18

Cuff Tear Arthropathyに対するリバース型人工肩関節置換術(RSA)②

Reverse Shoulder Arthroplasty: Indications and Techniques②

Gilles Walch and Xinning Li

A Purpose and Background

Glenohumeral arthritis includes osteoarthritis, rheumatoid arthritis, and post-traumatic arthritis has been treated successfully with total shoulder arthroplasty for many years.[1-3] In 1974, Dr. Neer[3] reported the first series of patients who were successfully treated with anatomically designed total shoulder prosthesis. Despite the initial success, a small subset of patients did not have satisfactory outcomes with this prosthesis and had unacceptable failure rates.[3-5] These patients typically presented with a chronic and massive rotator cuff tear in addition to advance stage arthritis. This condition is called cuff tear arthropathy (CTA) which was scribed by Neer et al[6] in 1983. The inciting event of CTA is a massive rotator cuff tear that alters the biomechanics of the shoulder leading to the development of degenerative arthritis. In addition, both nutritional and mechanical factors cause atrophy of the glenohumeral articular cartilage and osteoporosis of the subchondral bone of the humeral head in patients with CTA. Massive and chronic tear of the rotator cuff with retraction may result in severe atrophy and fatty infiltration of the cuff musculature preventing surgical repair.[7, 8] Without the compressive action of the rotator cuff, when the patient abducts the arm, there is unopposed contraction of the deltoid muscle creating a force vector that causes the humeral head to displace superiorly. The radiographic hallmark of CTA is proximal humeral head migration, joint space narrowing, glenoid erosion and articulation of the humeral head with the undersurface of the acromion which will eventually lead to acetabulization of the acromion.[9, 6] Although these patients made up a small percentage of those with glenohumeral arthritis, they present with reconstructive difficulties and compromised outcome when treated with a conventional unconstraint total shoulder arthroplasty.

Recognizing that without proper rotator cuff function, active arm elevation would be severely limited in patients with CTA. Several investigators both in Europe and the United States experimented with constrained and semiconstrained total shoulder designs. The goal was to provide a fixed-fulcrum prosthesis that would allow the deltoid muscle to raise the arm while the prosthesis remained stabilized. These early designs met with limited success, with most complications associated with poor glenoid fixation and early loosening which ultimately led to failure.[10-14] Most early designs featured a glenoid component that lateralized the glenohumeral center of rotation resulting in a significant moment arm and shear forces being placed on the gle-

noid component as the deltoid muscle pulls superiorly on the humerus. In addition, the high degree of constraint imposed by these prostheses also contributed to loosening. In response to the high failure rates, constrained and semiconstrained shoulder prostheses were largely abandoned, and many surgeons moved to hemiarthroplasty for patients with CTA with limited-goals rehabilitation.[15-17]

The original reverse shoulder arthroplasty was introduced in the 1970s which had minimal clinical success due to the constraint design and lateralized center of rotation that led to excessive shear forces and catastrophic failure of the glenoid component.[18] In 1987, Grammont et al[19] revolutionized the design of the reverse shoulder prosthesis by increasing the radius of curvature of the glenosphere and moving the center of rotation medially and distally. Recent literature has reported excellent outcomes in patients after the reverse shoulder arthroplasty for CTA.[18] In addition to the treatment of CTA, the success of reverse total shoulder arthroplasty has led to expanding indications to include failed total shoulder arthroplasty, proximal humerus fracture (3 or 4-part) in the elderly, and tumor reconstruction. Despite the popularity of the reverse shoulder, the surgeon must be cognizant of the complication rates, survivorship of the prosthesis and the limited long-term functional outcome data available in the literature.[18]

B Patient Evaluation and Surgical Indications

① Patient Presentation

Cuff tear arthropathy tends to affect the elderly with women more likely to present with this condition than men.[20, 21] Most patients will complaint of insidious onset of chronic shoulder pain with progressive loss in range of motion and strength. The pain is typically increased with activities and can be either sharp or dull in nature depending on the inciting etiology (cuff tear or arthritis). Night pain is very common and patients may have difficulties sleeping; either falling asleep or waking up throughout the night. Depending of the severity of the disease, patients maybe unable to perform overhead activities (unable to lift arm) or use the hand away from the body. In addition, activities of daily living (brushing hair, feeding, driving, etc.) maybe compromised. It is essential to obtain the patient's medical and surgical history including any history of inflammatory arthritis, infection, gout, previous history of rotator cuff tear, trauma, dislocation or fracture. 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 cervical disease which can often mimic CTA and primary glenohumeral disorder.

② Examination

Physical examination should include evaluation of the bony prominences, shoulder contours, deformity, and muscle atrophy. Neck examination assessing the 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. Patients with CTA will have classic signs of rotator cuff tear in addition to atrophy of the supraspinatus and infraspinatus muscle. This is best visualized from the back with the

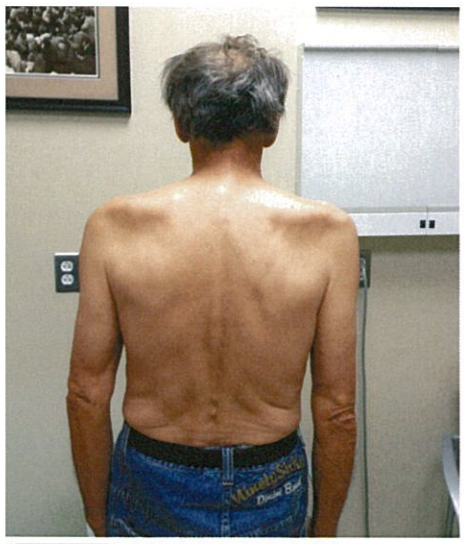

Figure 1
Examination of p[illegible] with rotator cuff tear arthroplasty in bilateral shoulder and severe atrophy in both the supraspinatus and infraspinatus.

shirt off, thus it is essential to have the patient expose the shoulder during physical examination **(Figure 1)**. Excessive fluid build up under the subdeltoid space or intra-articular joint space may lead to an inflated or swelling appearance of the shoulder. Range of motion (ROM) examination may reveal a loss of active ROM with preservation of passive ROM leading to pseudoparalysis of shoulder elevation. Both passive and active external rotation (ER) should be evaluated at 0° and 90° abduction. Patients presenting with active ER less than neutral and passive ER of greater than 45 degrees with a lag sign may benefit from a muscle transfer in addition to the reverse shoulder arthroplasty. Another important finding is anterosuperior instability or escape of the humeral head with arm elevation which signifies a subscapularis rupture. An internal rotation drop sign maybe also be present when the patient attempts to bring the hand up to the mouth (horn blower's sign). The presence of this sign usually indicates involvement of the infraspinatus or teres minor muscle. When the arthritis is in the advanced stage, the patient may present with severe loss of range of motion in all planes. Neurologic sensory and motor function should also be evaluated along with muscle strength.

3 Nonsurgical Treatment

Patients with mild to moderate symptoms initially should be managed with conservative treatment methods. This includes activity modification, anti-inflammatory medications, physical therapy, pool therapy, and moist heat. Physical therapy maybe use to help improve range of motion and strength. However, patients should not do any exercise that will exacerbate their pain and increase their symptoms. Exercises should focus on maintaining motion and strengthening the remaining structures; teres minor, subscapularis, and deltoid muscles. Oral anti-inflammatory medications (NSAIDs) should be the first line of systemic medical treatment. Both conventional NSAIDs and cyclooxygenase-2 selective inhibitors are effective in decreasing shoulder pain by inhibiting inflammation. Long-term risks include irritation of the stomach lining, ulcers, and kidney failure. Pa-

tients should be informed of the possible short or long-term side effects before taking the medications. Cortisone injections will also help to minimize inflammation, decrease fluid production, and facilitate pain control. It can be use up to three times within a one year period in patients who are interested in delaying surgery. However surgical treatment should be indicated in patients requiring more than three cortisone injections.

4 Surgical Treatment

The main surgical indication for patients with CTA is pain and functional limitation that persists after conservative management. Reverse shoulder arthroplasty is the standard surgical treatment in patients with CTA. Other options including hemiarthroplasty are available for patients with compromised glenoid bone stock; however, the pain relief along with postoperative outcomes and range of motion is unpredictable and inferior to the reverse arthroplasty.[22] Multiple studies on the modern day design reverse shoulder arthroplasty have reported excellent range of motion, pain relief and functional outcomes for patients with CTA.[22-26] The most predictable and optimal outcomes after the reverse shoulder arthroplasty is seen in patients who present with pseudoparalysis and pain.[27]

Other indications include:

1) Osteoarthritis with massive rotator cuff tear
2) Massive rotator cuff tear in the elderly without arthritis
3) Failed rotator cuff repair
4) Failed hemiarthroplasty or total shoulder arthroplasty
5) Proximal humerus fracture (3 or 4-part) in the elderly patient
6) Osteoarthritis with Walch B2 or C glenoid
7) Shoulder instability with glenoid wear or erosion in older patients
8) Rheumatoid arthritis
9) Posttraumatic arthritis and fracture sequelae
10) Chronic and recurrent shoulder instability
11) Proximal humerus resection (tumor) and reconstruction

Contraindications to reverse shoulder arthroplasty include active infection, young age and high activity level, compromised glenoid vault preventing implantation of the glenospheree component, and non-compliant patient. *Absence of deltoid functioning is an absolute contraindication*. In the United States, the FDA approved the reverse shoulder arthroplasty in 2004 to be utilized in patients over the age of 70 with cuff tear arthropathy. However, with the recent expanding indications and advances in implant design, patients younger than 70 maybe good candidates for a reverse arthroplasty based on the presenting etiology. Complications reported in the literature is variable and up to 50% depending on the study. Wall et al[28] reported an overall postoperative complication rate of 12.6% in 363 primary reverse shoulder arthroplasties. The most frequent complication is instability (3.3%), humeral fracture or loosening (2.8%), glenoid loosening (2.5%), and infection (2.2%). In addition, a common radiographic complication after the reverse arthroplasty is scapular notching. However, it is controversial as to whether the notching has a detrimental effect on clinical outcomes.[29-34] Few studies have evaluated the long-term survivorship of the reverese shoulder. Favard et al[35] retrospectively reviewed 527 reverse shoulders with a mean of 7.5 years of follow-up. The overall survivorship free of revision was 89% at 10 years. Radiographic notching progressed over time in size and the Constant-Murley score deteriorated over time.

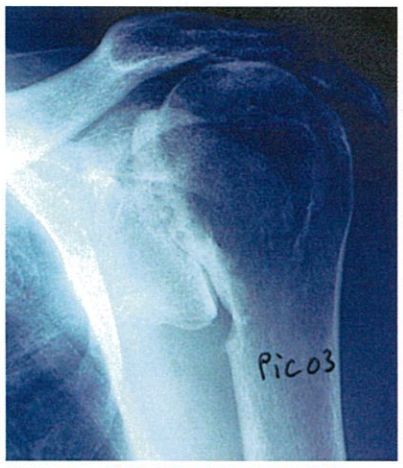

Figure 2
Anteroposterior shoulder radiograph demonstrating proximal humerus migration, osteophyte formation on the inferior humeral head, joint space narrowing, actabularization of the acromion, and eccentric bone wear of the proximal superior glenoid.

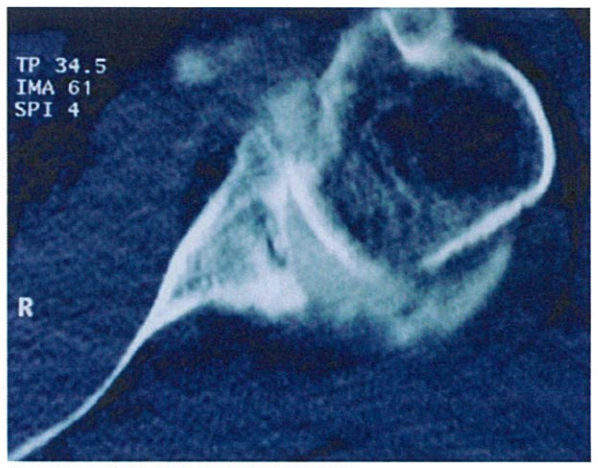

Figure 3
CT scan in axial view showing biconcaved glenoid with severe posterior glenoid bone loss.

Similar results were also reported by both Guery et al[36] and Sirveaux et al.[27]

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, scapular Y and axillary view. In addition, patients with significant proximal humeral deformity or destruction, full-length AP comparison views of both the affected and contralateral humerus can be helpful for preoperative template to help restore normal humeral length and deltoid tension. Hallmark of CTA is joint space narrowing, proximal humeral head migration with osteophyte formation, decreased humeral head to acromion distance, and glenoid wear **(Figure 2)**. Routine CT scans should also be obtained in all patients before reverse shoulder arthroplasty to evaluate for glenoid bone stock, version, and humeral head subluxation **(Figure 3)**. Deformation in the morphology of the glenoid associated with arthrits has been classified by Walch et al[37] (Type A1, A2, B1, B2, and C) and shown to have an effect on the surgical outcome after TSA **(Figure 4)**. It is essential to know the glenoid version and depth of the glenoid vault before surgery to properly plan for the insertion of the glenosphere component. Furthermore, in osteoarthritis patients with Walch B2 or C glenoid, a reverse shoulder arthroplasty should be considered.[38] In patients that does not have advanced osseous changes, it is essential to obtain either a CT scan or MRI to evaluate the status of the rotator cuff and more importantly, the muscle quality and fatty infiltration in order to evaluate for reparability. In pseudoparalytic patients who present with external rotation lag sign and active external rotation of less than neutral with fatty changes in the teres minor muscle, a latissmus dorsi/

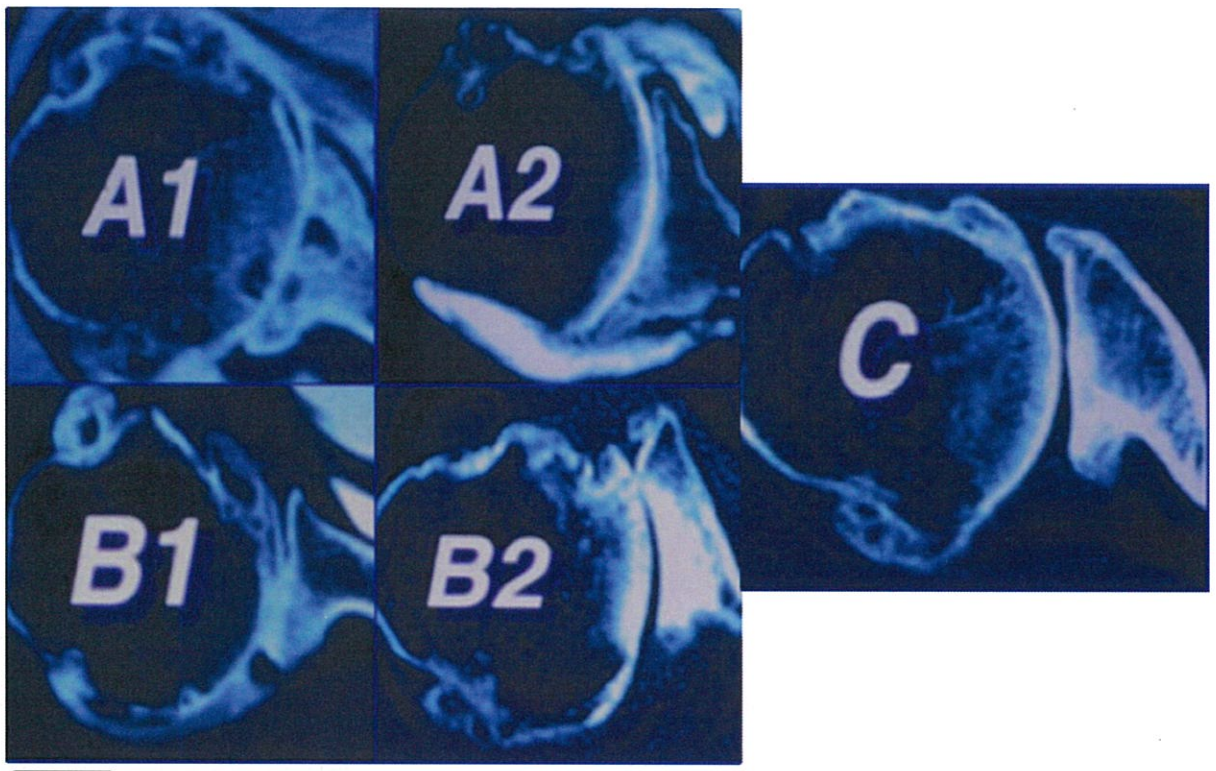

Figure 4
Walch classification of Gl morphology in patients with glenohumeral arthritis. Walch A is a centered humeral head on the glenoid. The amount of central bone wear separates A1 from A2. Walch B is a humeral head with posterior subluxation and B2 glenoid have biconcave wear.

teres major muscle transfer should be consider in addition to the reverse arthroplasty to restore the external rotation for activates of daily living.[39]

D Surgical Technique

① Preoperative Antibiotics/Anesthesia

Reverse 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 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[40] found some evidence that preoperative skin preparation with 0.5% chlohexidine solution let to a reduced risk of surgical site infection compared to the alcohol based povidone iodine solution. After the sterile prep, the arm is either placed in either an arm hold-

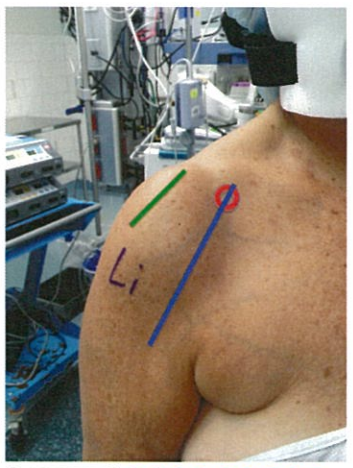

Figure 5
Two popular surgical approaches used for the reverse shoulder arthroplasty, the superolateral (green line) and the deltopectoral approach (blue line). The red circle represents the coracoid.

er (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

Two surgical approaches include superolateral and deltopectoral are utilized for implantation of the reverse shoulder prosthesis **(Figure 5)**. A superolateral approach is made with an incision at the anterior edge of the acromion and directed posterolaterally in an oblique fashion. Dissection is done to raise two flaps medially and laterally. The interval between the anterior and the middle deltoid is identified and split. The anterior third of the deltoid is detached from the acromion along with the coracoacromial ligament insertion (later repaired with transosseous sutures). Limit the distal dissection to 4cm from the edge of the acromion to avoid injury to the Axillary nerve. The proposed advantage to this approach is glenoid exposure to facilitate implantation. However, there are concerns for denervation and injury to the deltoid musculature with this approach. Furthermore, significantly more inferior scapular notching was observed in patients after the superolateral approach compared to the deltopectoral approach on long-term radiographic follow-up.[41] The advantage of the superolateral approach maybe a decrease in the rate of instability that is attributed to the preservation of the subscapularis muscle.

The preferred approach of the senior author is the 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. Sharp dissection is then employed through the subcutaneous tissues down to the fascia overlying the deltoid. The interval is best identified on the superior 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

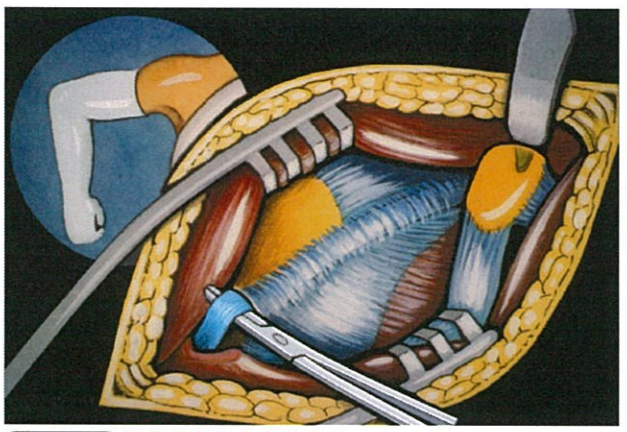

Figure 6
The biceps tendon is identified underneath the pectoralis major muscle. Both the lesser and greater tuberosity are visualized.

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 6)**. 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 Anterior Circumflex Humeral Vessels / Axillary Nerve

With the arm in adduction and external rotation, the anterior circumflex humeral vessels are located at the inferior aspect of the subscapularis muscle. The vessels are either ligated with two sutures or cauterized with a bovie to prevent bleeding. Next the axillary nerve is identified with the arm in adduction and flexion to open the space between the coracoid and subscapularis muscle. The axillary nerve is located on the anterior surface of the subscapularis muscle medially and underneath the conjoint tendon. In a revision case, it is important to identify the axillary nerve to prevent injury.

5 Subscapularis Dissection

Keeping the arm in adduction and slight external rotation, the superior border of the subscapularis is found just behind the tip of the coracoid process. Once all four borders of the subscapularis have been identified, two stay sutures are placed, and the tendon is divided approximately 1 cm medial to insertion on the lesser tuberosity, following the anatomic neck of the humerus. The upper portion of the tendon is cut using a regular scalpel blade. To avoid bleeding, electrocautery should be used to section the muscular portion of the subscapularis and release the inferior capsule at the humeral attachment. A humeral head retractor is introduced into the joint to subluxate the head posteriorly. The subscapularis is then released by performing a juxtaglenoid capsulotomy, which is begun by identifying the superior portion of the subscapularis tendon. Dissecting scissors can be slid along the superior tendon edge to re-

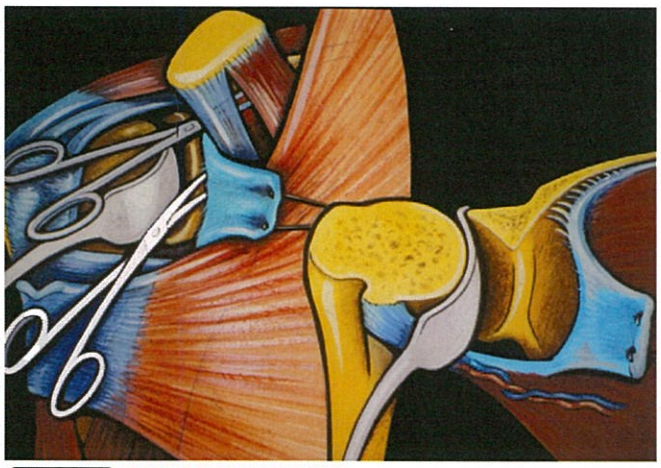

Figure 7

The subscapularis is [illegible]ly released superiorly, inferiorly, and under the coracoid with a curved Mayo scissor.

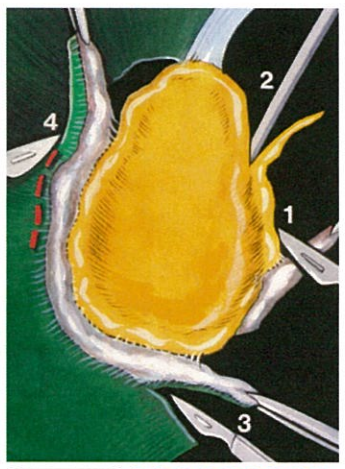

Figure 8

The labrum and re[illegible]al biceps tendon stump is released circumferentially around the glenoid to further facilitate the exposure.

lease any subcoracoid adhesions **(Figure 7)**. The tip of the scissor should always be visualize and avoid release past the medial edge of the coracoid to prevent injury to the brachial plexus. The deep surface of the muscle is then bluntly dissected free from the underlying capsule and middle glenohumeral ligament. The capsule and middle glenohumeral ligament are then sectioned, and the surgeon works back inferiorly and medially to the glenoid rim.

Next, the previously transected muscle fibers of the inferior subscapularis are identified. Lying just posterior to these fibers, which are seen in cross-section, is the inferior glenohumeral ligament. The inferior glenohumeral ligament and capsule are dissected free and sectioned superiorly and medially back to the level of the glenoid. The excursion of the muscle is then tested, and if found to be adequate, the muscle is buried in the subscapularis fossa and protected with a small sponge. If tendon excursion is still inadequate, a blunt instrument or finger tip can be used to manually palpate for the remaining adhesions on the undersurface of the subscapularis which is released with care. The muscle is then buried in the subscapularis fossa, and a sharp retractor can then be placed in the fossa to retract the medial structures. Typically, this is done using a Kolbel retractor, but a curved Homan retractor or pointed ribbon retractor can also be substituted if necessary.

6 Capsular Release

At this point, any remaining labral tissue and subcoracoid bursa is removed. Electrocautery is then used to release the inferior glenoid capsular attachments, past the 6 o'clock position and around to the 7 o'clock position in the right shoulder or the 5 o'clock position in the left shoulder. The release is done directly at the level of the bony attachment and extends medially to the glenoid rim for 2 to 3 mm **(Figure 8)**. The dissection must be performed at the bony insertion to avoid injury to the Axillary nerve. This step is essential in allowing for proper posterior retraction of the humeral head to obtain proper exposure and preparation of the glenoid.

7 Humeral Preparation

The humeral head is dislocated with pro-

Figure 9
An awl is used to identify the starting point for the axial reamers. Due to altered anatomy, it is best to visualize the most direct in-line access to the medullary canal. (Figure is courtesy of Tornier Inc., Warsaw, Indiana)

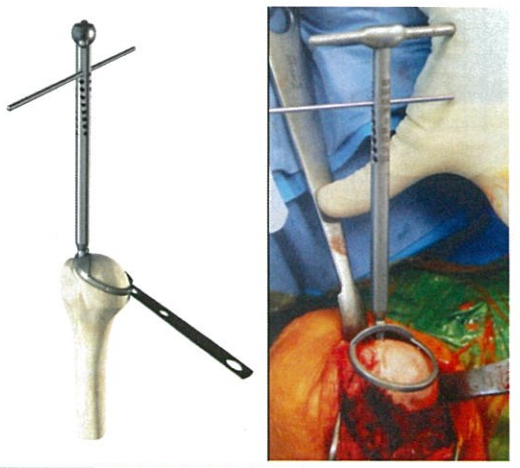

Figure 10
Monobloc cutting guide is inserted into the medullary canal with the retroversion set between 0 to 20 degrees using the rod. (Figure is courtesy of Tornier Inc., Warsaw, Indiana)

gressive arm external rotation with the assistance of blunt cobra retractors placed in the joint for leverage. Resection of the humeral head is done along the anatomical neck with an oscillating saw. We prefer minimal head cut to preserve the humeral length and also bone stock. 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 0 to 20 degrees depending on the native anatomy. The starting point of the humeral canal is identified and the entry point is marked with a starting awl. Altered humeral head shape and anatomy is frequently encountered in patients with CTA secondary to the proximal humeral head migration and articulation with the acromion. Thus the starting point can be different between patients. It is best to visualize the most direct in-line access to the medullary canal for the starting point **(Figure 9)**.

8 Humeral Head Resection

There are two cutting guides used for either the superolateral approach or the deltopectoral approach. The shaft of the monobloc cutting guide is inserted into the medullary canal and a retroversion rod is inserted to measure the retroversion (between 0 to 20 degrees **(Figure 10)**). The 0 degrees of retroversion will give patients more internal rotation whereas 20 degrees of retroversion with provide more external rotation for patients. Once the retroversion is set, an oscilling saw is used to make the head cut below the ring of the cutting guide. Subsequently, a metaphyseal reamer is used and the size is determined preoperatively and confirmed intraoperatively to match the proximal anatomy of the humerus **(Figure 11)**. This is usually a 36mm or 42 mm diameter metaphyseal reamer. Reaming is completed when the depth of the reamer head is at the level of the cut surface.

9 Metaphyseal reaming

The metaphsis is reamed with the appropriate reamers assembled to the T-handle. The reaming is completed when the reamers contacts the diaphyseal cortical bone. The last reamer will determine the final implant. Assemble the trial diaphyseal and metaphyseal trial components on the back table and then

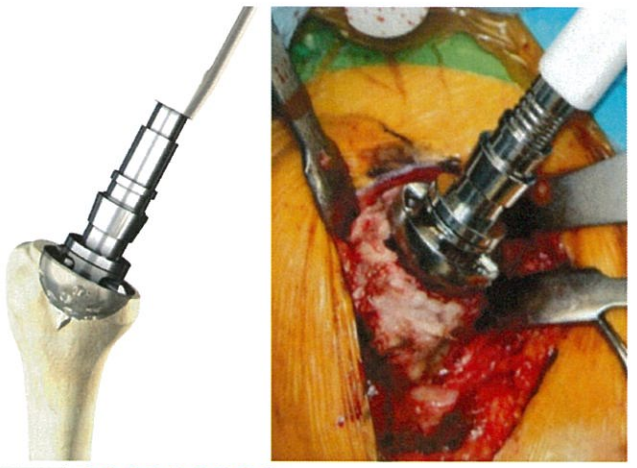

Figure 11
Metaphyseal reamer is used after the humeral head is resected. Reaming is completed when the depth of the reamer head is at the level of the cut surface.

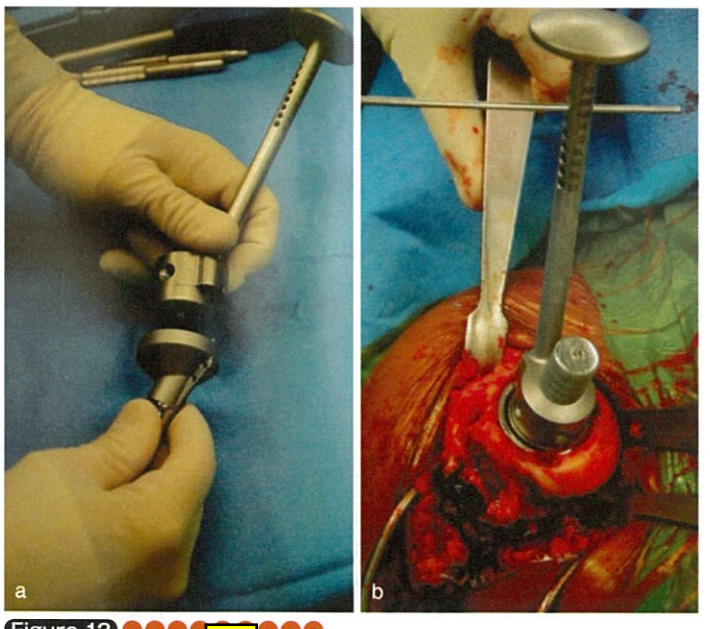

Figure 12
a: The final assembled monobloc component is attached to the insertion handle.
b: The component is inserted into the humerus and the degree of retroversion is verified with the rod.

insert into the reamed medullary canal **(Figure 12)**. The retroversion and the implant position is verified with the alignment rod (0 to 20 degrees). A humeral head cut protector is positioned onto the trial prosthesis during the glenoid preparation.

10 Glenoid Bone Loss and Grafting

In the subset of patients with severe glenoid wear or eccentric glenoid bone loss, obtaining a bone graft to augmentation to maximize the glenosphere fixation maybe indicated. This can be done with allograft, iliac crest autograft, or humeral head auto-

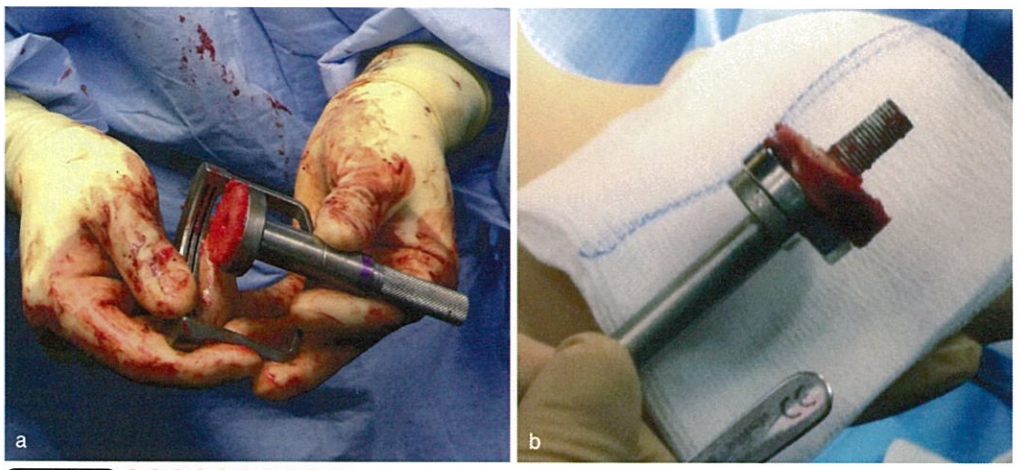

Figure 13
a: Tornier BIO-RSA system used to harvest the bone graft from the humeral head. A 7mm or 10mm graft can be harvested. The senior author will use the 7mm graft with a 42mm glenosphere and the 10mm graft with the 36mm glenosphere.
b: Asymmetric wedge shaped graft is threaded over the metaglene and the long post prior to implantation.

graft. The senior author prefers a humeral head autograft to minimize patient morbidity and avoid the higher failure rates associated with the allograft. This is done with the Tornier BIO-RSA system **(Figure 13a)**. It is essential that the BIO-RSA bone graft is harvested from the humeral head prior to the humeral cut. Using a humeral head alignment guide, a guide pin is placed into the central portion of the head. A BIO-RSA graft reamer is passed over the pin and reaming is done until a flat surface is encountered on the humeral head. The guide pin is then removed and the humeral cutting guide is place over the resection area. A 7 or 10mm graft is harvested with an oscillating saw. The graft is prepped on the back table with the glenoid baseplate and threaded over a long post. In the case of asymmetric glenoid bone loss, the bone graft can be shaped into a wedge to match the bone loss **(Figure 13b)**. The goal is to create a neutral or 10 degrees of inferior tilt for the glenosphere component.

11 Glenoid Exposure

A Fukuda retractor is inserted to displace the metaphysis posteriorly. After the subscapularis is globally released superiorly, inferiorly, and under the coracoid with a curved Mayo scissor, it is pushed into the fossa and a Koelbel or spiked ribbon retractor placed on the anterior glenoid and in the fossa. An angled retractor or pointed hohman is placed on the superior aspect of the glenoid to further facilitate exposure. At this time, the labrum is circumferentially excised along with any residual stump of biceps tendon. 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.

12 Glenoid Preparation

A guidewire is drilled down the center of the glenoid with the assistance of drill guide **(Figure 14)**. Either the neutral orientation or the 10 degrees of inferior tilt is used (the authors prefer the inferior tilt option **(Figure 15)**). The baseplate should be on the inferior aspect of the glenoid face: the inferior aspect

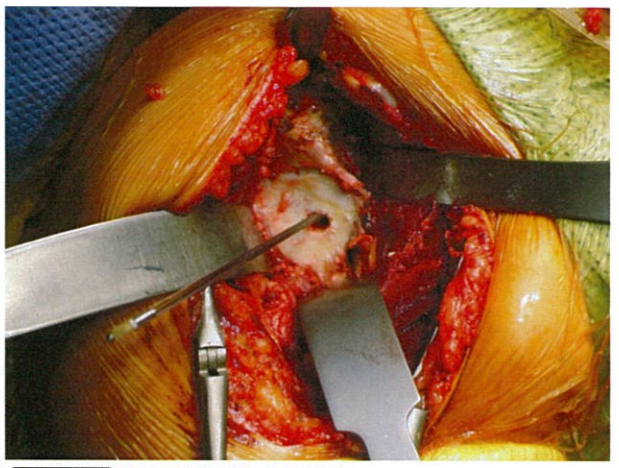

Figure 14
After the glenoid is adequ exposed, the guide pin is placed in the center of the glenoid with 10 degrees of inferior tilt. A central hole is drilled prior to the reaming.

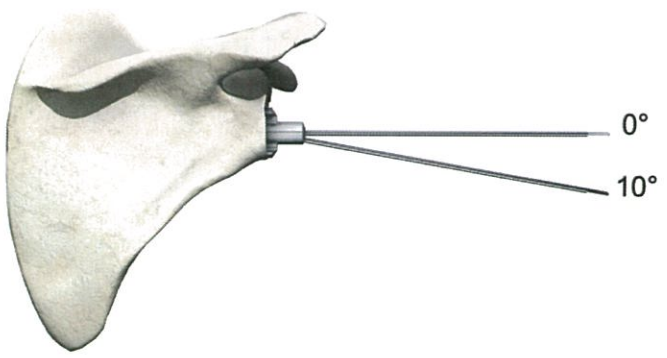

Figure 15
Guide pin is set at eithe 10 degrees of inferior tilt. (Figure is courtesy of Tornier Inc., Warsaw, Indiana)

of the guide should be flush to the inferior edge of the glenoid. This position will minimize scapular notching. The drill guide is then removed and glenoid surface is flattened with a central reamer. It is important to ream the glenoid to a flat surface but not to the cancellous bone because of limited bone stock. A central hole is drilled with the larger bit for the central post. At this time, the baseplate (with or without the bone graft) is inserted and four self-tapping screws are used to secure the baseplate. The authors prefer to place the compression screws in the superior and inferior position and the locking screws in the anterior and posterior position of the glenoid baseplate **(Figure 16).** A 36 mm or 42 mm glenosphere is inserted at this time to the baseplate with a special holder **(Figure 17)**.

13 Implant of the Final Prosthesis

The humerus is dislocated anteriorly and the trial broach is removed. Three #5 FiberWire sutures were placed through the metaphysis for repair of the subscapularis ten-

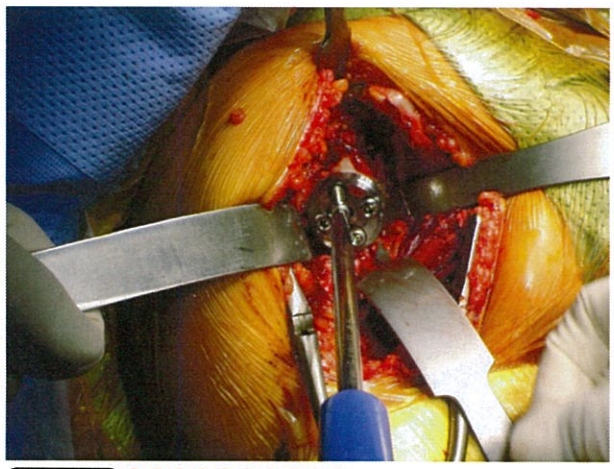

Figure 16
The metaglene with the lo entral post along with the bone graft harvested with the BIO-RSA system is impacted onto the glenoid. Superior/inferior screws are compression and the anterior/posterior screws are locking. (Tornier Aequalis Reverse Arthroplasty)

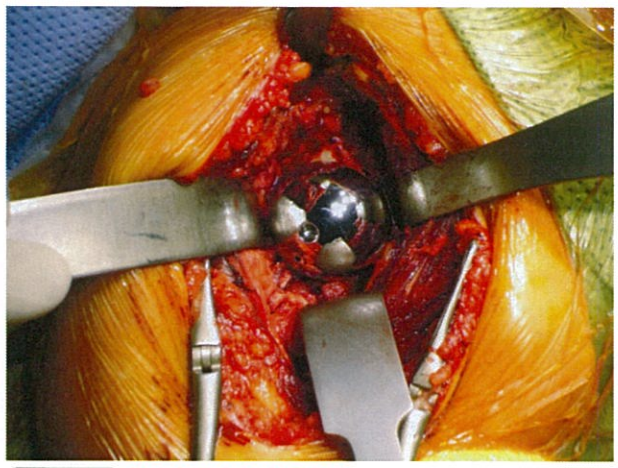

Figure 17
36mm glenosphere is i ed onto the metaglene.

← Please send Figure 18

Figure 18
Final humeral monoblo thesis is implanted into the humerus. #5 Ethibond sutures are used to repair the subscapularis peel after reduction of the humeral component to the glenosphere.

don or the tendon is directly sutured onto the residual stump **(Figure 17)**. The final component is then inserted after pulsatile lavage irrigation of the humeral canal. The humerus is then reduced onto the glenosphere. Trailing of the components should be done to ensure proper tensioning before implanting the final prosthesis. The subscapularis tendon is repaired with the transosseous sutures with additional #5 Ethibond sutures used to close the lateral part of the rotator interval **(Figure 18)**. Edwards et al[29] reported significantly more dislocations in patients whose subscapularis was not repaired after the reverse arthroplasty. Thus we recommend repair of the subscapularis tendon whenever it is possible and the tissue quality is adequate. The incision is 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) Cuff tear arthropathy with pain and pseudoparalysis is the best indication for a reverse shoulder arthoplasty.
2) Despite the expanded indications and popularity of the reverse shoulder, the surgeon must be cognizant of the complications, implant survivorship, and outcomes.
3) Preoperative CT or MRI to evaluate for rotator cuff status, muscle quality, fatty infiltration, glenoid version, glenoid erosion is essential for planning.
4) In patients with pseudoparalysis , external rotation lag with minimal active external rotation, or in case of absence of teres minor, a latissmus dorsi and teres major muscle transfer should be considered.
5) In patients with osteoarthritis and severe Walch B2 or C glenoid morphology, a reverse shoulder arthroplasty should be considered as an option.
6) In revision cases or patients with several proximal humerus bone loss, a full-length humerus radiograph should be obtained for both extremity preoperatively to locate the optimal height of the humeral component.
7) Absence of deltoid function is an absolute contraindication for reverse arthroplasty.
8) The glenoid baseplate should be positioned inferiorly on the glenoid face to reduce inferior scapular notching. (10 degrees of inferior tilt is preferred by the senior author)
9) Glenoid bone graft is essential to augment fixation in patients with compromised glenoid bone wear.
10) Humeral component should be placed anatomically, if a guide is used for humeral head resection, then we recommend between 0 to 20 degrees of retroversion.
11) Glenosphere size is typically 36mm, however, in larger males, a 42 mm glenosphere can be used.
12) If the BIO-RSA is indicated, then 7mm bone graft is used with the 42mm glenosphere and 10mm bone graft is used with the 36mm glenosphere.
13) A trial reduction should be performed to evaluate for range of motion to impingement and stability before the final implant is selected.

F Postoperative Protocol

Postoperative immobilization is achieved using a simple sling with the shoulder in internal rotation for 1 month to protect the subscapularis repair. This may be removed for patient hygiene. Although the patient is allowed to use the hand for simple activities of daily living, lifting activities should be avoided. Passive range-of-motion exercise is begun immediately. After 1 month, the sling is discarded, and the patient is allowed activity as tolerated. Strengthening maybe started after 3 months with or without formal physical therapy. We have found therapy in a swimming pool to be particularly helpful in this patient population and use this technique whenever possible.

References

1. Carter,MJ. et al. Impact of total shoulder arthroplasty on generic and shoulder-specific health-related quality-of-life measures: a systematic literature review and meta-analysis. J Bone Joint Surg Am. 94(17), 2012, e127.
2. Jeske,HC. et al. Functional and clinical outcome of total shoulder arthroplasty with oversized glenoid. Arch Orthop Trauma Surg. 132(7), 2012, 927-36.
3. Neer,CS 2nd. Replacement arthroplasty for glenohumeral osteoarthritis. J Bone Joint Surg Am. 56(1), 1974, 1-13.
4. Neer,CS,2nd. Shoulder arthroplasty today. Orthopade. 20(5), 1991, 320-1.
5. Neer,CS,2nd. Unconstrained shoulder arthroplasty. Instr Course Lect. 34, 1985, 278-86.
6. Neer,CS,2nd. et al. Cuff-tear arthropathy. J Bone Joint Surg Am. 65(9), 1983, 1232-44.
7. Cho,NS. et al. The factors affecting the clinical outcome and integrity of arthroscopically repaired rotator cuff tears of the shoulder. Clin Orthop Surg. 1(2), 2009, 96-104.
8. Chung,SW. et al. Arthroscopic repair of massive rotator cuff tears: outcome and analysis of factors associated with healing failure or poor postoperative function. Am J Sports Med. 41(7), 2013, 1674-83.
9. Moosikasuwan,JB. et al. Rotator cuff tears: clinical, radiographic, and US findings. Radiographics. 25(6), 2005, 1591-607.
10. Coughlin,MJ. et al. The semiconstrained total shoulder arthroplasty. J Bone Joint Surg Am. 61(4), 1979, 574-81.
11. Lettin,AW. et al. The Stanmore total shoulder replacement. J Bone Joint Surg Br. 64(1), 1982, 47-51.
12. Nwakama,AC. et al. Semiconstrained total shoulder arthroplasty for glenohumeral arthritis and massive rotator cuff tearing. J Shoulder Elbow Surg. 9(4), 2000, 302-7.
13. Post,M. Constrained arthroplasty of the shoulder. Orthop Clin North Am. 18(3), 1987, 455-62.
14. Post,M. et al. Constrained total shoulder arthroplasty. Long-term follow-up observations. Clin Orthop Relat Res. (173), 1983, 109-16.
15. DiGiovanni,J. et al. Hemiarthroplasty for glenohumeral arthritis with massive rotator cuff tears. Orthop Clin North Am. 29(3), 1998, 477-89.
16. Pollock,RG. et al. Prosthetic replacement in rotator cuff-deficient shoulders. J Shoulder Elbow Surg. 1(4), 1992, 173-86.
17. Sarris,IK. et al. Bipolar hemiarthroplasty for chronic rotator cuff tear arthropathy. J Arthroplasty. 18(2), 2003, 169-73.
18. Nam,D. et al. Reverse total shoulder arthroplasty: current concepts, results, and component wear analysis. J Bone Joint Surg Am. 92, Suppl 2, 2010, 23-35.
19. Grammont,PM. et al. Etude et ralisation d'une nouvelle prothse de l'paule. Rhumatologie. 1987, 3917-22.
20. Ecklund,KJ. et al. Rotator cuff tear arthropathy. J Am Acad Orthop Surg. 15(6), 2007, 340-9.
21. Loew,M. et al. [Shoulder arthroplasty following rotator cuff tear: acquired arthropathy of the shoulder]. Orthopade. 36(11), 2007, 988-95.
22. Leung,B. et al. Functional outcome of hemiarthroplasty compared with reverse total shoulder arthroplasty in the treatment of rotator cuff tear arthropathy. J Shoulder Elbow Surg. 21(3), 2012, 319-23.
23. Boulahia,A. et al. Early results of a reverse design prosthesis in the treatment of arthritis of the shoulder in elderly patients with a large rotator cuff tear. Orthopedics. 25(2), 2002, 129-33.
24. Frankle,M. et al. The reverse shoulder prosthesis for glenohumeral arthritis associated with severe rotator cuff deficiency. a minimum two-year follow-up study of sixty patients surgical technique. J Bone Joint Surg Am. 88, Suppl 1, Pt 2, 2006, 178-90.
25. Frankle,M. et al. The Reverse Shoulder Prosthesis for glenohumeral arthritis associated with severe rotator cuff deficiency. A minimum two-year follow-up study of sixty patients. J Bone Joint Surg Am. 87(8), 2005, 1697-705.
26. Nolan,BM. et al. Reverse total shoulder arthroplasty improves function in cuff tear arthropathy. Clin Orthop Relat Res. 469(9), 2011, 2476-82.
27. Sirveaux,F. et al. Grammont inverted total shoulder arthroplasty in the treatment of glenohumeral osteoarthritis with massive rupture of the cuff. Results of a multicentre study of 80 shoulders. J Bone Joint Surg Br. 86(3), 2004, 388-95.
28. Wall,BT. et al. Complications and revision of the reverse prosthesis: A multicenter study of 457 cases. J Shoulder Elbow Surg. 16(2), 2007, e55.
29. Edwards,TB. et al. Inferior tilt of the glenoid component does not decrease scapular notching in reverse shoulder arthroplasty: results of a prospective randomized study. J Shoulder Elbow Surg. 21(5), 2012, 641-6.
30. Kempton,LB. et al. A radiographic analysis of the effects of glenosphere position on scapular notching following reverse total shoulder arthroplasty. J Shoulder Elbow Surg. 20(6), 2011, 968-74.
31. Kempton,LB. et al. A radiographic analysis of the effects of prosthesis design on scapular notching following reverse total shoulder arthroplasty. J Shoulder Elbow Surg. 20(4), 2011, 571-6.
32. Kowalsky,MS. et al. The relationship between scapular notching and reverse shoulder arthroplasty prosthesis design. J Shoulder Elbow Surg. 21(10), 2012, 1430-41.
33. Levigne,C. et al. Scapular notching in reverse shoulder arthroplasty. J Shoulder Elbow Surg. 17(6), 2008, 925-35.
34. Levigne,C. Scapular notching in reverse shoulder arthroplasty: is it important to avoid it and how? Clin Orthop Relat Res. 469(9), 2011, 2512-20.
35. Favard,L. et al. Reverse prostheses in arthropathies with cuff tear: are survivorship and function maintained over time? Clin Orthop Relat Res. 469(9), 2011, 2469-75.
36. Guery,J. et al. Reverse total shoulder arthroplasty. Survivorship analysis of eighty replacements followed for five to ten years. J Bone Joint Surg Am. 88(8), 2006, 1742-7.
37. Walch,G. et al. Morphologic study of the glenoid in primary glenohumeral osteoarthritis. J Arthroplasty. 14(6), 1999, 756-60.
38. Denard,PJ. et al. Current concepts in the surgical management of primary glenohumeral arthritis with a biconcave glenoid. J Shoulder Elbow Surg. 2013 Sep 2.
39. Boileau,P. et al. Reverse shoulder arthroplasty combined with a modified latissimus dorsi and teres major tendon transfer for shoulder pseudoparalysis associated with dropping arm. Clin Orthop Relat Res. 466(3), 2008, 584-93.
40. Dumville,JC. et al. Preoperative skin antiseptics for preventing surgical wound infections after clean surgery. Cochrane Database Syst Rev. 3, 2013, CD003949.
41. Melis,B. et al. An evaluation of the radiological changes around the Grammont reverse geometry shoulder arthroplasty after eight to 12 years. J Bone Joint Surg Br. 93(9), 2011, 1240-6.

22(11), 2013, 1589-98. ?