Integra® Shoulder Portfolio
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Titan™ Modular Total Shoulder System

The Titan™ Modular Total Shoulder System offers a bone preserving option for patients needing total or hemi shoulder arthroplasty. The modularity of the system allows the surgeon to independently select distal stems and proximal bodies that best match patient anatomy and bone quality utilizing diaphyseal fixation and without the need for cement.

The system is fully interchangeable – allowing all primary and fracture bodies to be used with either press-fit or cemented stems and later converted to a reverse shoulder arthroplasty without removing a well-fixed stem. Modularity between the body and stem allows for the version to be altered during conversion.

- Interchangeable proximal bodies and distal stems to accommodate varying patient anatomy
- Multiple fixation options (press-fit vs cemented) to address varying bone quality
- Well-fixed stem provides an intraoperative building platform and a pathway for revision
**Integra® Proximal Humeral Fracture Plate System**

The versatile Integra® Proximal Humeral Fracture Plate System features two plate designs, the Low Profile Plate and the Greater Tuberosity Plate to address a wide range of fracture patterns, support anatomic healing, simplify positioning and minimize soft tissue interference.

Four precise holes for medial calcar support that provide a stable fixation in the calcar neck while preventing varus tilt and settling of the humeral head.

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**Titan™ Humeral Resurfacing Arthroplasty System**

The Titan Humeral Resurfacing Arthroplasty System implant’s unique four-fin stem design limits uncertainty by offering enhanced stability and excellent initial fixation through a press fit.

- Anatomic sizing for 8 anatomically designed sizes
- Under-surface coated with titanium plasma spray
- Simple, color-coded instrumentation for ease of use
Total Shoulder Arthroplasty

Total shoulder arthroplasty is usually recommended in older patients at least over the age of forty. The concern is loosening of the glenoid component in the future as compared to the humeral component.

Patient Profile/History

The patient is a 68 year old male who presents with severe pain and decreased range of motion to the left shoulder. He notes an approximate five year history of increasing pain and decreasing motion. This has significantly affected his ability to help take care of himself due to the pain and decreased range of motion to his shoulder. He comes in to discuss a possible total shoulder arthroplasty. Clinical examination showed no atrophy of the shoulder glenoid musculature. Active flexion was limited to approximately 70 degrees of flexion with 20 degrees of external rotation and 40 degrees internal rotation with severe crepitus and pain.

Surgical Treatment

A standard deltopectoral approach was made. Evaluation of the glenohumeral joint showed marked deformity and flattening of both the glenoid and the humerus. The patient elected to proceed with total shoulder arthroplasty. Utilizing the low profile Integra glenoid retractors, an Integra pegged glenoid component was cemented in place. These low profile retractors tremendously improve exposure to the glenoid. The Titan™ Total Shoulder System press-fit humeral body and stem were placed in the humerus with good stability.

Postoperatively, the patient underwent a physical therapy program and achieved excellent range of motion. He was quite pleased with the procedure. His final range of motion at last follow-up was 150 degrees of flexion, 80 degrees of internal rotation, and 80 degrees of external rotation. His strength was graded at four plus over five in abduction and forward flexion.

Physician Profile

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Press-fit arthroplasty has a significant advantage over previously cemented prosthesis. It significantly reduces operative time and simplifies future revision procedures. Sometimes, it is difficult to identify how well the rotator cuff is functioning in patients with severe arthritis of the shoulder. If the patient ever requires a conversion to a reverse shoulder arthroplasty, utilizing the Titan Modular Shoulder System will significantly simplify the procedure by leaving the well-fixed humeral stem component, removing the body of the total prosthesis, and replacement with a reverse body without the need for cement.

Pre-Op and Post-Op Radiograph/MRI/CT Images and Surgical Pictures

Figure 1 – Anterior/posterior radiograph demonstrating advanced arthritis of the glenohumeral joint. Note the bone on bone contact, with a large inferior humeral spur both on the glenoid and humerus.

Figure 2 – Axillary view showed advanced bone on bone arthritic changes with large ossified formation particularly on the glenoid posteriorly. There is more bony deformity of the proximal humerus posteriorly as well.

Figure 3 – Anterior/posterior radiograph postoperatively showing the Titan Total Shoulder System humeral component. There is good humeral head positioning in relation to both the greater tuberosity and the glenoid component.

Figure 4 – Fluoroscopic radiograph showing excellent positioning of the prosthesis in relation to the glenoid. It is well centered.

Physician Conclusion
Press-fit arthroplasty has a significant advantage over previously cemented prosthesis. It significantly reduces operative time and simplifies future revision procedures. Sometimes, it is difficult to identify how well the rotator cuff is functioning in patients with severe arthritis of the shoulder. If the patient ever requires a conversion to a reverse shoulder arthroplasty, utilizing the Titan Modular Shoulder System will significantly simplify the procedure by leaving the well-fixed humeral stem component, removing the body of the total prosthesis, and replacement with a reverse body without the need for cement.
Total Shoulder Arthroplasty for Advanced Arthritis in Young Patient

Advanced arthritis in relatively young patients is a difficult problem to manage. Most authors do not recommend formal glenoid replacement in very young patients despite glenoid involvement. In these instances, some investigators have recommended replacement with a soft tissue patch to act as a pillow on the glenoid in combination with traditional hemiarthroplasty of the humerus.

Patient Profile/History

The patient is a 24 year old female who underwent previous arthroscopic surgery to her right shoulder approximately three years ago for instability. Despite the surgery, she developed rapid chondrolysis of the joint and pain. She presented with severe limitation of motion to her shoulder with approximately 60 degrees of flexion and no external rotation. She was very crippled with pain with any type of motion to the shoulder and was quite tearful.

Radiographs anterior/lateral showed marked cartilage loss with bone-on-bone appearance. On the axillary view, the normal oval appearance of the humeral head had completely flattened to a square configuration.

Surgical Treatment

The patient was brought to surgery and went to standard deltopectoral approach. Evaluation of the glenohumeral joint revealed a flat sclerotic humeral head with marked deformity. The glenoid showed complete cartilage loss and deformity as well. It was elected, in this patient with severe deformity both of the glenoid and humeral head, to utilize a soft tissue patch on the glenoid to help cushion the humeral hemiarthroplasty. It was felt the patient was too young for consideration of a traditional glenoid component. Multiple suture anchors were placed around the four corners of the glenoid, passed through the soft tissue patch then tied down and secured to the glenoid. The Titan™ Modular Shoulder System press-fit hemiarthroplasty was placed on the humerus avoiding cement in this young patient.

The patient returned following physical therapy quite pleased with the final result. At last follow-up visit, she had approximately 140 degrees of flexion, 100 degrees abduction, 70 degrees rotation, and 80 degrees of internal rotation with minimal pain.
Advanced arthritis in a young person is a relatively rare problem. However, when it occurs, it is very difficult to manage. In a young patient, the goal would be to avoid cement if at all possible. In this instance, utilizing the press-fit humeral component of the Titan Modular Shoulder System allowed good distal fixation with minimal bone loss of the calcar. By impacting the stem and utilizing a smaller metaphysical body, this preserved bone which was vital in this young patient. Looking ahead, if she requires any type of revision, it was important to preserve as much bone as possible. The Titan Shoulder System allows for excellent press-fit stability by removing a minimal amount of bone compared to other shoulder systems.

Physician Conclusion

Pre-Op and Post-Op Radiograph/MRI/CT Images and Surgical Pictures

Figure 1 – Anterior/posterior radiograph demonstrating advanced glenohumeral arthritis in this young patient.

Figure 2 – Axillary view showed advanced collapse of the humeral head with bone on bone contact.

Figure 3 – Photograph demonstrating the advanced collapse and deformity to the humeral head. It was extremely deformed in this young patient.

Figure 4 – The patient’s glenoid was quite deformed matching the humeral head. Suture bone anchors were placed at the four corners of the glenoid. The suture was passed through a soft tissue patch which is then tied down to help support and cover the deformed glenoid.

Figure 5 – Anterior/posterior radiograph showing the hemiarthroplasty of the humerus in good position and alignment with the soft tissue patch of the glenoid.
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**Total Shoulder Arthroplasty in Young Sickle Cell Disease Patient**  
Sickle cell disease is a blood disorder that may result in avascular necrosis involving particularly the hip and proximal humerus. These patients generally have a very sclerotic humeral canal, and frequently reaming of the canal will be required in order to place the humeral stem down the sclerotic proximal humerus.

**Patient Profile/History**  
The patient was a 42 year old Afro-American female presenting with a two year history of progressive left shoulder pain. The patient had similar symptoms of the right shoulder, but to a lesser degree. The patient complained of severe pain and quite limited range of motion to her left shoulder. She had previously undergone bilateral hip replacements. Her act of flexion to the left shoulder was approximately 70 degrees with 30 degrees of external rotation. Any active motion shoulder resulted in severe crepitus and pain.

**Surgical Treatment**  
The patient was brought to surgery and the standard deltopectoral approach was made. Exposure of the glenohumeral joint, showed a deformed and flattened humeral head. The humeral head was cut which exposed virtually no humeral canal. It was extremely sclerotic. Under fluoroscopic control, a guide pin was then placed down the calcar into the center of the humeral shaft. This was confirmed under both anterior/posterior lateral planes. The canal was then circumferentially reamed with cannulated reamers to open the canal enough for it to be impacted with the Stem Trials. The canal was then impacted with the size 6 Titan impactor. As the calcar was quite sclerotic, a short fracture body was placed with the 6 size stem. The small fracture body takes up a minimum of calcar compared to the other bodies. As the glenoid was deformed as well, an extra small pegged glenoid was utilized.
The Titan™ Modular Shoulder system proved to be ideal for this patient. As noted in sickle cell disease, the calcar is usually quite sclerotic and the canal sometimes can be non-existent. Utilizing the modular shoulder system, we were able to use the smallest stem, and utilized the short fracture body. This allowed us to remove a minimal amount of hard sclerotic bone to allow the prosthesis to be fully seated in the patient. The problem in patients with very sclerotic canal is the prosthesis may not be fully seized causing rotator cuff dysfunction. Using the Titan Modular Shoulder System makes it easier to fully insert the prosthesis.

Pre-Op and Post-Op Radiograph/MRI/CT Images and Surgical Pictures

Figure 1 – Anterior/posterior view demonstrating severe avascular necrosis to the proximal humerus with bony collapse and deformity. There is also involvement of the glenoid. There appears to be a separate avascular fragment which is detached from the proximal humerus. Note the sclerosis of the canal.

Figure 2 – Photograph demonstrating the advanced collapse of the humeral head which was quite sclerotic and deformed.

Figure 3 – The proximal calcar in the humeral shaft was quite sclerotic with no real canal. Under fluoroscopic control, a guide wire had to be placed down the canal in order to ream the canal before the proximal humerus could be impacted with the Titan compactors.

Figure 4 – Anterior/posterior radiographs of the Titan Modular Shoulder. Note good coverage of the greater tuberosity and the alignment of the head relative to the glenoid. By utilizing the smallest stem and short fracture body, the prosthesis was able to be fully seated in the shoulder so it would not be too proximal thereby, causing impingement.

Figure 5 – The lateral scapular view shows the head of the humerus well centered to the glenoid.

Physician Conclusion

The Titan™ Modular Shoulder system proved to be ideal for this patient. As noted in sickle cell disease, the calcar is usually quite sclerotic and the canal sometimes can be non-existent. Utilizing the modular shoulder system, we were able to use the smallest stem, and utilized the short fracture body. This allowed us to remove a minimal amount of hard sclerotic bone to allow the prosthesis to be fully seated in the patient. The problem in patients with very sclerotic canal is the prosthesis may not be fully seized causing rotator cuff dysfunction. Using the Titan Modular Shoulder System makes it easier to fully insert the prosthesis.
Total Shoulder Arthroplasty

Patient Profile/History

This is a 63 year old gentleman, right hand dominant, who presented with complaints of right shoulder pain, instability, and weakness. He had night pain which interrupted his sleep. He had symptoms for several months. He did not report any specific injury or trauma to his shoulder. He had taken anti-inflammatory medication as needed and used ice or heat as needed for pain control. His pain was to the point that activities of daily living which required reaching overhead, reaching behind his back, and lifting above shoulder level became quite difficult. Sleeping on his right side also exacerbated his pain. Plain films taken showed severe glenohumeral osteoarthritis. Range of motion preoperatively: Forward elevation = 90 degrees, external rotation = 0; abduction / external rotation = 45 degrees. Patient was doing very well with no complaints at his three month post op appointment.

Surgical Treatment

The Titan™ Total Shoulder System was utilized with a size large all poly pegged glenoid, a 14 stem, a 14 large body and a 50 x 19 concentric humeral head. The biceps was released with the superior labrum and the glenohumeral joint was noted to have grade 4 changes, large osteophytes which were removed.

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Pre-Op and Post-Op Radiograph/MRI/CT Images and Surgical Pictures

Pre-Op:

Post-Op:

Physician Conclusion
The ability to independently size and fit both the humeral stem and humeral body gave us an excellent fill of the distal medullary canal and proximal metaphysis. The concentric humeral head covered the humeral osteotomy anatomically.
Total Shoulder Arthroplasty (TSA) for Osteoarthritis Utilizing a Lesser Tuberosity Osteotomy

Patient Profile/History
61 year old female seen for evaluation of longstanding left shoulder pain and dysfunction. She was found to have primary osteoarthritis of the left shoulder. The patient felt as though conservative measures had failed. Operative options were discussed. The patient elected to proceed with TSA.

Surgical Treatment
The patient was taken to the OR for left shoulder TSA. A deltopectoral approach was used. A standard lesser tuberosity osteotomy was performed. There was significant degenerative change and osteophyte formation on the proximal humerus. The posterosuperior rotator cuff was intact. A standard head cut was made in approximately 30 degrees of retroversion, and a provisional sizing of the humeral head was done. Attention was then turned to glenoid exposure. There was significant arthritic change of the glenoid. A size extra-small peg glenoid was implanted. Humeral components were then placed: size 9 stem, 10 standard body, and eccentric 42 x 16 head.
Pre-Op Imaging

Pre-operative AP and axillary plain films of the left shoulder. On the AP film, note the loss of joint space and the formation of a sizable inferior osteophyte. Posterior is toward the top of the axillary film. The patient has increased posterior glenoid wear and posterior subluxation of the humeral head.

Post-Op Imaging

Post-operative AP radiograph of the left shoulder demonstrating an anatomic total shoulder arthroplasty in place. Note the re-establishment of the proximal humeral anatomy and joint space. Cement mantle is visible on the x-ray around all three pegs of the glenoid component.

Physician’s Conclusion

The diaphyseal press-fit stem obviates any concern that the metaphyseal bone could be compromised by the lesser tuberosity osteotomy. The modularity of the humeral components allows for excellent diaphyseal and metaphyseal fit. In this case, a size 9 stem got excellent purchase in the diaphysis, while a 10 standard body was used to fill the metaphysis. The wide variety of concentric and eccentric head sizes allows for outstanding recreation of the proximal humeral anatomy. Additionally, the ability to match humeral head sizes to, potentially, more than one glenoid component size allows greater flexibility when preparing the glenoid. In this case, an extra small glenoid component was paired with a 42 x 16 head.
Reverse shoulder arthroplasty (RSA) for massive cuff tear, pseudoparalysis, and recurrent instability after dislocation

Patient Profile/History

60 y.o. female seen approximately two months status post right shoulder traumatic dislocation. Prior to the dislocation event, she had no issues with the right shoulder. Closed reduction was performed in the emergency room. Immediately after the dislocation event, the patient complained of pain and an inability to raise her right arm. The patient was initially managed with conservative measures including an injection and physical therapy. However, pain & mobility failed to improve with conservative measures and she continued to have instability events of the right shoulder. She was referred for definitive management after a CT arthrogram revealed a massive rotator cuff tear. Soft tissue procedures including (but not necessarily limited to) rotator cuff repair and labral repair were discussed. It was determined that her best option to regain function and prevent continued instability was RSA.

Surgical Treatment

The patient was taken to the OR for right shoulder RSA utilizing the Titan™ Reverse Shoulder System. A deltopectoral approach was used. A size 10 stem was used along with a +5mm concentric glenosphere, small body, and +6mm polyethylene component were used to obtain appropriate intra-operative soft tissue tensioning.
This is a young patient with a massive rotator cuff tear, pseudoparalysis, and recurrent instability. Consideration was given to soft tissue repair. However, it was decided that the likelihood of continued poor function and/or continued symptomatology was high. The Titan Reverse Shoulder System prosthesis offered the best option for improved function with a single-operative procedure. Because of the patient’s young age, there was good reason to avoid cementation. The availability of a diaphyseal press-fit eliminated the need for cementation. The press-fit also will make any potential revision procedure much easier should the patient outlive the life span of this prosthesis. The modular system allowed for soft tissue tensioning through use of a +5mm concentric glenosphere, a small reverse body, and a +6mm polyethylene humeral component.
Reverse shoulder arthroplasty (RSA) for massive, irreparable cuff tear with compromised function

Patient Profile/History

74 year old LHD male with pain and weakness of the right shoulder. The patient had a long history right shoulder pain. However, several weeks prior to presentation, he had felt a snap in the right shoulder. Since that time, his pain has been accompanied by significant weakness and loss of function. The patient had minimal active elevation of the right shoulder on physical exam, and an MRI demonstrated a massive rotator cuff tear (RCT) with a high-riding humeral head. Multiple options were discussed with the patient. Ultimately, he elected to proceed with RSA.

Surgical Treatment

The patient was taken to the OR for right shoulder RSA utilizing the Titan™ Reverse Shoulder System. A deltopectoral approach was used. The patient had a large proximal humeral canal, requiring implantation of a size 15 stem. A +5mm concentric glenosphere, large body, and +9mm polyethylene component were used to obtain appropriate intra-operative soft tissue tensioning.
Physician Conclusion

The diameter of the patient’s proximal humeral canal was quite large. The availability of large stems for diaphyseal press-fit obviated the need to consider cement fixation in this patient. Additionally, despite a relatively conservative head cut, significant soft tissue tensioning was needed to obtain adequate intra-operative stability of the prosthesis. The Titan™ Reverse Shoulder System allowed for soft tissue tensioning through use of a +5mm glenosphere, and +9mm polyethylene, and a size large body.
Revision of TSA to RSA due to continued pain and massive RCT

Patient Profile/History

47 year old female with h/o six previous right shoulder surgeries. The patient’s index procedure was a labral repair with an indwelling catheter for postoperative pain control. Ultimately, the patient developed arthritic change. She underwent right shoulder hemiarthroplasty in 2008. The hemiarthroplasty was converted to TSA in 2012. Her most recent surgical procedure was in 2014, at which time arthroscopy was done for debridement of a massive, irreparable RCT and DCR. She presented with continued shoulder pain and dysfunction. On physical examination, the patient had significantly decreased strength and ROM with pain. She had good motor and sensory function for the axillary nerve. CT arthrogram of the right shoulder confirmed massive RCT. Aspiration and serum labs were not indicative of infection.

Surgical Treatment

The patient was taken to the OR for removal of TSA prosthesis and conversion to RSA utilizing the Titan™ Reverse Shoulder System. A deltopectoral approach was used. There was significant formation of scar tissue and adhesions. Appropriate soft tissue releases were performed, however the soft tissues remained quite contracted.

The anterior soft tissue structures were dissected off the proximal humerus. There was no gross purulence. The previously implanted TSA was identified and dislocated. There was no viable posterosuperior cuff tissue. The TSA was removed successfully. Proximal humeral membrane was sent for culture and pathology, with specimens to be held for 14 days for P. acnes. The proximal humeral bone was of exceedingly poor quality.

Attention was turned to the glenoid component. An osteotome was used to dislodge the polyethylene glenoid component. There was a significant cement mantle between the component and the native glenoid. There was also significant distortion of the normal glenoid anatomy. The reamer was used to re-contour the glenoid face, and a baseplate and +5mm concentric glenosphere were successfully implanted. Because of the soft tissue contracture and poor quality bone, some damage to the proximal humeral bone was unavoidable during retraction for glenoid preparation and glenosphere implantation.

The proximal humerus was then brought back forward into the wound. An excellent diaphyseal press fit was obtained with a size 9 stem. A large reverse body and +9mm poly were used to ensure appropriate soft tissue tensioning.

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Pre-operative AP radiograph of the right shoulder showing TSA. Note that the proximal humerus is high-riding and articulating with the acromion, indicative of a massive RCT.

Post-operative AP radiograph of the right shoulder demonstrating RSA in place.

Physician Conclusion
The patient had multiple prior surgeries; therefore she was at higher than normal risk for infection. The press fit stem obviated the need for cementation. Additionally, the proximal humeral bone stock was of exceedingly poor quality and was compromised during preparation of the glenoid. A metaphyseal press fit would not have been possible. However, excellent press fit was obtained in the diaphysis with the Titan™ Reverse system. Removal of the previously implanted glenoid component left a cavitary defect in the glenoid vault. The Titan baseplate post filled the cavitary defect and provided optimal bony contact to ensure a stable press fit. The lateralized glensphere and multiple body and polyethylene sizes allowed for appropriate soft tissue tensioning even with the loss of structural bone proximally.
Revision Total Shoulder Arthroplasty to Reverse Shoulder Arthroplasty

The conversion of a total shoulder to a reverse shoulder can be a difficult procedure. Frequently, this results in significant proximal bone loss during the procedure to remove the previous stem from the humerus.

Patient Profile/History

The patient is a 68 year old female who is approximately five years status post total shoulder arthroplasty at an outside institution. The patient presented with severe pain in crepitus to her shoulder. Physical examination showed marked limitation of motion and increasing pain. The patient desires further surgical intervention.

Her radiographs show a well-fitted humeral stem with proximal migration of the humerus. Radiographically, signs of rotator cuff insufficiency was present with potential loosing of the glenoid component. It was recommended to proceed with conversion of the total shoulder arthroplasty to a reverse shoulder arthroplasty due to the rotator cuff insufficiency.

Surgical Treatment

The patient was brought to surgery and the standard deltopectoral approach was made. The patient had a well-fitted humeral stem. In order to extract the stem, a significant amount of proximal humerus had to be removed. Once the stem was removed, a Titan™ Reverse Shoulder System was placed. The distal-fitting stem had excellent stability.
Pre-Op and Post-Op Radiograph/MRI/CT Images and Surgical Pictures

Figure 1 – Anterior/posterior radiograph of the right shoulder showing previous total arthroplasty. There is proximal migration of the humerus, relative to the glenoid, and potential loosening of the glenoid component.

Figure 2 – Axillary view to the right shoulder showing loosening of the glenoid component.

Figure 3 – Lateral/scapular view showing partial migration of the humerus in relation to the glenoid component.

Figure 4 – Fluoroscopic view showing revision of the previous total shoulder arthroplasty to the Integra Titan Reverse Shoulder System. Note the amount of bone proximally that had to be removed in order to extract the patient’s previous humeral component.

Figure 5 – Six month postoperative radiograph showing an excellent reduction of the humerus to the glenosphere. Utilizing a distal-fitting prosthesis allows one to remove bone proximally in order to extract the previously placed stem without a concern for subsequent diaphyseal press-fit fixation.

Figure 6 – Fluoroscopic review shows excellent reduction of the humerus under the glenosphere postoperatively.

Physician Conclusion

Revision of a patient’s total shoulder arthroplasty to a reverse shoulder arthroplasty is usually a very difficult procedure. Particularly, when the patient’s humeral stem is well-fixed. Removal of the stem normally requires some amount of proximal bone loss, particularly in stems that are primarily proximally-fit dependent for stability. The advantage of the Integra distal-fitting stem is quick removal of the proximal body of the humeral component as the revision prosthesis will be distally-based. This greatly simplifies the procedure. In this instance, the proximal portion of the humerus was removed in order to gain access to the existing in-situ stem and extract it. Generally, the bone has to be removed just distal to the lateral fins of the previous prosthesis to simplify extraction. Once the humeral prosthesis is removed, it is relatively easy to proceed with the Integra reverse shoulder arthroplasty with the distal-fitting stem.
Integra®
Conversion from TSA to RSA

Revision of TSA to Reverse TSA for Cuff Failure

Patient Profile/History
A seventy year old female presented eight months post right total shoulder arthroplasty for osteoarthritis. Post-operatively she has had pain, weakness, limited range of motion and mechanical symptoms. Plain radiographs obtained on presentation revealed the humeral component to be slightly proud but without radiographic evidence of loosening or mechanical failure. The patient's history and physical exam were suggestive of cuff failure and a CT arthrogram was obtained. The study was consistent with rotator cuff tear and demonstrated elevation of the humeral head relative to the glenoid. The CT scan also allowed assessment of the glenoid component central peg position facilitating preoperative planning for revision as well as aspiration of the joint to rule out infection. Revision to reverse total shoulder arthroplasty was offered and the patient elected to proceed.

Surgical Treatment
The subscapularis was found to have failed and there was a tear of the anterior supraspinatus. The posterior cuff was intact and was protected throughout the procedure. The primary component was a modular stem. Although new modular stem designs allow for conversion of humeral components from TSA to RSA, the lack of glenoid component fixation and stability was seen as a potential concern due to the variance between the large central peg diameter of the in-situ anatomic glenoid component and the smaller post diameter of the subsequent baseplate component. The humeral head was removed and flexible osteotomes were utilized to independently free the proximal and distal components and then extract the prosthesis as one unit. The modular design significantly facilitated removal with a minimum of bone loss.

The humeral canal was sequentially impacted until a stable press-fit was achieved with the Titan® Reverse Shoulder System Trial Stem. The appropriate body height was selected and the proximal humerus reamed and the trial components placed with excellent stability. Attention was then turned to the glenoid and the implants were removed utilizing flexible osteotomes. The glenoid was prepped to receive the Titan® Reverse Baseplate with the appropriate guide wire and drills. The diameter of the baseplate post was greater than the void in the glenoid created from removing the anatomic glenoid central peg therefore excellent purchase was achieved from both a press fit of the post and cortical purchase of the central compression screw. The peripheral baseplate screws were then placed in standard fashion with excellent purchase and the superior and inferior screws locked. A 5mm offset concentric glenosphere was selected and impacted into the Morse taper. A trial reduction was carried out confirming excellent stability and the final implant was assembled and implanted. A standard layered closure was performed. The patient was immobilized in a sling for 3 weeks postoperatively and then advanced through a course of physical therapy. She has had an excellent early result with resolution of pain and significant improvement in range of motion and function.

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Pre-Op and Post-Op Radiograph/MRI/CT Images and Surgical Pictures

Pre-Op:

Figure 1, 2 & 3:
70 yo Female 8 months post TSA

Figure 4, 5 & 6:
CT Arthrogram

Post-Op:

Figure 7, 8 & 9:
Revision to RSA

Physician Conclusion

The Titan Reverse Shoulder System demonstrated unique advantages in the management of this patient’s complex problem. The press-fit stem allowed stable fixation of the humeral component in the diaphysis without concern for poor metaphyseal bone quality, bone loss or fracture often encountered in the setting of revision and avoiding the need for cement. The modular humeral stem also allowed selection of a reverse body that most closely fit the patient’s anatomy and appropriately tensioned the soft tissues. This case also demonstrates the advantage of a modular stem in the setting of revision facilitating removal of the humeral component with minimal bone loss.

The glenoid post diameter allowed stable press-fit fixation in the central peg hole and the baseplate could be oriented to avoid alignment of the peripheral screws with the peg holes. This was further facilitated by the ability to place the peripheral screws at variable angles to achieve an optimal trajectory and to lock the superior and inferior screws.
Conversion from TSA to RSA

Conversion of total shoulder arthroplasty to reverse arthroplasty following dislocation of glenoid and noted deficient rotator cuff

Patient Profile/History

The patient is a 64 year old RHD female who presented to my office with complaints of left shoulder pain and weakness when she was three years post left total shoulder arthroplasty. She stated that she injured her shoulder in a fall at the Grand Canyon five months previous to this encounter, but she did not seek treatment or have plain x-rays taken at the time of injury. On exam, there was weakness noted on forward flexion. Range of motion: Forward elevation = 90 degrees; External rotation = 30 degrees. I obtained plain films and these showed her glenoid to be dislocated. We sent her for a CT scan for evaluation. The CT scan showed the dislocated glenoid as well as a rotator cuff tear. The patient elected to proceed with a revision total arthroplasty with possible conversion to a reverse total shoulder arthroplasty.

Of note, this patient had a previous reverse arthroplasty in her opposite (right) shoulder. The recent injury allowed us to evaluate her x-rays and clinical examination as well.

Surgical Treatment

The patient was taken to the OR for a left revision TSA and possible conversion to reverse shoulder arthroplasty. Intraoperatively, the superior surface of the rotator cuff was noted to be deficient. It was decided at that point that a reverse arthroplasty should be performed due to the deficient cuff.

The dislocated glenoid component, proximal humeral head and proximal humeral body were removed without difficulty and the proximal humerus was prepared for the reverse body. We were able to leave the stem in place and attach it to the reverse body. The glenoid was exposed, scar tissue was removed, and it was templated. Its central pin was placed in the center of the glenoid followed by overreaming for the peg and the glenoid baseplate. The proximal and distal holes were made for the baseplate and then the baseplate was inserted without difficulty.

Central screw was placed. It was 20 mm in length and 5.5 mm in diameter. After the baseplate was inserted, then the proximal and distal holes were drilled and 4.5 mm screws 25 mm inferiorly and 20 mm superiorly were inserted followed by the caps over those. The +5 concentric glenosphere was then inserted onto the 15mm
The modularity of the Titan™ Reverse Shoulder system allowed us to retain the humeral stem and construct a reverse shoulder replacement around that stem. The conservation of bone when using the pegged glenoid for the primary shoulder replacement allowed us to use a central peg for the reverse base plate without bony compromise.

Pre-Op and Post-Op Radiograph/MRI/CT Images and Surgical Pictures

Pre-Op:

The above axillary x-ray demonstrates the radiographic marker in the glenoid component which has dislocated and is positioned anterior to the humerus.

Post-Op:

While the patient was positioned for her CT scan, we were able to visualize a previously placed reverse arthroplasty in the opposite (right) shoulder. We were able to visualize the reverse components in a rather unusual position. This demonstrates the remarkable stability of a reverse shoulder arthroplasty construct. The x-ray demonstrates superior migration of the humeral component (on the left) consistent with a rotator cuff deficient shoulder.

Clinical pictures of the reverse arthroplasty of the right shoulder demonstrating the remarkable range of motion.

Physician Conclusion

The modularity of the Titan™ Reverse Shoulder system allowed us to retain the humeral stem and construct a reverse shoulder replacement around that stem. The conservation of bone when using the pegged glenoid for the primary shoulder replacement allowed us to use a central peg for the reverse base plate without bony compromise.
Reverse Shoulder Arthroplasty (RSA) for Four-Part Proximal Humerus Fracture with Proximal Bone Loss

Patient Profile/History
This patient was a 75 year old right hand dominant female with four-part left proximal humerus fracture after mechanical fall. Multiple options were discussed with the patient including: conservative management, osteosynthesis, and RSA. The patient elected to proceed with RSA.

Surgical Treatment
The patient was taken to the OR for RSA. Approach was through a superolateral incision. The shaft had button-holed through the anterior musculature. Additionally, there was proximal humeral shaft comminution and bone loss. The Titan™ Reverse Shoulder System prosthesis was successfully implanted. A +5mm eccentric glenosphere and high retention polyethylene were used to ensure stability of the prosthesis.

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Physician Conclusion
The ability to use a reverse prosthesis to address the fracture obviated the need to re-establish anatomic head height therefore, no cumbersome jigs were needed. Additionally, the patient had suffered significant proximal humeral shaft comminution and bone loss. The diaphyseal press-fit design allowed for implantation of the prosthesis without the need for cementation. The proximal bone loss created the prospect of instability. A +5mm eccentric glenosphere was used to increase soft tissue tensioning. Additionally, a high-retention polyethylene component was used to increase the jump distance of the prosthesis, leading to greater stability. These components were implanted in conjunction with a size small body with ideal intra-operative soft tissue tensioning and stability. In the event the prosthesis became unstable post-operatively, the modularity of the Titan Reverse Shoulder System would have allowed for easy conversion to one of the two taller body height options.
Press-fit Reverse Total Shoulder Arthroplasty for Comminuted Proximal Humerus Fracture

Patient Profile/History

The patient is a 73 year old female who suffered a mechanical fall onto her right upper extremity. She was seen in the emergency room on the date of injury where x-rays confirmed a comminuted and displaced right proximal humerus fracture. She was placed in a sling and was subsequently referred for definitive management. Review of the outside x-rays confirmed a four-part proximal humerus fracture with displacement of both tuberosities and dislocation of the articular fragment. The patient had significant swelling and ecchymosis about the shoulder and pain and crepitation with attempted range of motion. She had intact axillary sensation and demonstrated active deltoid function. Options for management were discussed at length with the family and it was felt that the patient would be optimally managed with reverse total shoulder arthroplasty. She underwent medical evaluation and clearance and was scheduled for surgery.

Surgical Treatment

The patient was taken to the operating room and under combination regional and general anesthesia was placed in a low beachchair position. A standard deltopectoral approach was utilized. The biceps tendon was identified distally and utilized to define the interval between the greater and lesser tuberosity fragments. The articular fragment was completely devascularized and was removed. The greater and lesser tuberosity fragments were tagged with trans-osseous suture incorporating the rotator cuff and were retracted to expose the glenoid. The biceps tendon and labrum were excised and the Integra® Titan™ Reverse Baseplate was inserted in standard fashion. A 5mm offset eccentric glenosphere was selected and impacted into the morse taper controlling for orientation to maximize inferior offset.

Attention was returned to the humerus. The humeral canal was sequentially impacted until a stable press-fit was achieved with the Integra Titan trial stem. Trial reduction was then carried out to select the appropriate body height to restore soft tissue tension and allow anatomic reduction of the tuberosities. The final implant was assembled and inserted with excellent press-fit diaphyseal purchase and trial reduction carried out to select the optimal height polyethylene liner. The tuberosities were then reduced anatomic and secured to the reverse body by passing the trans-osseous/trans-tendonous sutures through the suture holes in the reverse body fins. The final reconstruction was stable.

Physician Conclusion

The Titan™ Reverse Shoulder System demonstrated unique advantages in the management of this patient’s complex fracture. The press-fit stem allowed for stable fixation of the prosthesis without the need for cement. The modularity of the humeral component allowed selection of the most appropriate body height to optimize soft tissue tension and to allow an anatomic and stable reduction of the tuberosities.
Pre-Op and Post-Op Radiograph/MRI/CT Images and Surgical Pictures

Pre-Op:

Figure 1 & 2:
73 year old female presents post fall

Intra-Op:

Figure 3:
RSA – Intra-Op
• Press fit stem
• Body height selected for optimal GT reduction

Post-Op:

Figure 4, 5 & 6:
Post-Op – 4 months
Union of tuberosities in anatomic position

Figure 7:
Post-Op – 4 months
Reverse Shoulder Arthroplasty for Proximal Humerus Fracture

Reverse shoulder arthroplasty is becoming increasingly popular for management of comminuted fractures of proximal humerus in older patients. Range of motion in patients who have been managed with reverse shoulder arthroplasty is, generally, significantly greater compared to traditional hemiarthroplasty.

Patient Profile/History

The patient was a 69 year old male who presented to the emergency room with a comminuted fracture to the proximal humerus following a fall. He was seen at an outside hospital and initially treated non-operatively. The patient had a second fall with a recurrent fracture to the proximal humerus.

The patient presents today with marked deformity, pain, and limitation of motion. Physical examination showed marked clinical deformity of the shoulder. He had no active motion to the shoulder secondary to pain and crepitus. He was extremely sensitive to palpation of the proximal humerus and there was marked crepitus with any passive motion. Due to the marked deformity and chronic fracture to the proximal humerus, it was recommended the patient undergo reverse shoulder arthroplasty.

Surgical Treatment

This patient was brought to surgery and the standard deltopectoral approach was made. On evaluation of the proximal humerus showed multiple small fragments complicated by early callus formation. Multiple comminuted bone fragments were removed. Due to the multiple small fragments, internal fixation of the fracture was not possible. At that point the Titan™ Reverse Shoulder System arthroplasty prosthesis was utilized.

Postoperatively, the patient underwent a physical therapy program. At final follow-up, he had approximately 130 degrees of flexion and abduction. His strength was greatest grade four plus out of five. He was extremely pleased considering he had absolutely no motion preoperatively and in severe pain.

Physician Profile

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The patient presented with an extremely comminuted fracture of the proximal humerus which was chronic in nature with secondary callus formation. Once multiple, small callus fragments were excised, leaving virtually no proximal humerus, internal fixation was not a viable option. In this case, the Titan™ Reverse Shoulder System prosthesis was ideal because of its distal-fitting capability. The lack of proximal humerus bone to stabilize the prosthesis was not a concern as excellent fixation was achieved with diaphyseal fixation provided by the splined stem. The patient had excellent results following reverse shoulder arthroplasty in this unusual situation.
Reverse Shoulder Arthroplasty (RSA) for Four-Part Proximal Humerus Fracture with Ipsilateral ORIF of a Humeral Shaft Fracture

Patient Profile/History

This patient is a 59 year old female with four-part left proximal humerus fracture after being struck by a motor vehicle. She also had an ipsilateral humeral shaft fracture. The patient required Open Reduction and Internal Fixation (ORIF) of her humeral shaft fracture. The treatment options discussed with the patient included: ORIF, hemiarthroplasty, and reverse shoulder arthroplasty (RSA). The patient elected to proceed with left shoulder RSA with ORIF of her left humeral shaft fracture.

Surgical Treatment

Approach was through a deltopectoral incision that was extended distally into an anterior approach to the humeral shaft. The humeral shaft fracture was identified, reduced, and provisionally held in place with a lag screw. There was no comminution at the humeral shaft fracture site and an anatomic reduction was achieved. A cable plate was applied, with cables proximal to the fracture site and screws distal to the fracture site. Attention was then turned to the proximal humeral fracture. The head fragment was devoid of soft tissue attachments. The Titan™ Reverse Shoulder System prosthesis was successfully implanted with excellent diaphyseal press-fit fixation. A +5mm eccentric glenosphere and high re-tention polyethylene were used to maximize stability of the prosthesis.
Physician Conclusion

Because the humeral shaft fracture could be reduced anatomically, a diaphyseal press-fit was possible for the RSA. This eliminated the need for a cemented implant in this 59 year old patient. Additionally, the ability to use a reverse prosthesis to address the proximal humerus fracture obviated the need to re-establish anatomic head height therefore, no cumbersome jigs were needed. A +5mm eccentric glenosphere was used to increase soft tissue tensioning. Additionally, a high retention polyethylene component was used to increase the jump distance of the prosthesis, leading to greater stability. Should the prosthesis become unstable post-operatively, the modularity of the system allows for easy conversion of the size small body to a standard or large size body, increasing humeral construct height and thus soft tissue tension for increased stability.
Integra®
ORIF

ORIF of a 3-part proximal humerus fracture with medial comminution

Patient Profile/History
A 35 year old right-hand dominant female, who was riding as a passenger in a motor scooter and was struck by a passing vehicle at 35-45 miles per hour. She sustained multiple injuries including a right closed proximal humerus fracture with varus angulation and marked comminution of the greater tuberosity and calcar. Due to the perceived complexity of the fracture by the initial consulting orthopaedic surgeon, a shoulder and elbow specialist was consulted. The patient's medical history is complicated with hypertension and sickle cell trait. Upon examination, the patient was alert and oriented, with no apparent distress. Her right shoulder was in a shoulder immobilizer. Examination of the right upper extremity showed the skin to be intact with moderate soft tissue swelling. The axillary nerve was intact to light touch along with full motor and sensory of her median, radial and ulnar nerves. She had +2 radial pulses with less than two second capillary refill.

Surgical Treatment
An open reduction was performed with internal fixation of her proximal humerus utilizing the Integra® Proximal Humeral Fracture Plating System. Standard ORIF techniques were utilized.

Physician Conclusion
Displaced proximal humerus fractures are technically demanding and can be associated with a high rate of screw cut out. Locking plates can provide greater angular and axial stability as well as preserve the periosteal blood supply. Proximal humerus fractures with loss of medial support present a surgical challenge with rates of varus collapse ranging from 15-40%. Several studies have shown anatomic reduction of the medial calcar region and well placed calcar screws can reduce secondary loss of reduction. Insertion of screws tangentially to the medial curvature of the surgical neck are denoted calcar screws. Fractures of the greater tuberosity allow for secondary shear forces at the humeral head–greater tuberosity interface further leading to varus collapse. Zhang et al. noted an increase in varus collapse in three – and four-part proximal humerus fractures without medial column support. Ponce et. al, performed a biomechanical study showing that medial comminution decreased the mean load-to-failure by 48% and that calcar screw fixation increased the mean-to-lead failure by 31% and the mean energy-to-failure by 44%. They also demonstrated improved stability in non-commminated fractures and recommended use of calcar screws for the treatment of all proximal humerus fractures in osteoporotic bone regardless of the quality of the reduction. Studies have shown calcar screws to be safe for the circumflex vessels as well as the axillary nerve especially when using a deltopectoral approach. Current research is in favor of placement of calcar screws in the treatment of these two – or three-part proximal humerus fractures with or without, medial comminution.

The Integra Low Profile Plate offers four screw hole options for medial calcar support that provide stable fixation to prevent varus collapse.
Pre-operative imaging of a three-part proximal humerus fracture with greater than 1cm of displacement of the surgical neck with marked comminution of the surgical neck and calcar.

Intra-operative AP illustrating initial fixation with the 3 locking screws in the head and one cortical screw in the shaft.

Intra-operative AP showing reduction of the fracture as well as stable alignment of the proximal humerus and associated comminuted pieces. Note the 2 calcar screws stabilizing the medial column.

Intra-operative Lateral radiograph demonstrating near anatomic alignment of the tuberosities as well as proximal screw placement.

Referenced Citations:
Greater Tuberosity (GT) Plate for Proximal Humerus Fracture in Young Male Patient

Fractures of the proximal humerus can be extremely difficult to operatively stabilize. Exposure can be difficult due to the surrounding deltoid musculature. The rotator cuff is compromised due to the soft tissue attachments. The case described is a common fracture of the proximal humerus utilizing the Integra GT proximal humerus plate.

Patient Profile/History

The patient is a 23 year old male, status post a high energy motorcycle accident. He presented at the emergency room with marked pain and deformity to his proximal humerus. Clinical examination showed marked swelling and hematoma formation around the shoulder girdle. There was severe crepitus on palpation and pain. Sensation was intact over the axillary nerve.

Plan radiographs showed a comminuted fracture of the proximal humerus with extensive metaphyseal comminution. The patient underwent further CT evaluation revealing the amount of displacement and metaphyseal comminution. Due to the amount of comminution and displacement, it was recommended to proceed with open reduction and internal fixation.

Surgical Treatment

A standard deltopectoral approach was made. The bicep tendon was located distally, traced proximally through the fracture which revealed the extensive metaphyseal comminution. The Integra® Greater Tuberosity Plate was selected. Initially placing a screw in the anterior tab allowed the plate to be slid proximally/distally ideally to the level of the greater tuberosity. The thickness of the plate in its middle third helped provide support due to the medial comminution of the fracture. The plate was filled with a series of 3.5 locking and non-locking screws.

Postoperatively, the patient underwent a physical therapy program. Despite the amount of comminution, the patient demonstrated approximately 140 degrees of flexion and abduction. At last follow-up, the patient’s strength was grade four plus out of five abduction, forward flexion with 70 degrees of external rotation. He has returned to work without restriction.
Fractures of the proximal humerus can be extremely difficult to stabilize. The fractures that require stabilization are very unstable and the deltoid can significantly restrict their reduction. The anterior tab of the Greater Tuberosity Plate is a significant advantage and feature. Placing the first screw in the tab which is situated more anteriorly allows the plate to be more easily applied to the shaft and to be slid proximal/distal to the ideal height relative to the greater tuberosity. With significant metaphyseal comminution, the thickness of the plate directly over the area, provides greater stability and less chance of plate fracture. The plate was designed to sit fairly proximal, so fractures of the greater tuberosity could be stabilized with the greater tuberosity screws. In addition, suture holes for sutures placed through the rotator cuff for comminuted smaller fragments are available for added stabilization.

Pre-Op and Post-Op Radiograph/MRI/CT Images and Surgical Pictures

Figure 1 – Anterior/posterior radiographs showing displaced fracture of the proximal humerus. Note the metaphyseal comminution.

Figure 2 – CT evaluation showed the marked comminution of the humeral metaphysis. There is a severe displacement of the humeral head in relation to the humeral shaft.

Figure 3 – Fluoroscopic evaluation demonstrating reduction of the head back to the shaft. The first screw was placed through the anterior tab allowing the plate to be slid proximally/distally for ideal positioning in relation to the greater tuberosity fragment.

Figure 4 – Lateral fluoroscopic view showing anatomic reduction of the head in relation to the shaft.

Figure 5 – Anterior/posterior radiograph at approximately 9 months postoperatively. Note the extensive callus formation over the medial calcar comminution plate. The humerus is well reduced in relation to the glenoid.

Physician Conclusion
Fractures of the proximal humerus can be extremely difficult to stabilize. The fractures that require stabilization are very unstable and the deltoid can significantly restrict their reduction. The anterior tab of the Greater Tuberosity Plate is a significant advantage and feature. Placing the first screw in the tab which is situated more anteriorly allows the plate to be more easily applied to the shaft and to be slid proximal/distal to the ideal height relative to the greater tuberosity. With significant metaphyseal comminution, the thickness of the plate directly over the area, provides greater stability and less chance of plate fracture. The plate was designed to sit fairly proximal, so fractures of the greater tuberosity could be stabilized with the greater tuberosity screws. In addition, suture holes for sutures placed through the rotator cuff for comminuted smaller fragments are available for added stabilization.
Integra®
Humeral Resurfacing

Humeral Resurfacing Arthroplasty for a Young Patient with Secondary Arthritis

Patient Profile/History
This is a 32 year old RHD female seen for right shoulder pain. The patient has an underlying diagnosis of multiple epiphyseal dysplasia. Her connective tissue disorder has led to multiple joint issues. She previously has undergone bilateral hip replacements. She also had a left shoulder hemiarthroplasty performed at an outside facility with good results. She is now having pain, crepitance, and decreased range of motion on the right side.

Surgical Treatment
Given the patient’s young age and success with a contralateral hemiarthroplasty, the decision was made to forego a glenoid component. A traditional stemmed hemiarthroplasty had successfully been implanted on the left side by an outside surgeon. However, the patient was extremely small in stature and had significant bowing of the right proximal humerus. While a stemmed implant may have been possible, there was concern that broaching could weaken or perforate the cortical bone. Therefore, the decision was made to proceed with a Titan™ Humeral Resurfacing Arthroplasty System.

A deltopectoral approach was used. A subscapularis tenotomy was performed, and great care was taken to ensure full soft tissue release around the proximal humerus. The proximal humerus was delivered into the wound. The posterosuperior rotator cuff was intact. There was significant arthritic change to the proximal humerus. The glenoid was evaluated and there was no significant arthritic change.

The humeral head was sized for a 40 x 16 component and prepared in the standard fashion. The component was implanted without complication. There was excellent range of motion and stability. The subscapularis tenotomy was repaired and the wound was closed in layers.

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Physician Conclusion
The patient’s anatomy placed her at risk for complication with a traditional stemmed hemiarthroplasty. The humeral resurfacing option achieved the same result as a stemmed hemiarthroplasty without concern for damage to the proximal humeral shaft cortical bone. The wide range of sizes available for the Titan™ Humeral Resurfacing Arthroplasty System allowed appropriate sizing even in this very small patient. Furthermore, the aiming guide and shaping tool allowed for anatomic resurfacing of the humeral head. In order for these tools to be effective and accurate, the surgeon must obtain a full soft tissue release around the proximal humerus to allow for visualization of the entire articular surface.
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