulder arthroplasty continue to be able to participate in sports or recreation. This high level activity generates increased demands on the prosthesis accelerating polythelene wear. Long-term studies [6, 7] have shown evidence of implant loosening and deterioration of function with use of anatomical TSA in young patients. Sperling et al. [6] reported unsatisfactory outcomes in 48% of 25 TSA pts younger than 55 years with a minimum of 10 years follow-up. In the same study, it was noted that 76% of TSA pts had radiographic evidence of glenoid component loosening and 60% had humeral head subluxation.

Another important point to consider for younger pts is the etiology of their shoulder pathology and the effect on long-term outcomes. Saltzmann et al. [8] showed that only 21% of shoulder arthroplasties performed for pts younger than 50 were for OA as compared with 66% for patients older than 50. These other diagnoses include inflammatory arthritis (RA), avascular necrosis (AVN), chondrolysis, glenoid dysplasia, posttraumatic arthritis, and osteoarthritis (OA) in weightlifters and instability (post-treatment or primarily) which all have less predictable outcomes making interpretation of TSA difficult. This combination of younger age at implantation, increased expectation and activity level, more difficult pathology make the need for future revision surgery post-TSA more likely. This presents the shoulder surgeon with unique challenges.

Therefore, alternative treatment

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strategies have been developed focused on avoiding use of prosthetic glenoid implants (Hemiarthroplasty [HA]), to preserve glenoid bone stock (ream and run, and biologic resurfacing) and to use humeral implants that facilitate revision surgery (humeral head resurfacing [HHR], short stem, stemless hemi arthroplasty, and platform systems).

Patient Evaluation and Diagnostic Considerations

As discussed younger patients with shoulder arthritis may be affected by primary glenohumeral OA, which is associated with progressive internal rotation contracture and posterior glenoid wear, subluxation. However, more often the arthritis is secondary to uncommon causes like.

Proximal Humerus Fractures

Proximal humerus fractures which result in nonunion, malunion, osteonecrosis, and cartilage degeneration secondary to articular injury and incongruity. Malunion of the humeral head or tuberosities is a common problem encountered in patients undergoing arthroplasty for treatment of post-traumatic sequelae [8]. Results tend to be inferior particularly when a greater tuberosity osteotomy is needed [9].

Instability Related Arthropathy

Overly tight anterior capsular plication and Bankart surgery may lead to anterior contracture which, in turn, causes eccentric loading of the posterior glenoid resulting in posterior glenoid wear and posterior humeral subluxation [10]. GHOA can also develop in patients with untreated anterior instability.

Inflammatory Arthropathies

Inflammatory arthropathies such as rheumatoid arthritis are progressive diseases and affect all of the periarticular tissue. They are associated with osteopenia, glenoid, and humeral erosion and bone loss as well as with rotator cuff degeneration [11].

Glenohumeral Chondrolysis

Glenohumeral chondrolysis is an uncommon and devastating condition seen in young post arthroscopy patients resulting in symmetric articular loss, periarticular osteopenia, progressive loss of motion, and deep shoulder pain. Bioabsorbable anchors (PLLA) and thermal capsulorrhaphy have also been reported in the literature as potential causes of postarthroscopic glenohumeral chondrolysis [12]. It has also been linked to intra-articular local anesthetics [13].

Humeral Head Osteonecrosis

Humeral head osteonecrosis results most commonly from systemic corticosteroid use. Other causes include trauma, alcoholism, Caisson disease, Gaucher disease, sickle cell anemia, and use anti-retroviral drugs. Severity varies from varying degrees of humeral head collapse and soft-tissue contracture to erosion of peripheral edges of glenoid creating a convex glenoid as the collapsing humeral head engulfs it.

Glenoid Dysplasia

A relatively uncommon developmental anamoly resulting from abnormal ossification and fusion of the 2 ossification centers within the glenoid, more commonly manifesting in men in their fifth or sixth decades of life. It is characterized by severe retroversion of the glenoid in the absence of posterior humeral subluxation [14].

Clinical Evaluation

Clinical evaluation should include thorough history regarding medical comorbidities, expectations from the procedure, functional goals, and psychosocial issues. Examination of the shoulder should include assessment of muscle atrophy, glenohumeral stability or subluxation, range of motion documentation, and rotator cuff strength evaluation in shoulders without significant contracture.

Investigations

Standard plain radiographs include true ap view and axillary lateral view. Further advanced imaging includes computed tomography (CT) scan which is more accurate than axillary lateral X-ray for evaluating glenoid anatomy (glenoid wear pattern) and version. CT images must be appropriately oriented relative to the plane of the scapular body [15]. Magnetic resonance imaging is done to confirm rotator cuff integrity.

For the young, more active patients with GHOA before arthroplasty is considered all non-operative treatments must be exhausted. Activity modification (avoiding weight lifting, and overhead activity), physical therapy along with focus on scapular strengthening, anti-inflammatory medications, and guided glenohumeral steroid injections (under maximum aseptic precautions) can all be used to delay surgical intervention.

Comprehensive Arthroscopic Management (CAM procedure) of GHOA

Millett et al. [16, 17] described the CAM procedure which builds on previously described arthroscopic techniques for GHOA, including debridement, chondroplasty, synovectomy, loose body removal, capsular release, and subacromial decompression, but adds inferior humeral osteophyte excision (osteoplasty), a complete capsular release, axillary nerve neurolysis, long head of the biceps tenodesis, and microfracture.

This study demonstrated significant improvements in patient reported outcomes (survivorship of 63%) and satisfaction at long-term follow-up (minimum 10 years) in patients with end-stage GHOA who underwent a CAM procedure.

TSA was suggested over the CAM procedure if patients had a Walch Type B2 or C glenoid, age was >50 years, <2 mm of joint space as well as higher Kellgren-Lawrence grade as arthroscopic procedure was more likely to fail in them. Humeral head flattening and severe joint incongruity were risk factors for CAM failure.

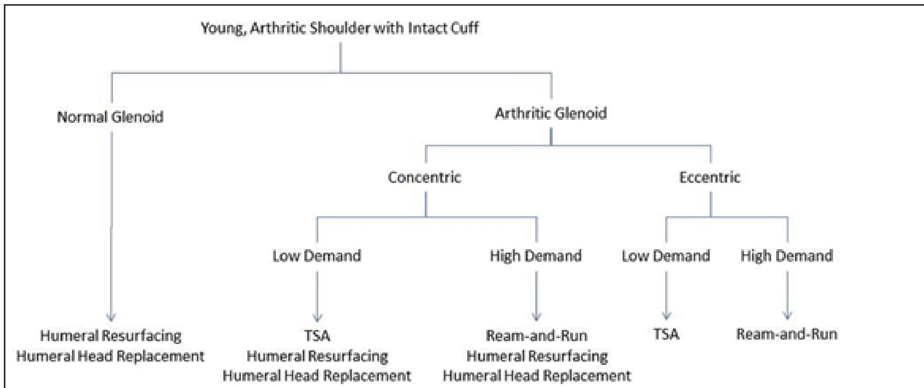
The algorithm below provides a few guidelines to manage the young arthritic shoulder.

Arthroplasty Options

The gold standard for the treatment of end stage glenohumeral OA that has failed non-operative treatment is TSA. The average patient age for patients undergoing TSA is 68.8 years, however and the question remains if the same outcomes and implant longevity can be attained for younger patients [18].

In the past, treatment options in younger and more active patients commonly favored HA over TSA because of the concern of glenoid loosening. However, as prostheses have improved, more TSAs are being performed in younger and more active patients.

The indications for HA, humeral head replacement now tend to be more limited which include patients with end-stage AVN, isolated humeral head arthritis without glenoid articular involvement, focal humeral osteochondral defects, and post-traumatic arthritis. Humeral head replacement can be achieved with full resurfacing, partial resurfacing, stemless, and stemmed humeral head replacement.



Algorithm for arthroplasty treatment of glenohumeral arthritis in young patients. *TSA*, total shoulder arthroplasty.

Figure 1: ??

Humeral Arthroplasty without Glenoid Treatment

HHR

HHR has been proposed as an alternative to HA in younger pts as it preserves the intact native cartilage replacing only the focal defect in the humeral head. It avoids an anatomic neck cut thus preserving more proximal humeral bone stock. It also avoids stem placement reducing the risk of periprosthetic fracture in these younger active individuals likely to participate in sports. Whereas HHR has potential advantages, the procedure is technically demanding and there have been concerns regarding its ability to reliably reproduce the proximal humeral anatomy [20].

Mansat et al. placed resurfacing shoulder implants in 61 patients (64 shoulders) and demonstrated that HHR reproduced the normal joint anatomy with a tendency to position prostheses in varus.

In 2015, Levy et al. [21] evaluated 54 HHRs performed on patients younger than 50 years and reported favorable symptomatic and functional results with a minimum of 10-year follow-up (mean 14.5 years). Mean Constant Score (CS) improvement (10.5 to 62 points); pain scores improved (0.8 pre-operative to 13.8); and ROM improvement (pre-operative active FE 78–116°, ER 13–51°, and IR 13–47°). Patient satisfaction scores at final follow-up were 8.7 OF 10. Of note, ten of the 54 shoulders (18.5%) required revision arthroplasty secondary to rotator cuff failure (4), glenoid erosion (1), and traumatic fracture (1).

Hemiarthoplasty (stemmed and stemless)

It provides for anatomic humeral replacement and easy access to the glenoid for primary biologic glenoid treatment as well as later revision (newer modular designs allow easy removal) if needed.

Stemless HHR involves removal of the entire humeral head articular segment and implantation of an epiphyseal implant to which the modular head is attached.

Clearly surgeons have hesitation with placing a glenoid component in younger patients as highlighted by a study conducted by Griffin et al. [22].

There are clinical situations, such as AVN with unipolar changes and OA in young weightlifters or heavy laborers, in which the surgeons will lean toward the use of HA over TSA.

In fact much of the literature for HA in young patients has been for the diagnosis of AVN. The largest study (27 shoulders) for the same was conducted by Hattrup and Cofield [23]. At an average of 7.9 years of follow-up, the mean American Shoulder and Elbow Surgeons (ASES) Score was 63 for HA and 62 for TSA. There was no difference in ROM or rates of revision as well.

Much of the long-term survival and outcomes data for HA use in young patients comes from two studies out of Mayo clinic [24, 25]. The estimated 10 years, 15 years, 20 years HA implant survival rates were 82%, 75%, and 75%. At 15 years and 20 years follow-up, HA resulted in satisfactory Neer rating in only 40% and 27% of patients, respectively. Overall, 20 (26.6%) of the original 75 patients receiving an HA required a revision before the 20 year follow-up mark, with 64% (16 of 20) of these being for painful glenoid arthrosis. Results after conversion of failed HA to TSA have been unsatisfactory. Carroll et al. [26] in their series (16 pts, 5.5 years follow-up) noted that 7 (47%) of 15 pts had poor outcomes. This was similar to the Sperling and Cofield study [27], in which 39% had an unsatisfactory result due to lack of ROM or need for revision.

Humeral Arthroplasty with Glenoid Treatment

Anatomical TSA

As already discussed the gold standard for end-stage GHOA that has failed non-operative management is TSA. With improvements in prosthesis design more TSAs are being performed in younger and more active patients. Overall, TSA has shown a greater increase in use, with a 5-fold increase, compared with HA which has had only a 1.9-fold increase; but in this same study, patients with TSA tend to be older [19].

Robertson et al. [28] performed a systematic review of six studies looking at the outcomes of TSA in patients younger than 65 years. The average rates of revisions and complications were 17.4% and 9.4%, respectively, at an average of 9.4 years follow-up. The investigators concluded TSA can provide predictable pain relief and outcomes, but reported outcomes appear to be inferior to the TSA population as a whole.

Denard et al. [29] retrospectively reviewed 50 pts of OA who underwent TSA with keeled glenoid component at 55 years or younger. The CS improved from 37% to 73.4%. Overall survivorship which was as high as 98% at 5 years unfortunately dropped to 62.5% at 10 years. Other important observations noted were that glenoid components were 6 times more likely to loosen if the humeral head was not anatomically positioned. Glenoid morphology had a significant effect on survival as well; the 10 years survival for concentric glenoids was 87.5% and eccentric glenoids was 50%.

The study from Mayo clinic [24] reported survival rates for TSA OF 83.2% at a minimum of 20-year follow-up.

HA versus TSA

Several studies have specifically compared TSA with HA in younger patients [30, 31, 32]. Dillon et al. [30] conducted a retrospective cohort study (504 of 2981 shoulder arthroplasties in pts younger than 59 years). Younger pts had more than 2 times the risk of revision compared with older patients. These investigators therefore supported the use of TSA in younger patients.

Eichinger et al. [31] retrospectively reviewed patients younger than 50 years receiving an HA or TSA. The investigators found a failed outcome in 22% of HA compared with 7% for TSA. Furthermore, both implant survival (89% vs. 95%) and satisfaction (72% vs. 95%) were inferior with HA compared with TSA.

Bartelt et al. [7] evaluated a total of 66 shoulder arthroplasties (46 TSAs and 20 HAs) retrospectively, with a mean follow-up of 7 years. Implant survival was 100% at 5 years and 92% at 10 years for TSA compared with 85% and 72%, respectively, for HA. Pts receiving a TSA had a higher satisfaction (87% vs. 65%), greater forward elevation, and better pain relief. Glenoid erosion was seen in all HAs with 6 (46%) of 13 being moderate or severe.

Humeral HA with Biologic Glenoid Resurfacing

As shown by multiple studies above HA generally performed inferiorly to TSA in younger pts. However, TSA too has problems of long-term survival due to prosthetic glenoid complications (loosening and wear).

To circumvent above problems, it was hypothesized that combining humeral head replacement and glenoid resurfacing with biologic surfaces (anterior capsule, lateral meniscus, autogenous fascia lata, Achilles tendon allograft, and acellular dermal matrix) will limit glenoid attrition caused by HA alone and avoid premature TSA failure in young pts.

Only two early reports showed favorable results for patients undergoing biologic resurfacing. Krishnan et al. [32] reported on 36 shoulders that had biologic resurfacing with a 7-year follow-up. Eighteen had excellent results, 13 had satisfactory results and five had unsatisfactory results. Despite the theoretical advantage of preserving the glenoid, these patients had an average of 7.2 mm of glenoid erosion.

Wirth [33] reported that meniscal allograft with reaming of the glenoid to a concentric surface in 27 patients resulted in improved simple shoulder test and ASES scores at 3 years, but with progressive decrease in glenohumeral joint space.

In contrast, Strauss et al. reported on 45 patients (mean age of 42.2 years and mean follow-up of 2.8 years) who underwent biologic resurfacing of the glenoid with HA (31 lateral meniscus and ten acellular dermal matrix). They found a high failure rate of 51%.

Similarly Elhassan et al. reported on 13 pts with a mean age of 34 years who had a HHR and biologic resurfacing of the glenoid (11 Achilles tendon allograft, one fascia lata autograft, and one anterior shoulder capsule). Ten of 13 pts required revision as early as 14 months (mean).

In view of the above poor outcomes biologic resurfacing is presently out of vogue.

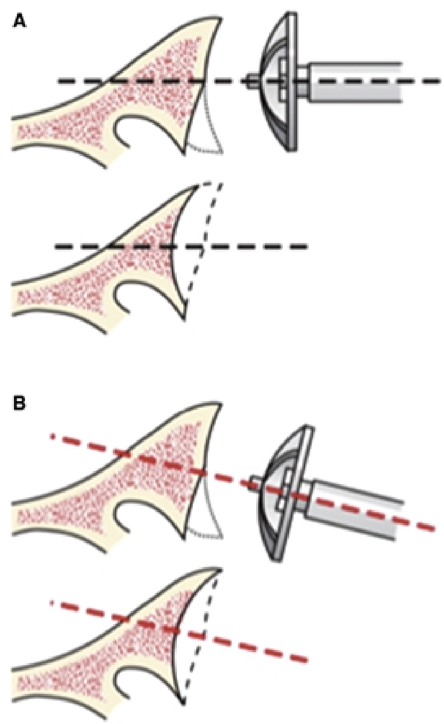


Figure 2: Concentric Reaming as per Matsen concept

Ream and Run

Glenoid morphology, such as glenoid retroversion and glenoid biconcavity, as well as humeral head posterior subluxation has been shown to increase the risk of glenoid loosening and clinical failures in both TSA and HA. These changes decrease the amount of available glenoid bone stock not only making glenoid component fixation during TSA difficult, but also if left uncorrected, can lead to eccentric glenoid loading, increased wear, and persistent posterior subluxation of the humeral head. This triad presents a complex clinical challenge for shoulder surgeons especially in younger patients. Ream and run arthroplasty was described by Matsen et al. [36] and that uses a traditional humeral prosthesis with concentric reaming of the glenoid (Fig 2). The radius of curvature of glenoid reaming is slightly larger than that of the humeral head, providing a concentric articulation, as well as stimulating fibrocartilage growth on the glenoid surface. The goal is not to completely correct glenoid retroversion, allowing glenoid bone stock preservation as well as allowing a more durable surface from the fibrocartilage stimulation.

Matsen et al. [37] showed significant improvement in function and pain (mean SST scores improved from 5 ± 3 pre-operative to 10 ± 4 post-operative)with ream and run arthroplasty in patients younger than 55 years. Only two of the 30 shoulders underwent revision surgery and both had history of instability repairs.

Clinton et al. compared functional outcomes between the ream and run procedure and TSA. They concluded that ream and run can reliably produce similar functional results offered by TSA although with more difficult and slow recovery times.

Whereas the described technique does not ream completely through the subchondral bone, there is some concern that excessive reaming into the subchondral bone will lead to progressive glenoid erosion and medialization of the glenohumeral joint. It is unclear how this will affect long-term outcome, but it might make subsequent placement of a glenoid prosthesis difficult if not impossible.

Future Frontiers in Shoulder Arthroplasty and Management of Shoulder Arthritis

Although most patients have excellent pain relief and functional outcomes with shoulder arthroplasty, long-term failure rates continue to be unacceptably high. Future areas that may improve implant survival include advances in surgical approach, such as subscapularis-sparing approaches, and computer-assisted surgical planning; advances in humeral component geometry and fixation, such as stemless, short stem, and convertible implants; advances in bearing surfaces, such as pyrocarbon, ceramic, and metal-on-metal; and advances in glenoid component geometry and fixation such as augmented components, in-growth pegs, and in-lay glenoid components.

Summary

Treatment of GHOA in young pts is still a challenge for shoulder surgeons. At present, there is no single arthroplasty option that is able to provide reliable pain relief and improve outcomes, without the increased risk of revision surgery. The surgeon has to therefore rely on available data and pt specific characteristics to formulate surgical treatment strategy.

TSA has been shown to be a superior, cost effective, and viable option compared to HA for most young pts with glenohumeral OA (low demand) with consistently good pain relief, satisfaction, and postoperative outcomes.

However, HA remains an alternative to TSA in patients who are unable or unwilling to stringently restrict activities in the postoperative period. HA is also ideally suited for AVN with unipolar changes.

A study by Franta et al. [39] examined the characteristics of 282 unsatisfactory shoulder arthroplasties. Glenoid-sided problems represented the vast majority of failures for both TSA and HA, confirming this as the “weak link” in shoulder arthroplasty.

Ream and run seems to be a reasonable option for high demand patients with glenoid arthritis. This technique provides an option for the subset of pts with eccentric glenoid wear, excessive glenoid retroversion and posterior humeral head subluxation in whom conventional TSA and HA have lower clinical outcomes.

HA with biologic glenoid resurfacing does not appear to be a viable option for young shoulder arthritis patients in view of poor outcomes and high failure rates.

HHR is a good option for unipolar and sectorial lesions in younger population but literature seems to point towards inferior outcomes as compared to stemmed HA.

Most of the arthroplasty options available today are providing good pain

relief and outcomes; however, each procedure has its own set of advantages and disadvantages.
The surgeon and the patient need to have a detailed discussion and select the best arthroplasty option based on expected outcomes and willingness to curtail physical activity in post-operative period with the aim of avoiding complications and increasing implant longevity.

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