Total Shoulder Arthroplasty for Primary Shoulder Osteoarthritis

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変形性肩関節症に対する
人工肩関節全置換術 (TSA) ②
Total Shoulder Arthroplasty for
Primary Shoulder Osteoarthritis ②

Gilles Walch and Xinning Li

A Purpose and Background

Arthritis affecting the shoulder includes osteoarthritis, rheumatoid arthritis, osteonecrosis, posttraumatic arthritis, cuff tear arthropathy, and post-capsulorrhaphy arthropathy. Primary osteoarthritis is the most common form and characterized as a slow progressing disease that leads to cartilage thinning and ultimately, complete cartilage loss resulting in bone on bone contact and pain. There are many risk factors for shoulder arthritis including age, sex, race, genetics, weight, trauma, dislocation, and history of previous surgery. The prevalence of shoulder arthritis increases with age and have a significant impact and burden on the world population and economy.[1] Treatment of shoulder arthritis includes pharmacotherapy, physical therapy, cortisone injections, and activity modification. Patients with persistent symptoms after conservative management will benefit with surgical intervention.

Although the first shoulder prosthesis was implanted in 1893 by the French surgeon Jules-Émile Péan,[2] the development of shoulder arthroplasty only started in the 1950's when Charles Neer[3] from Columbia University reported good results utilizing a vitallium shoulder replacement to treat comminuted fractures of the humeral head. During this time, several groups in both Europe and United States attempted to apply the concept of a constraint prosthesis utilized in hip replacements to total shoulder arthroplasty. However, this resulted in unacceptable rates of glenoid loosening, early component failure and poor clinical outcome with high revision rates.[4] Twenty years later, with the addition of a glenoid component, Neer presented excellent results and patient satisfaction after unconstraint total shoulder arthroplasty for the treatment of primary shoulder osteoarthritis.[5, 6] Since then there has been a progressive, evolutionary improvement in shoulder replacement culminating in the current day concept of anatomical reconstruction of the proximal humerus and glenoid.[7-11]

Today, unconstrained prosthetic arthroplasty of the shoulder is widely used to treat glenohumeral osteoarthritis, rheumatoid arthritis, and osteonecrosis with excellent and reproducible results.[12] Unfortunately, the results of unconstrained prostheses in complex proximal humeral fractures and in patients with cuff tear arthritis have been less predictable. Although good pain relief was usually obtained, most patients still had limited range of motion and difficulties with activities of daily living. These poor results lead to the development of specific implants for these difficult problems: a low-profile prosthesis for

fractures and a semi-constrained reversed shoulder prosthesis for cuff tear arthritis.[7, 13] This chapter will focus on total shoulder arthroplasty for primary glenohumeral osteo-arthritis. Specifically, the following sections will outline patient evaluation, indications, preoperative planning, surgical techniques and postoperative protocols.

B Patient Evaluation and Surgical Indications

1 Patient Presentation

Most patients will complain of insidious onset of shoulder pain that is typically deep seated and characterized as a dull ache that is activity related. A comprehensive medical and surgical history is invaluable in the diagnosis of shoulder arthritis. This should include the onset and duration of symptoms, aggravating or alleviating factors, previous injuries or surgeries, medication use (steroid) or alcohol use, and family history of musculoskeletal conditions. Stiffness and progressive loss of function are common among patients with osteoarthritis. Patients with mild to moderate arthritis may have limitations in function at the extremes of range of motion, i.e. overhead activities or reaching for objects on a shelf. When the arthritis is severe, the patient will have difficulties performing activities of daily living including dressing, personal hygiene, and hair washing. Night pain is another common symptom in patients with shoulder arthritis. Furthermore, these patients frequently will have cervical arthritis and complaint of both neck and shoulder pain. It is essential to rule out symptoms relating to the cervical disease that can often mimic primary glenohumeral disorder.

2 Examination

Physical examination should include evaluation of the bony prominences, shoulder contours, deformity, and muscle atrophy. Neck examination accessing range of motion and Spurling test is essential to exclude any cervical pathology that may present as shoulder pain. Both passive and active shoulder range of motion in forward flexion, abduction, internal and external rotation should be assessed and documented. It is also essential to compare the range of motion of the affected shoulder with the contralateral shoulder. Preservation of the passive range of motion with loss of active forward flexion may indicate a dynamic problem and possible rotator cuff tear. When the arthritis is in the advanced stage, the patient may present with severe loss of both passive and active range of motion in all planes. Patients will have painful crepitus, joint swelling, and audible grinding when mechanical stress is placed on the shoulder. Neurologic sensory and motor function should also be evaluated along with muscle strength. Most patients with arthritis will have normal strength with abduction and external rotation when testing is performed in the lower degrees of scaption. Other etiologies should be excluded including morning stiffness which may suggest rheumatoid arthritis, or intense inflammation and erythema which can be caused by infection, gout, or pseudo-gout.[14]

3 Nonsurgical Treatment

Patients with mild to moderate shoulder osteoarthritis initially should be managed with conservative treatment methods. This includes activity modification, anti-inflammatory medications, physical therapy, pool therapy, and moist heat. In patients with mild OA, physical therapy maybe use to help improve range of motion and strength. However, patients should not do any exercise that

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will exacerbate their pain and increase their symptoms. Oral anti-inflammatory medications (NSAIDs) should be the first line of systemic medical treatment for patients with OA. Both conventional NSAIDs and cyclo-oxygenase-2 selective inhibitors are effective in decreasing shoulder pain.[15] Long-term risks include irritation of the stomach lining, ulcers, and kidney failure. Patients should be informed of these possible short or long-term side effects before taking the medications. Cortisone injections can also be helpful for patients who are interested in delaying surgery. Recent clinical trials have reported short-term efficacy (up to 6 months) in pain relief and functional improvement in patients with mild shoulder arthritis after viscosupplementation with hyaluronic acid treatment (Hylan G-F 20). Merolla et al[16] reported significant improvement in both the Visual Analog Scale (VAS) for pain and satisfaction and Constant-Murley scores in patients after the HA injection that lasted greater than 6 months. In the group of patients that had the corticosteroid injection, the effects lasted only one month. Overall, results were better in both groups when the patients presented with mild osteoarthritis and without any full thickness rotator cuff tear.

④ Surgical Treatment of cut

The main indication of surgery for patients with shoulder OA is pain and functional limitation that persists after conservative management. Total shoulder arthroplasty is the standard surgical treatment in patients with primary glenohumeral osteoarthritis. Other surgical interventions are also available for younger patients with shoulder OA. This include arthroscopic or open debridement, biologic resurfacing of the glenoid, microfracture, osteochondral autograft transplantation, resection arthroplasty, and gleohumeral ar-

throdesis. However, pain relief and functional outcome improvement is more predictable after total shoulder arthroplasty. Contraindications to total shoulder replacement include active infection, young age and high activity level, massive rotator cuff tear, glenoid retroversion > 30 degrees, posterior humeral subluxation >80%, and non-compliant patient. Advanced age is not a contraindication to shoulder arthroplasty, given if the pain warrants the surgery and the patient is medically able to tolerate the procedure.

Recent long-term outcome studies have reported survivorship of the total shoulder prosthesis at 97% after 10 years and 84% after 20 years.[17, 18] Several prognostic factors affect the outcome after total shoulder arthroplasty. Small rotator cuff tears when involving only the supraspinatus tendon does not affect the long-term outcome of TSA. Furthermore, repairing the cuff tear at the time of surgery does not change the functional outcome results.[19] Another factor to consider is the long head of the biceps tendon. Over 30% of patients with primary OA will have an abnormal biceps (partial tear, delamination, hypertrophy, etc.) at the time of surgery. Biceps tenodesis will reduce pain and improve outcome after TSA and is routinely performed by the senior author. Severe fatty infiltration and atrophy of the infraspinatus muscle is associated with decrease in mean active elevation and functional results in patients after TSA.[20] Complications include infection, glenoid loosening, instability, subscapularis tendon rupture, fracture, humeral stem loosening, radiographic lucencies on either the glenoid or the humeral side, and neurological complications. With advancement in technology and surgical technique, the overall complication rate is less than 10%.[12]

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Figure 1

Anteroposterior radiograph in the scapular plane (Grashey View) demonstrating joint space narrowing, inferior humeral head osteophyte formation and glenoid wear. Proximal humeral head migration is not observed which indicates that the rotator cuff is likely intact.
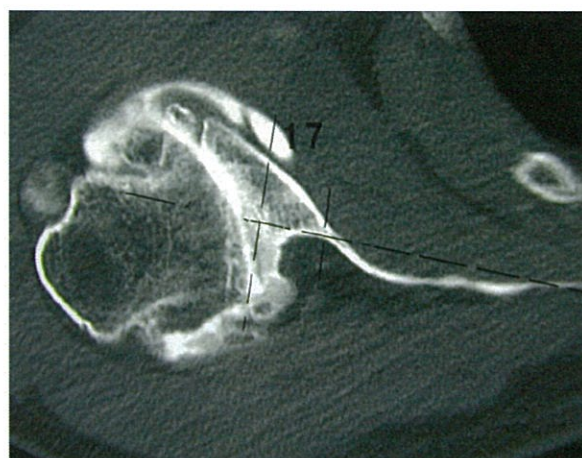

Figure 2

CT scan in the axial plane demonstrates cartilage loss and glenoid wear. Retroversion of the glenoid measures 30 degrees which is classified as Walch C glenoid. Posterior humeral head subluxation is also measured in the axial plane on the CT scan. The depth of the glenoid vault should also be measured in both the axial and coronal views.

C Preoperative Preparation and Surgical Setting

1 Radiographs

Preoperative planning must include shoulder radiographic series consisting of anteroposterior view in the plane of the scapula (Grashey view), AP view in internal and external rotation, and axillary view. Hallmark of shoulder osteoarthritis is joint space narrowing, osteophyte formation, and posterior glenoid wear **(Figure 1)**. In patients with large rotator cuff tears, proximal humeral head migration with acetabulization of the acromion may be observed. Routine CT scans should also be obtained in all patients before total shoulder arthroplasty (TSA) to evaluate for glenoid bone stock, version, and humeral head subluxation **(Figure 2)**. Deformation of the glenoid associated with OA has been classified by Walch et al[21] (Type A1, A2, B1, B2, and C) and shown to have an effect on the surgical outcome after TSA **(Figure 3)**. Both range of motion and functional outcome are significantly lower after TSA in patients with either a biconcave glenoid (Walch B2) or glenoid version >25 degrees (Walch C).[20] It is essential to know the glenoid version and depth of the glenoid vault before surgery to properly plan for the insertion of the glenoid component. Furthermore, in patients with Walch B2 or C glenoid, a reverse shoulder arthroplasty should be considered.[22]

D Surgical Technique

1 Preoperative Antibiotics / Anesthesia

Total shoulder arthroplasty should be performed either under general anesthesia or regional block and sedation. All patients should receive one dose of weight-based antibiotics prior to the skin incision. Typically, 1 to 2
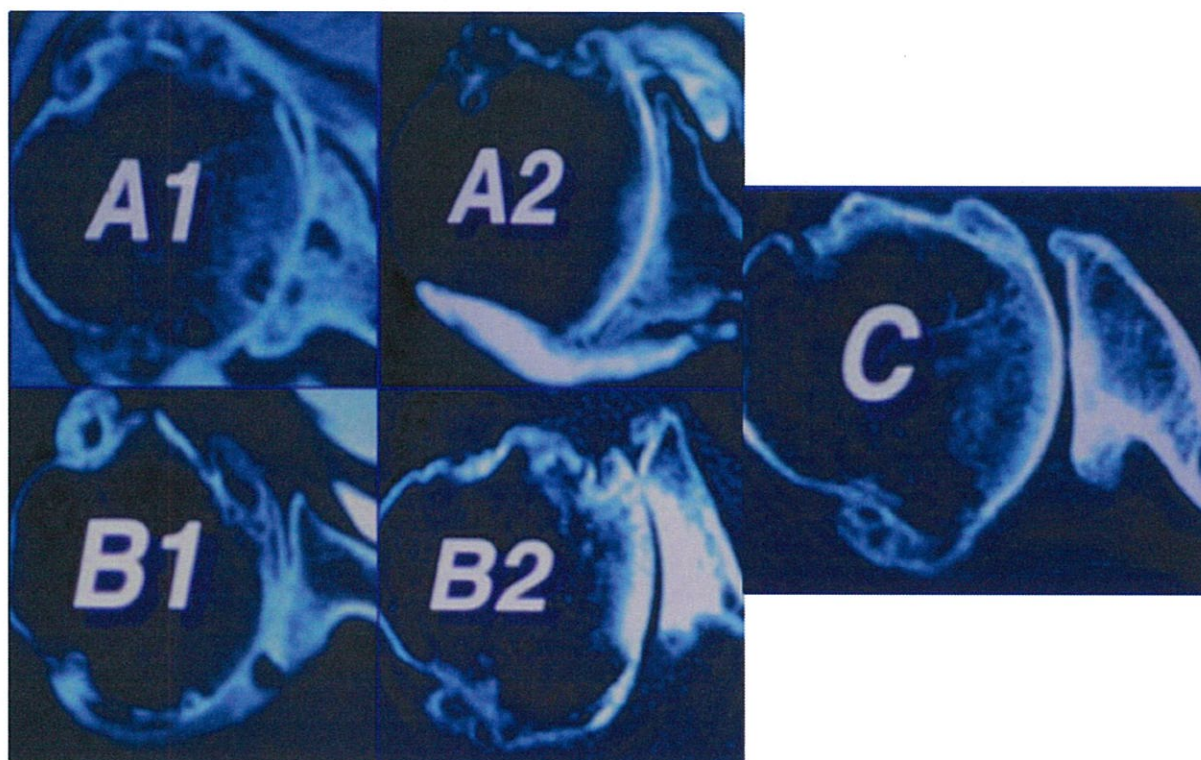
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Figure 3 ●●●●●▱●●●●
Walch classification of Glenoid morphology in patients with glenohumeral arthritis. Walch A is a centered humeral head on the glenoid. The amount of central bone wear seperates A1 from A2. Walch B is a humeral head with posterior subluxation and B2 glenoid have biconcave wear. Walch C glenoid is retroversion > 25 degrees.

grams of intravenous cefazolin is adequate, however in patients with allergies to penicillin, clindamycin or vancomycin can be used as alternatives.

② Positioning

The patient is placed on the operating table on a beach chair in the supine position. After the induction of anesthesia, the patient is brought up into an upright position (45-60 degrees). The operative shoulder should be just lateral to the edge of the table to facilitate exposure. The shoulder and arm is prepped in the usual sterile fashion with either Betadine solution or Chlorhexadine solution. In a recent Cochrane review, Dumville et al[23] found some evidence that preoperative skin preparation with 0.5% chlohexidine solution led a reduced risk of surgical site infection compared to the alcohol based povi-

done iodine solution. After the sterile prep, the arm is either placed in either an arm holder (Spider limb positioner, Smith and Nephew, USA) or laid on an arm support attached to the beach chair. It is essential that the arm can be adducted, extended, and externally rotated after the final set up so that the surgeon can access the humeral canal for broaching and placement of the prosthesis.

③ Approach

The preferred approach of the senior author is the extended deltopectoral approach. An incision is made starting at the coracoid process and extended down distally and laterally for 10 to 15 cm towards the mid aspect of the humerus **(Figure 4)**. Sharp dissection is then employed through the subcutaneous tissues down to the fascia overlying the deltoid. The interval is best identified on the superior
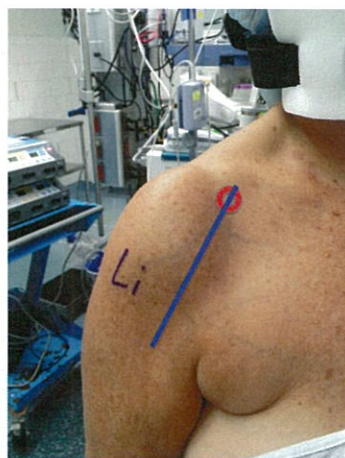
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Patient is positioned on a beach chair and brought up to an upright position (45 to 60 degrees). The coracoid is marked (red circle) and the deltopectoral incision is centered over the coracoid and extended down 10 to 15 cm to the mid aspect of the humerus (blue line).
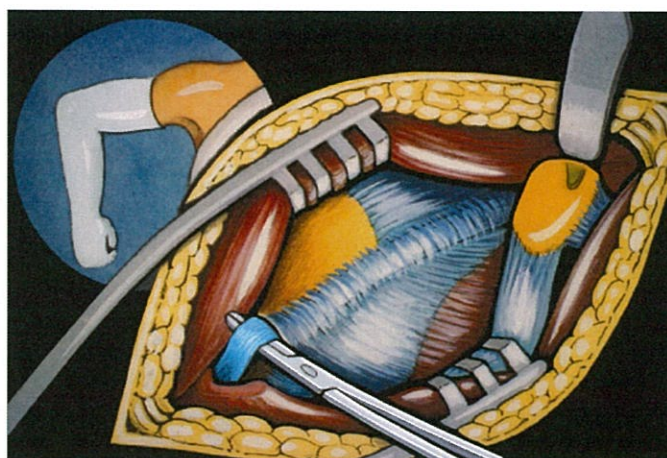

Figure 5
The biceps tendon is identified underneath the pectoralis major muscle. Both the lesser and greater tuberosity are visualized.

portion of the incision. There will be a small triangle of tissue devoid of muscle tissue between the pectoralis major and deltoid just below the clavicle. The subcutaneous flaps are then mobilized with sharp dissection of the deltopectoral interval and subsequent release of the subdeltoid plane is performed with the arm in abduction with curved Metzenbaum or Mayo scissors. A Browne retractor is placed under in the subdeltoid space to expose the shoulder along with the subscaplaris tendon and lesser tuberosity. Identifying the biceps tendon underneath the pectoralis major tendon is the key step in finding the interval between the greater and lesser tuberosity **(Figure 5)**. The biceps tendon is elevated out of the bicipital groove, dissected proximally and tenotomized at its origin. It is then brought out distally and tenodesed into the upper border of the pectoralis major muscle using interrupted #2 Ethibond sutures. The extra length of the tendon is removed with scissors or #15 scalpel.

④ Lesser Tuberosity / Subscapularis tendon

Exposure of the glenohumeral joint for implanting the prosthesis can be done through a subscapularis tenotomy, subscapularis peel, or lesser tuberosity osteotomy. Randomized controlled trial evaluating over 80 patients comparing subscapularis peel versus lesser tuberosity osteotomy showed no significant differences in subscapularis muscle strength and functional outcome at the two year follow-up time period.[24] The senior author's preferred method of exposure is the subscapularis peel. After identifying the lesser tuberosity, the entire subscapularis tendon is peeled off starting at the intertubercular groove. Two sutures are used to tag the subscapularis tendon **(Figure 6)**. Following the arthroplasty, the tendon will be repaired with three non-absorbable mattress transosseous sutures into the humeral shaft **(Figure 7)**. Alternatively, a lesser tuberosity osteotomy is done with a half-inch curved osteotome. A fragment of the lesser tuberosity (~5-10 mm

Figure 6
Two sutures are placed into the subscapularis tendon in a horizontal mattress fashion to help facilitate with the subscapularis peel or tenotomy.

Figure 7
Subscapularis tendon peel is repaired back to the humeral shaft with transosseous non-absorbable sutures at the end of the procedure.
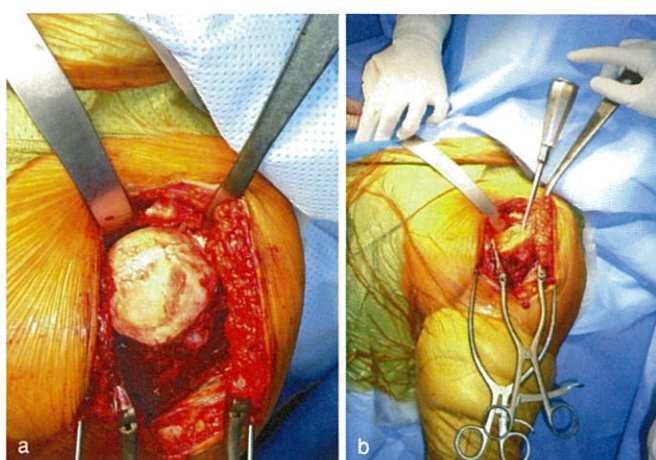

Figure 8
a: After the subscapularis peel and release, capsular release around the humeral shaft, the humeral head is dislocated anterior with adduction, extension, and external rotation of the arm.
b: The starting position of the axial reamer is found superiorly and in-line with the humeral shaft.

thick and ~2cm in length) is elevated and then repaired back onto the lesser tuberosity with three #5 FibroWire sutures in a transosseous fashion. After the subscapularis peel or lesser tuberosity osteotomy, the capsule on the humeral side is released with the electrocutery to facilitate exposure. The capsular release should extend inferiorly to the superior edge of the latissmiss dorsi tendon.

⑤ Humerus Preparation

The humeral head is dislocated with progressive arm external rotation with or without the assistance of blunt cobra retractors placed in the joint for leverage **(Figure 8a)**. Marginal osteophytes around the humeral head is resected or trimmed down with either a curved osteotome or Rongeur to help define
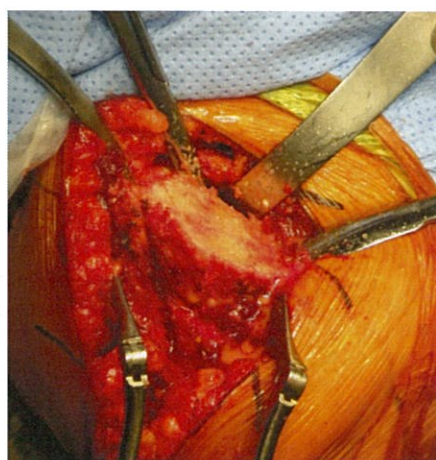
Figure 9 ●●●●●●●●●●
The humeral head is resected anatomically along the head neck junction restoring the native anatomy.
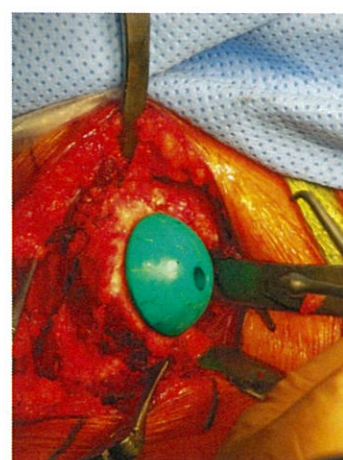

Figure 10 ●●●●●●●●●●
An eccentric head trial component is used to match the height and size of the humeral head. It is essentially to restore the head to tuberosity distance of 5 to 10mm with the final component.

the anatomical neck. Resection of the humeral head is done along the anatomical neck with an oscillating saw **(Figure 9)**. Alternatively, both an intra and extra humeral medullary guide can be used to assist in the resection of the humeral head. The retroversion is typically set between 20 to 30 degrees depending on the native anatomy. The starting point of the humeral canal is identified and axial reamers/broaches are used to prepare the humeral canal for the prosthesis insertion **(Figure 8b)**. The trial component is then inserted and the humeral head is sized. Either an eccentric or concentric trial humeral head is selected and rotated on the humeral trial component until a concentric fit is achieved **(Figure 10)**. It is essential to restore the head to tuberosity distance (5 to 10mm) without any posterior overhang. Once the humeral head and prosthesis is selected, a humeral head protector is placed to protect the proximal humeral metaphysis during the glenoid exposure.

6 Glenoid Exposure

A Fukuda retractor is inserted to displace the metaphysis posteriorly. The subscapularis is globally released superiorly, inferiorly, and under the coracoid with a curved Mayo scissor **(Figure 11)**. Subsequently, the subscapularis is pushed into the fossa and a spiked ribbon retractor is placed on the anterior glenoid to retract the subscapularis medially and expose the glenoid. An angled retractor or pointed hohman is placed on the superior aspect of the glenoid to further facilitate exposure **(Figure 12)**. At this time, the labrum is circumferentially excised along with the stump of the biceps tendon **(Figure 13)**. Additional release of the inferior capsule is done with an electrocautery. It is essential to stay on the inferior glenoid bone during the inferior capsule release to avoid injury to the Axillary nerve. If more glenoid exposure is needed, the triceps origin, latissimus dorsi tendon or the pectoralis major tendon can also be released.

7 Glenoid Preparation

A guidewire is drilled down the center of the glenoid inline with the glenoid vault **(Figure 14)**, and then using the appropriate reamers, the glenoid is reamed to a uniform concave surface **(Figure 15)**. The guidewire

Figure 11
The subscapularis is globally released superiorly, inferiorly, and under the coracoid with a curved Mayo scissor.

Figure 12
Retractor positions and glenoid exposure. Fukuda retractor posteriorly, pointed Hohman is placed superiorly, pointed ribbin or anterior bankart retractor is placed in the subscapularis fossa, and a double pointed (Bunny ear) retractor is placed inferiorly on the glenoid.

is removed, and either peg holes are drilled for a peg component or a central trough is created for a keeled component **(Figure 16)**. There has been no scientific analysis that has shown that one configuration is better than the other.[25, 26] Throckmorton et al[25] reported no difference in the initial postoperative radiolucent lines between the pegged versus keeled glenoid components. The lucencies did progress over time, but the final incidence is very low (8-10%) with >2 years of followup and no difference in the final clinical outcome.

The trial glenoid component is inserted to evaluate the fit. It is important to look at the backside of the trial component to make sure it is flush with the native glenoid. The glenoid is then prepared with pulsatile lavage and epinephrine-soaked Ray-Tec sponges to prevent bleeding before cementation. The cement is then injected into each peg hole or the keeled area and manually pressurized. The remainder of the cement is painted onto the back of
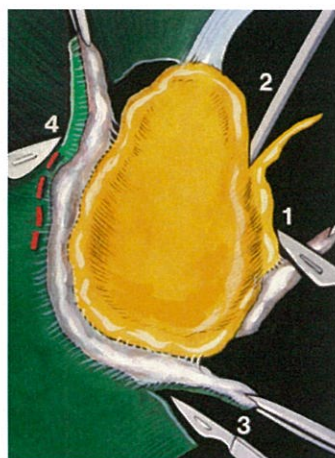
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Figure 13 ●●●●●●●●●●●
The labrum and residual biceps tendon stump is released circumferentially around the glenoid to further facilitate the exposure.

Figure 14 ●●●●●●●●●●●
A guide wire is drilled down the center of the glenoid inline with the glenoid vault.
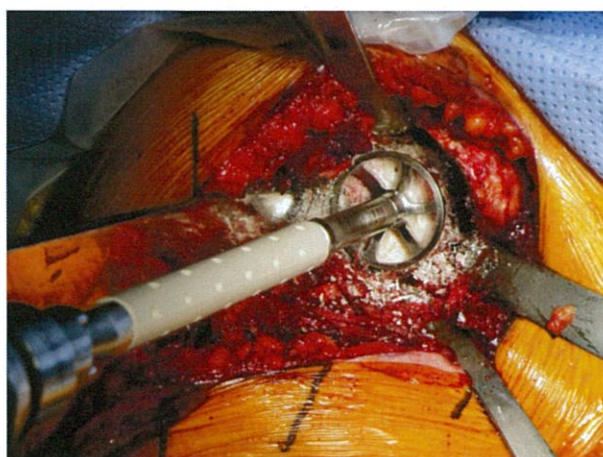

Figure 15 ●●●●●●●●●●●
Using the appropriate reamers, the glenoid is reamed to a uniform concave surface.

the glenoid component. After drying the face of the glenoid, the component is inserted and impacted down. Manual pressure is maintained while excess cement is removed with the curved curettes. Once the cement has completely hardened, the glenoid is inspected to make sure that the component is well seated **(Figure 17)**.

⑧ Implant of Final Prosthesis:

The humerus is dislocated anteriorly and the trial broach is removed. Three #5 Fiber-Wire sutures were placed through the metaphysis for repair of the subscapularis tendon or the lesser tuberosity. The final component is then inserted after pulsatile lavage irrigation of the humeral canal **(Figure 18)**. The humerus is then reduced onto the glenoid. The subscapularis tendon or the lesser tuberosity is repaired anatomically with the transosseous sutures with additional #5 Ethibond sutures used to close the lateral part of the rotator interval. The incision is
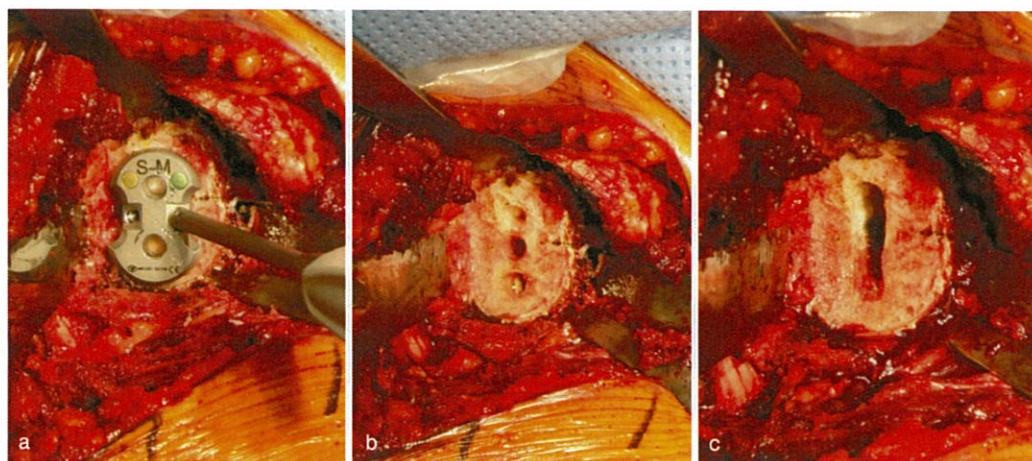
Figure 16 ●●●●▤●●●●
The guide wire is removed, and either peg holes are drilled for a peg component or a central trough is created for a keeled component. Figure 16a demonstrates the glenoid guide for the preparation of a keeled component (Tornier Inc), which is the preferred method of the senior author. Both the superior and the inferior holes are drilled (16b). The trough is completed with either a Ronguer or Burr (16c).
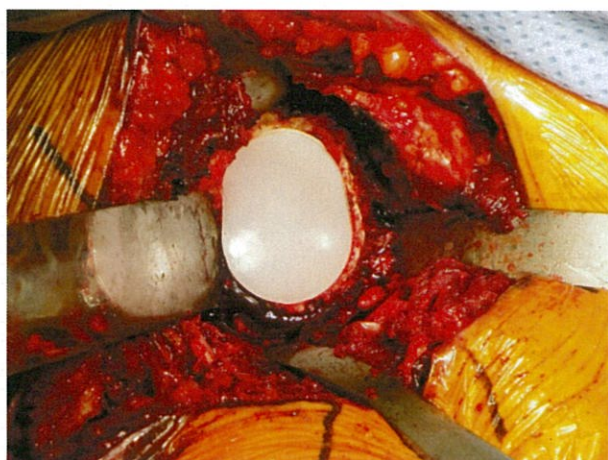

Figure 17 ●●●▤●●●●
The final glenoid component is well seated on the glenoid surface. Manual pressure is held onto the glenoid until the cement is hardened.

Figure 18 ●●●▤●●●●
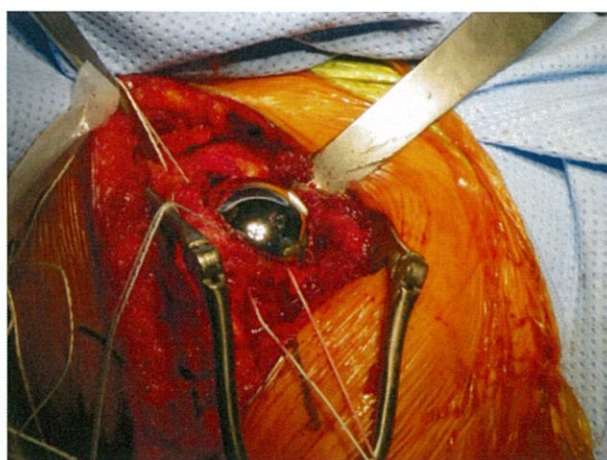Insertion of the final humeral component and then reduction of the humeral head onto the glenoid. The three non-absorbable sutures are placed in the humerus for the transoseous repair of the subscapularis peel.

then closed with vicryl sutures and running subcuticular monocryl sutures. Sterile dressing is applied and the arm is placed in an Ultra sling immobilizer.

E Tips and Pearls

1) CT scan to evaluate for glenoid version and depth of glenoid vault is essential for preoperative planning.
2) Patients with severe Walch B2 or C glenoid morphology may benefit with reverse shoulder arthroplasty.
3) No difference in outcomes between subscapularis peel and lesser tuberosity osteotomy.
4) Biceps tendon is best identified under the pectoralis major tendon.
5) Release the subscapularis tendon in three

regions, superior, inferior and under the Coracoid to maximize glenoid exposure.

6) Resect the marginal osteophytes around the humeral head to identify the head-neck junction. Anatomic resection of the humeral head with oscillating saw.

7) Release the inferior capsule and/or triceps origin to improve glenoid exposure.

8) If additional glenoid exposure is needed, then partial release of the latissimus dorsi or pectoralis major tendon maybe performed.

9) Maintain the subchondral glenoid bone

to minimize future glenoid component loosening.

10) Restoring the head to tuberosity distance essential to maximize outcome.

11) Repair the subscapularis peel or lesser tuberosity osteotomy with non-absorbable sutures in a transosseous fashion.

12) Passive range of motion can be started immediately after surgery, however, external rotation should be limited until the subscapularis tendon or lesser tuberosity is healed.

F Postoperative Protocol

The postoperative protocol is standardized including immediately passive range of motion followed by active assisted mobilization and then using the shoulder for activities of daily living. Total rehabilitation time is 3 months and at any time, it should not cause pain to the patient. During the first 4 weeks, the arm is in a sling with or without an immobilizer. Passive range of motion is started with limitation to external rotation (20-30 degrees depending on intra-operative subscapularis tension after repair). The second phase of the rehab program is between week 4 to 8 and emphasis is placed on active-assisted and active range of motion. Patient may discontinue the sling between week 4 and 6 depending on progress. Activities of daily living may also be started during the second phase, however no strengthening is allowed. During the third phase between weeks 8 and 12, the patient may start light strengthening exercises with pulley and weights less than 5 pounds. Patients can drive a car after 1-2 months, swim after 3 months, and engage in home repair and gardening activities after 6 months. Sporting activities such as golf, tennis, skiing are possible after 12 months. Patients will regain on average around 150 degrees of forward elevation with optimal functional results 12 months after surgery.

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