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Reverse® Shoulder System

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At DJO Surgical, our end goal is to help patients reach their greatest altitudes. We strive to achieve this through innovation, proven results, and clinical heritage. Our approach is to partner with surgeon experts in the field to design systems that ultimately provide extremity solutions. DJO Surgical Extremity Solutions are anatomic designs engineered to provide optimized function, enhanced fixation, and flexibility and versatility to manage differing patient needs. Our aim is to reach new elevations by providing clinicians solutions to help their patients reach higher.
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DJO shoulder systems are designed to provide a complete and seamless shoulder solutions platform. Conversion Modules minimize the potential challenges of removing a well-fixed humeral stem by allowing conversion of a primary total shoulder to a reverse shoulder and a reverse shoulder to a hemiarthroplasty prosthesis.

Altivate™ extremity systems are designed to provide a complete and seamless extremity solutions platform. Conversion Modules minimize the potential challenges of removing a well-fixed humeral stem by allowing conversion of a primary total shoulder to a reverse shoulder and a reverse shoulder to a hemiarthroplasty prosthesis.
Reverse Total Shoulder Arthroplasty without bone-grafting for severe glenoid bone loss in patients with osteoarthritis and intact rotator cuff

McFarland EG, Huri G, Hyun YS, Petersen SA, Srikumaran U.

Source
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Abstract
BACKGROUND:
Treating shoulders with osteoarthritis, an intact rotator cuff, and substantial glenoid bone loss is challenging. One option is reaming the glenoid flat and inserting a reverse prosthesis. This study reports the subjective, objective, and radiographic results of reverse total shoulder arthroplasty (RTSA) in this population.

METHODS:
We retrospectively reviewed 42 consecutive patients (23 women; mean age, 71 years [range, 53 to 89 years]) with primary glenohumeral osteoarthritis, intact rotator cuffs, and Walch type-A2 (n = 19), B2 (n = 5), or C glenoids (n = 18) who had undergone a total of 42 RTSAs with glenoid reaming without bone-grafting between 2008 and 2013 (mean follow-up, 36 months [range, 24 to 66 months]). All patients were evaluated before and after surgery subjectively (using a visual analog scale for pain and 5 shoulder-specific outcome instruments), objectively (with goniometric examination of shoulder range of motion), and radiographically (to assess baseplate loosening and degree of scapular notching).

RESULTS:
One baseplate (2%) failed, requiring revision surgery. There were no other signs of baseplate loosening in any patient at the last follow-up. Preoperatively to postoperatively, pain improved significantly (p < 0.001), as did all patient-reported outcome measures and the following range-of-motion parameters (p £ 0.001): active abduction, active flexion, and active external rotation with the arm elevated 90°. Eight (19%) of the patients had notching.

CONCLUSIONS:
RTSA without bone-grafting and with medialization of the baseplate in patients with osteoarthritis and severe glenoid bone loss resulted in significant improvement in pain and function with reliable short-term implant survivorship and may be a good alternative to anatomical TSA. Longer follow-up is needed to determine the relative advantages and disadvantages. This was an “off-label” indication for this device.

Reverse shoulder prosthesis in the treatment of locked anterior shoulders: a comparison with classic reverse shoulder indications

Kurowicki J, Triplet JJ, Momoh E, Moor MA, Levy JC.

Source
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Abstract
BACKGROUND:
Locked anterior shoulder (LAS) with static instability and anterior glenoid bone loss is challenging in the elderly population. Reverse shoulder arthroplasty (RSA) has been employed in treating these patients. No study has compared RSA for LAS with classically indicated RSA.

METHODS:
A retrospective case-control study of patients treated with RSA for LAS with glenoid bone loss and static instability was performed using matched controls treated with primary RSA for classic indications. Twenty-four cases and 48 controls were evaluated. Average follow-up was 25.5 months, and median age was 76 years. Motion, outcome assessments, and postoperative radiographs were compared.

RESULTS:
Preoperatively, LAS had significantly less rotation and lower baseline outcome scores. Glenoid bone grafting was more common (P = .05) in the control group (26%) than in the LAS group (6.3%). Larger glenospheres were used more often (P = .001) in the LAS group (25%) than in the control group (29%). Both groups demonstrated significant improvements in pain, function, and outcome scores. Postoperatively, the control group had significantly better elevation and functional outcome scores. With the exception of flexion and Simple Shoulder Test score, effectiveness of treatment was similar between groups. Postoperative acromion stress fractures were seen in 21% of LAS patients and 9% of controls (P = .023) with a predominance of type 3 fractures in LAS. Two LAS patients remained dislocated.

CONCLUSIONS:
Patients with LAS treated with RSA can anticipate improvements in pain and function by use of larger glenospheres, often without the need for glenoid bone grafting. Worse postoperative motion and function and a higher incidence of acromion stress
Revision for a failed reverse: a 12-year review of a lateralized implant


Abstract

BACKGROUND:
The purpose of this study was (1) to evaluate the rates of reverse shoulder arthroplasty (RSA) revisions during a 12-year period, (2) to assess the influence of primary diagnosis and the impact of implant modifications on revisions, (3) to describe surgical management of failed RSA, and (4) to analyze outcomes of patients with minimum 24-month follow-up.

METHODS:
A retrospective database review identified primary diagnosis for 1418 patients who underwent RSA from 2000 to 2012. A subgroup of 85 patients required return to the operating room for removal or exchange of components. Indication to reoperate, intraoperative management, and outcomes were reviewed. Indications were grouped into 7 categories: baseplate failure, humeral component dissociation, glenosphere dissociation, glenohumeral dislocation, aseptic humeral loosening, periprosthetic fracture, and infection. During the study, design modifications were made to the baseplate, humeral socket, and glenosphere. Surgical strategies were analyzed through operative reports. Range of motion, American Shoulder and Elbow Surgeons scores, and Simple Shoulder Test scores were collected before and after surgery and compared for 58 patients with 2-year follow-up.

RESULTS:
Overall revision rate was 6%. Patients undergoing RSA for failed hemiarthroplasty had the highest revision rate (10%). Indications for revision included baseplate failure (2.5%), infection (1.3%), humeral dissociation (0.7%), glenosphere dissociation (0.6%), periprosthetic fracture (0.4%), glenohumeral dislocation (0.4%), and aseptic humeral loosening (0.3%). Baseplate modifications reduced the incidence of baseplate failure to 0.3%. Range of motion and the Simple Shoulder Test and American Shoulder and Elbow Surgeons scores improved.

CONCLUSION:
Although revision RSA is challenging, with higher risk for complications compared with primary RSA, patients still exhibit significant clinical improvements.

The effect of glenoid bone loss on reverse shoulder arthroplasty baseplate fixation

Formaini NT, Everding NG, Levy JC, Santoni BG, Nayak AN, Wilson C, Cabezas AF.

Abstract

BACKGROUND:
Glenoid bone loss is commonly observed during primary and revision reverse shoulder arthroplasty. Glenoid baseplates are often implanted with incomplete glenoid bone support. The purpose of this study was to evaluate the glenoid component fixation of the glenoid baseplate with variable amounts of incomplete coverage.

METHODS:
Twenty-eight polyurethane trabecular bone surrogates were instrumented with the same center screw–type glenoid baseplate with 4 peripheral 5.0-mm locking screws in a glenoid bone loss model consisting of 25%, 50%, 75%, and 100% coverage. Each construct was tested through a 55° arc of motion with both compressive and shear forces across the glenosphere. Baseplate micromotion was recorded throughout 10,000 cycles for each model.

RESULTS:
There was no significant difference in baseline micromotion between the 4 experimental groups (P = .099). In the 25% baseplate coverage group, 3 of 7 exhibited micromotion above the 150-mm threshold (62.5, 46.9, and 71.2 mm) during cyclic loading. After 10,000 cycles of loading, the 25% coverage group exhibited significantly more micromotion than the 50% (P = .049), 75% (P = .026), and 100% (P = .040) coverage groups. There was no significant difference between the 100%, 75%, and 50% coverage groups (P = 1.00).

CONCLUSIONS:
Glenoid baseplate fixation in the setting of glenoid bone loss is no different when 50%, 75%, or 100% of the baseplate is supported by glenoid bone. Bone loss resulting in only 25% coverage results in significantly greater micromotion, often above the 150-mm threshold.
Glenosphere dissociation after reverse shoulder arthroplasty
Cusick MC, Hussey MM, Steen BM, Hartzler RU, Clark DJ, Cuff DJ, Cabezas AF, Santoni BG, Frankle MA.

Source
Florida Orthopaedic Institute Research Foundation, 13020 North Telecom Parkway, Tampa, FL 33637, USA.

Abstract
BACKGROUND:
Reverse shoulder arthroplasty (RSA) is gaining popularity for the treatment of debilitating shoulder disorders. Despite marked improvements in patient satisfaction and function, the RSA complication rate is high. Glenosphere dissociation has been reported and may result from multiple mechanisms. However, few RSA retrieval studies exist.

METHODS:
We reviewed our RSA database and identified patients with glenosphere dissociation between 1999 and 2013. Prosthesis type, glenosphere size, and contributing factors to dissociation were noted. Five retrieved implants were available for analysis, and evidence of wear or corrosion on the Morse taper was documented. Further, we biomechanically investigated improper Morse taper engagement that may occur intraoperatively as a potential cause of acute dissociation.

RESULTS:
Thirteen patients with glenosphere dissociation were identified (0.5 months to 7 years postoperatively). Glenosphere size distribution was as follows: 32 mm (n = 1), 36 mm (n = 4), 40 mm (n = 6), and 44 mm (n = 2). Incidence of dissociation was correlated to glenosphere size (P = .001). Taper damage was limited to fretting wear, and there was minimal evidence of taper corrosion. Biomechanically, improper taper engagement reduced the torsional capacity of the glenosphere-baseplate interface by 60% from 19.2 ± 1.0 N-m to 7.5 ± 1.5 N-m.

CONCLUSIONS:
We identified several mechanisms contributing to glenosphere dissociation after RSA, including trauma and improper taper engagement. Limited evidence of corrosive wear on the taper interface was identified. Although it is rare, the incidence of glenosphere dissociation was higher when 40- and 44-mm gleneospheres were implanted compared with smaller gleneospheres (32 and 36 mm), probably because of the larger exposed surface area for potential impingement.

The effects of glenoid wear patterns on patients with osteoarthritis in total shoulder arthroplasty: an assessment of outcomes and value
Hussey MM, Steen BM, Cusick MC, Cox JL, Marberry ST, Simon P, Cottrell BJ, Santoni BG, Frankle MA.

Source
Florida Orthopaedic Institute, 13020 North Telecom Parkway, Tampa, FL 33637, USA.

Abstract
BACKGROUND:
Despite the success of total shoulder arthroplasty (TSA), concerns remain about the longevity of the implant, in particular, glenoid component survival. The purpose of this study was to determine whether preoperative glenoid wear patterns affect clinical outcomes and value in patients undergoing TSA.

METHODS:
A comparative cohort study was conducted of 309 patients with a total of 344 TSA procedures, performed for primary glenohumeral osteoarthritis. Computed tomography scans were obtained in all patients, with preoperative glenoid wear pattern characterized as either concentric (n = 196, follow-up time, 49.2 months) or eccentric (n = 148, follow-up time, 52.3 months) according to a modified Levine classification. A clinical, radiographic, and economic assessment was performed between the 2 wear patterns.

RESULTS:
There was no significant difference in American Shoulder and Elbow Surgeons (ASES) score in the concentric group (80.8 ± 20.8) compared with the eccentric group (77.6 ± 21.2) at final follow-up (P = .159). Range of motion and final visual analog scale for pain score were similar between the 2 groups. Radiographic evidence of gross glenoid loosening was significantly lower in the concentric group (11 of 195 [5.6%] compared with the eccentric group [18 of 147 [12.2%]] (P = .030). Revision rates were similar between the concentric group [4 of 195 (2.0%)] and the eccentric group [3 of 147 (2.0%)] A value assessment also showed no significant difference between the concentric and eccentric groups [concentric 26.1 vs. eccentric 25.5 (ASES score/$10,000 hospital cost) (P = .479)].

CONCLUSIONS:
Similar clinical results and value can be expected with both concentric and eccentric glenoid wear patterns in TSA. Concerns arise, however, as the eccentric group demonstrated a more than 2-fold increased rate of glenoid component loosening compared with the concentric group.
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Results of closed management of acute dislocation after reverse shoulder arthroplasty
Teusink MJ, Pappou IP, Schwartz DG, Cottrell BJ, Frankie MA.

Source
Shoulder and Elbow Division, Florida Orthopaedic Institute, 13020 Telecom Parkway North, Tampa, FL 33637, USA.

Abstract
BACKGROUND:
Postoperative instability continues to be one of the most common complications limiting outcomes of reverse shoulder arthroplasty (RSA). The optimal management of this complication remains unknown. The purpose of this study was to evaluate the outcomes of patients with postoperative dislocation after RSA managed with closed reduction.

METHODS:
All patients who were treated with a closed reduction for dislocation after RSA in the period between May 2002 and September 2011 were identified and retrospectively reviewed. Final outcomes including recurrent instability, need for revision surgery, American Shoulder and Elbow Surgeons outcome score, and range of motion were evaluated.

RESULTS:
A total of 21 patients were identified. Nearly 50% of cases (10 of 21) had previous surgery, with 80% (8 of 10) of these being previous arthroplasty. The average time to first dislocation was 200 days, with 62% (13 of 21) occurring in the first 90 days. At average follow-up of 28 months, 62% of these shoulders remained stable (13 of 21), 29% required revision surgery (6 of 21), and 9% remained unstable (2 of 21). The average American Shoulder and Elbow Surgeons score was 68.0 for patients treated with closed reduction for instability and 62.7 for those treated with revision surgery (P = .64).

DISCUSSION:
This study shows that an initial dislocation episode after RSA with use of this implant can be successfully managed with closed reduction and temporary immobilization in more than half of cases. Given that outcomes after revision surgery are not different from those after closed treatment, we would continue to recommend an initial attempt at closed reduction in the office setting in all cases of postoperative RSA dislocation.


Glenoid subchondral bone density distribution in male total shoulder arthroplasty subjects with eccentric and concentric wear

Source
Florida Orthopaedic Institute Research Foundation, 13020 North Telecom Parkway, Tampa, FL 33637, USA.

Abstract
BACKGROUND:
Glenoid component loosening in total shoulder arthroplasty may be prevented by component placement on a congruent and adequate bony surface. Glenoid subchondral bone density (SBD) variability may be correlated with this concept. This study analyzed the 3-dimensional distribution of glenoid SBD in total shoulder arthroplasty patients with osteoarthritis.

MATERIALS AND METHODS:
Three-dimensional computed tomography osteoabsorptiometry (CT-OAM) was performed in 42 men (21 with eccentric and 21 with concentric wear patterns) with glenohumeral arthritis. Glenoid SBD was measured from the joint surface based on 5 clinically relevant topographic zones. The correlation of the wear pattern with the SBD distribution was investigated.

RESULTS:
The glenoid subarticular layers could be separated into distinct regions: calcified cartilage (≤ 4.5 mm), subchondral plate (2.45 mm) and cancellous bone (≥ 5 mm). There were significant differences in SBD among these layers within and between patients with concentric and eccentric wear patterns. In concentric glenoids, the SBD distribution was homogeneous, with greater mineralization in the central zone, 1,749 ± 162.3 Hounsfield units (HU) (at 2.5 mm), compared with the posterior, anterior, and superior zones (P < .001). In the eccentric group, the SBD distribution was inhomogeneous. Mineralization was greatest in the posterior zone, 1,729.0 ± 172.6 HU (at 2.5 mm), followed by the inferior zone, 1,722.1 ± 186.6 HU (at 3 mm).

CONCLUSION:
This study represents the first study using CT-OAM to evaluate the 3-dimensional SBD distribution of the glenoid vault for different arthritic wear patterns. The study findings indicate that the SBD distribution is dependent on (1) depth from the articular surface, (2) topographic zone, and (3) wear pattern. CT-OAM may be an effective tool to assist in preoperative planning for shoulder arthroplasty.
Outcome and value of reverse shoulder arthroplasty for treatment of glenohumeral osteoarthritis: a matched cohort
Steen BM, Cabezas AS, Santoni BG, Hussey MM, Cusick MC, Kumer AG, Frankle MA.

Source
Shoulder and Elbow Division, Florida Orthopaedic Institute, 13020 Telecom Parkway North, Tampa, FL 33637, USA.

Abstract
BACKGROUND:
Total shoulder arthroplasty (TSA) is commonly used to treat glenohumeral osteoarthritis (GHOA) with an intact rotator cuff. Recently, reverse shoulder arthroplasty (RSA) has been used for GHOA patients who are elderly or have eccentric glenoid wear. We evaluated patients with GHOA scheduled to have TSA but who were changed to RSA because of intraoperative difficulties with the glenoid component or instability and compared them with a cohort that underwent TSA to determine if the groups had similar outcomes.

METHODS:
We identified 24 consecutive GHOA patients who underwent RSA and matched them to 96 patients who underwent TSA. Glenoid wear and rotator cuff musculature were assessed with preoperative computed tomography scans. Direct hospital costs of the procedure were collected.

RESULTS:
Postoperative American Shoulder and Elbow Surgeons score, Simple Shoulder Test score, and range of motion were similar between the 2 groups. Five TSA patients had radiographic glenoid loosening, whereas no RSA patients did. Neither group required a revision. One RSA patient required surgery for treatment of a periprosthetic fracture. RSA was $7274 more costly than TSA, related mainly to implant cost.

CONCLUSIONS:
Patients with GHOA who were converted intraoperatively to RSA because of improper seating of the glenoid trial or persistent posterior subluxation had outcomes comparable to those of a similar group of patients in whom TSA was performed. At midterm follow-up, TSA is associated with lower cost than RSA. The higher rate of radiographic loosening in the TSA group warrants longer follow-up to assess revision costs. In cases in which a TSA cannot be performed with confidence, RSA is a reasonable alternative.

Accuracy of patient-specific guided glenoid baseplate positioning for reverse shoulder arthroplasty
Levy JC, Everding NG, Frankle MA, Keppler LJ.

Source
Florida Orthopaedic Institute Research Foundation, 13020 North Telecom Parkway, Tampa, FL 33637, USA.

Abstract
BACKGROUND:
The accuracy of reproducing a surgical plan during shoulder arthroplasty is improved by computer assistance. Intraoperative navigation, however, is challenged by increased surgical time and additional technically difficult steps. Patient-matched instrumentation has the potential to reproduce a similar degree of accuracy without the need for additional surgical steps. The purpose of this study was to examine the accuracy of patient-specific planning and a patient-specific drill guide for glenoid baseplate placement in reverse shoulder arthroplasty.

METHODS:
A patient-specific glenoid baseplate drill guide for reverse shoulder arthroplasty was produced for 14 cadaveric shoulders based on a plan developed by a virtual preoperative 3-dimensional planning system using thin-cut computed tomography images. Using this patient-specific guide, high-volume shoulder surgeons exposed the glenoid through a deltopectoral approach and drilled the bicortical pathway defined by the guide. The trajectory of the drill path was compared with the virtual preoperative planned position using similar thin-cut computed tomography images to define accuracy.

RESULTS:
The drill pathway defined by the patient-matched guide was found to be highly accurate when compared with the preoperative surgical plan. The translational accuracy was 1.2 ± 0.7 mm. The accuracy of inferior tilt was 1.2° ± 1.2°. The accuracy of glenoid version was 2.6° ± 1.7°.

CONCLUSION:
The use of patient-specific glenoid baseplate guides is highly accurate in reproducing a virtual 3-dimensional preoperative plan. This technique delivers the accuracy observed using computerized navigation without any additional surgical steps or technical challenges.
Factors that predict postoperative motion in patients treated with reverse shoulder arthroplasty  
Schwarts DG, Cottrell BJ, Teusink MJ, Clark RE, Downes KL, Tammembaum RS, Frankle MA.

Abstract
BACKGROUND:
Reverse shoulder arthroplasty (RSA) has proven to be a useful yet inconsistent tool to manage a variety of pathologic conditions. Factors believed to lead to poor postoperative range of motion (ROM) may be associated with preoperative diagnosis, poor preoperative ROM, and surgical factors such as inability to lengthen the arm. The purpose of this study was to analyze multiple factors that may be predictive of motion after RSA. Our hypothesis is that intraoperative ROM is most predictive of postoperative ROM.

METHODS:
Between February 2003 and April 2011, 540 patients (217 men and 323 women) treated with RSA were evaluated with measurements of preoperative, intraoperative, and postoperative ROM at a follow-up, where ROM was found to have plateaued at 1 year as determined by a pilot study. A regression analysis was performed to define independent predictive factors of postoperative active ROM.

RESULTS:
Intraoperative forward flexion was the strongest predictor of final postoperative ROM, followed by gender and preoperative ROM. Age and arm lengthening were not significant independent predictors. Controlling for gender and preoperative ROM, patients with an intraoperative elevation of 90° gained 29° in postoperative forward elevation (P < .001), 120° gained approximately 40° in postoperative forward elevation (P < .001), 150° gained approximately 56° in postoperative forward elevation (P < .001) and 180° gained approximately 62° in postoperative forward flexion (P < .001).

CONCLUSIONS:
Intraoperative forward flexion is the strongest predictor of postoperative ROM. Surgeons may use intraoperative motion as a powerful decision-making tool regarding soft tissue tension in RSA.

Speed of recovery after shoulder arthroplasty: a comparison of reverse and anatomic total shoulder arthroplasty
Levy JC, Everding NG, Gil CC Jr, Stephens S, Giveans R.

Abstract
BACKGROUND:
Whereas patient expectations after anatomic total shoulder arthroplasty (TSA) and reverse shoulder arthroplasty (RSA) relate to sustained improvements in pain, function, and motion, the time necessary to reach these goals is unclear. Our purpose was to investigate the speed of recovery and to compare the effectiveness of primary TSA and RSA.

METHODS:
We analyzed (preoperative, 3 month, 6 month, 1-year, and 2-year score) pain scores, functional scores, and motion for 122 patients treated with primary RSA and 166 patients treated with primary TSA with a minimum of 1 year of follow-up. Comparisons were made to determine the effectiveness of treatment, time required to reach a plateau in improvement, and percentage of overall improvement at 3 and 6 months.

RESULTS:
Significant improvements were observed for both TSA and RSA at all intervals (P < .001), except with internal rotation for RSA. Pain relief was rapid after both TSA and RSA. TSA patients reached a consistent plateau for pain and function by 6 months and for shoulder elevation by 1 year. RSA patients demonstrated variability with multiple false plateau points. By 6 months, TSA patients had achieved 90% to 100% of functional improvement, whereas RSA patients reached 72% to 91%. The effectiveness of TSA was greater than that of RSA for all measures with the exception of elevation and abduction.

CONCLUSIONS:
Whereas patients treated with primary TSA and RSA can expect rapid improvements in pain, those treated with TSA can anticipate a more consistent and effective recovery of pain, function, and shoulder rotation. Patients receiving RSA can expect a variable length of recovery with greater improvements in forward elevation and abduction.
Comparison of hemiarthroplasty and reverse shoulder arthroplasty for the treatment of proximal humeral fractures in elderly patients

Cuff DJ, Pupello DR.

Source
Foundation for Orthopaedic Research and Education 13020 N. Telecom Parkway, Tampa, FL 33637, USA.

Abstract

BACKGROUND:
Treatment of complex three and four-part proximal humeral fractures with hemiarthroplasty in elderly patients has yielded mixed clinical results. Reverse shoulder arthroplasty has emerged as a treatment option for comminuted proximal humeral fractures for these patients. The purpose of the study was to perform a prospective evaluation of patient outcomes comparing hemiarthroplasty and reverse shoulder arthroplasty for the treatment of comminuted proximal humeral fractures in elderly patients.

METHODS:
Fifty-three consecutive elderly patients (average age, 74.4 years) underwent an arthroplasty for a complex proximal humeral fracture. Indications for arthroplasty were four-part fractures, three-part fractures with severe comminution of the greater tuberosity, and fractures that involved an articular split of the humeral head. Twenty-six patients underwent hemiarthroplasty (the HA group), followed by twenty-seven patients who underwent reverse shoulder arthroplasty (the RSA group). A total of forty-seven patients (twenty-three in the HA group and twenty-four in the RSA group) were available for follow-up at a minimum of two years.

RESULTS:
Final average outcome scores were lower in the HA group than in the RSA group (American Shoulder and Elbow Surgeons [ASES] score of 62 versus 77 [p = 0.0001] and Simple Shoulder Test [SST] of 5.8 versus 7.4 [p = 0.0062]), and patient-reported satisfaction was lower in the HA group than in the RSA group (61% versus 91% [p = 0.038]). Radiographic healing of the tuberosities occurred in 61% of the patients in the HA group compared with 83% of the patients in the RSA group (p = 0.17). Forward elevation of the arm was higher in the RSA group (139°) than in the HA group (100°) (p = 0.0002), but no significant differences were observed for shoulder external rotation or internal rotation. Complication rates in both groups were similar. Three patients (13%) in the HA group elected revision to reverse shoulder arthroplasty because of failed tuberosity healing and resultant shoulder pseudoparesis.

CONCLUSIONS:
In this series, reverse shoulder arthroplasty resulted in better clinical outcomes and a similar complication rate compared with hemiarthroplasty for the treatment of comminuted proximal humeral fractures in the elderly.
Glenoid screw position in the Encore reverse shoulder prosthesis: an anatomic dissection study of screw relationship to surrounding structures
Hart ND, Clark JC, Krause W, Kissenberth MJ, Bragg WE, Hawkins RJ.

Source
Steadman Hawkins Clinic of the Carolinas, Greenville Hospital System, Greenville, SC 29615, USA.

Abstract
BACKGROUND:
Fixation of the baseplate to the glenoid for the Reverse Shoulder Prosthesis (DJO Surgical, Austin, TX, USA) requires secure screw purchase to avoid excessive micromotion and baseplate failure. The best screw length for fixation is unknown. In addition, excessively long screws or a plunge of the drill bit during baseplate insertion could injure surrounding structures.

METHODS:
Reverse Shoulder Prosthesis baseplates were inserted in 10 fresh-frozen shoulders by use of a 6.5-mm central screw and four 5.0-mm peripheral locking screws placed 90° to the baseplate. The top superior screw was placed into the base of the coracoid, corresponding to the 1-o’clock position in a right shoulder. The distances to surrounding vital structures were recorded, screws were removed, and screw hole lengths were measured to determine the most effective lengths in different parts of the glenoid scapula.

RESULTS:
The screw length was 30 mm for the superior screw holes, 28 mm for the inferior screw holes, 13 mm for the anterior screw holes, and 15 mm for the posterior screw holes. The central screw trajectory was through the anterior cortex. The anterior screw trajectory violated the subscapularis belly in all specimens. The posterior screw touched the suprascapular nerve or artery in 3 of 10 specimens.

DISCUSSION:
The superior and inferior screws have the longest bony fixation. Drill bit plunge during placement of the anterior screw poses a risk to the subscapularis muscle. Drilling for the posterior screw risks injury to the suprascapular nerve and artery at the spinoglenoid notch.

CONCLUSIONS:
The posterior screw should be placed with care to avoid neurovascular complications.
Isometric strength, range of motion, and impairment before and after total and reverse shoulder arthroplasty
Puskas B, Harreld K, Clark R, Downes K, Virani NA, Frankle M.

Source
Shoulder & Elbow Division, Florida Orthopaedic Institute, Tampa, FL, USA.

Abstract
BACKGROUND:
Medicare Part A provides similar resources for coverage of inpatient hospitalization costs for patients treated with total shoulder arthroplasty (TSA) and reverse shoulder arthroplasty (RSA). This is based on an assumption that TSA and RSA are used to treat similar patient populations with comparable disease severity. However, no objective clinical information is available to support this resource allocation. The purpose of this study is to quantify the disease severity and subsequent improvement from primary TSA, primary RSA, and revision arthroplasty (TSA and RSA).

METHODS:
From March 2004 through May 2006, 174 shoulders (87 primary TSA, 55 primary RSA, and 32 revision cases) were prospectively studied using Biodex (Biodex Medical Systems, Shirley, NY, USA) isometric strength and standardized video range of motion measurements performed by an independent third-party observer at 1 week before surgery and at an average of 49 months (range, 32-69 months) postoperatively. Patient impairment ratings were calculated using the Florida Impairment Guidelines.

RESULTS:
Primary TSA had the lowest average preoperative impairment (21%), and revision arthroplasty had the highest (28%). All patients demonstrated improvement in the parameters tested. At an average 49 months, all 3 groups demonstrated a similar reduction in impairment ratings (TSA: 21% to 10%; RSA: 25% to 15%; revision arthroplasties: 28% to 20%).

CONCLUSION:
There are distinct differences in preoperative disease severity among patients undergoing primary TSA, primary RSA, and revision arthroplasty. Greater impairment is evident in patients undergoing a revision arthroplasty. However, all groups may be expected to achieve improvements and maintain these improvements 4 years postoperatively.

Surgically treated humeral shaft fractures following shoulder arthroplasty
Andersen JR, Williams CD, Cain R, Mighell M, Frankle M.

Source
Foundation for Orthopaedic Research and Education, Tampa, FL 33637, USA.

Abstract
BACKGROUND:
We reviewed a consecutive series of patients with a humeral fracture around either an anatomic or a reverse shoulder prosthesis treated with either open reduction and internal fixation (ORIF) or revision shoulder arthroplasty. The purposes of the study were to (1) describe the treatment of these fractures by either method, (2) report the outcomes, and (3) assess the validity of a current classification system.

METHODS:
Indications for surgery were a displaced unstable fracture, a fracture around a loose humeral stem, or a patient who was unable to tolerate conservative treatment. Outcomes were reported for two groups (patients treated with revision arthroplasty and those treated only with ORIF) and included American Shoulder and Elbow Surgeons (ASES) scores, radiographic evidence of fracture union, and complications.

RESULTS:
The mean ASES score for the entire cohort was 50.3 (95% confidence interval: 41.2 to 59.5). Thirty-five of the thirty-six fractures healed, in a mean of 7.2 months (range, 1.25 to 13.5 months). Complications occurred in fourteen (39%) of the thirty-six patients. Our ability to classify these fractures with a previously defined system had a low interobserver reliability (mean kappa, 0.37; range, 0.24 to 0.50) and a high intraobserver reliability (mean kappa, 0.69; range, 0.52 to 0.89).

CONCLUSIONS:
Periprosthetic fracture around a humeral stem implant is a difficult clinical problem involving complex decision-making. Fracture union occurred in 97% of our patients. Complications were frequent, and a reoperation was required in 19% of the patients. More than half of the patients in our study had a loose humeral component that required revision.
Complications of the reverse prosthesis: prevention and treatment

Source
Department of Orthopaedic Surgery, Johns Hopkins University School of Medicine, Baltimore, MD, USA.

Abstract
Reverse total shoulder arthroplasty was developed in the late 1980s for elderly patients with rotator cuff arthropathy. Several biomechanical advantages of the reverse shoulder arthroplasty result in improved deltoid function, which improves shoulder motion and function compared to other types of shoulder arthroplasty. The main indication for the reverse prosthesis is painful rotator cuff tear arthropathy. The indications for reverse shoulder arthroplasty have continued to expand since it was first performed in the United States in 2004. Although the results of reverse total shoulder arthroplasty have been generally favorable, the complication rate is higher than that of conventional total shoulder arthroplasty. Complications include those common to other shoulder procedures (infection, instability, and nerve injury) and those unique to reverse total shoulder arthroplasty (scapular notching, glenoid baseplate failure, component disassociation, and scapular stress fractures). It is helpful for orthopaedic surgeons to understand ways to avoid these complications and methods with which to treat them.

Reverse shoulder arthroplasty for the treatment of rotator cuff deficiency: a concise follow-up, at a minimum of five years, of a previous report
Cuff D, Clark R, Pupello D, Frankle M.

Source

Abstract
We previously evaluated ninety-four patients (ninety-six shoulders) who underwent reverse shoulder arthroplasty with use of a central compressive screw along with 5.0-mm peripheral locking screws for baseplate fixation and a center of rotation lateral to the glenoid. The purpose of this study was to report updated results at a minimum follow-up of five years. Since the last report, an additional two patients underwent revision surgery: one for recurrent instability and one for resorption of a proximal humeral allograft. The patients continue to have improved outcome scores and range of motion. Survivorship with the end point being revision for any reason was 73.5 months, with 94% survival at sixty months. Radiographic follow-up showed that two (3%) of seventy-six patients included in the survivorship analysis had asymptomatic humeral loosening, seven (9%) had scapular notching, and no patient had glenoid baseplate loosening or baseplate failure. The patients have maintained their improved function with durable clinical and radiographic results at a minimum of five years.
Management of deep infection after reverse total shoulder arthroplasty: a case series
Zavala JA, Clark JC, Kissenberth MJ, Tolan SJ, Hawkins RJ.

Source
Orthopaedic Specialists of Dallas, Rockwall, TX, USA.

Abstract
BACKGROUND:
Reverse total shoulder arthroplasty (RSA) is being increasingly used in the treatment of disabling shoulder conditions. This study reports the management of deep infections after RSA.

MATERIALS AND METHODS:
Eight of 138 patients were treated for deep infection after the index procedure. A retrospective review was performed to identify risk factors, methods of management, and determine ultimate outcome. A minimum of 12-month follow-up was available in 7 of 8 patients.

RESULTS:
Six infections occurred in patients who had had previous shoulder surgery. The causative bacterial organism was identified in 6 patients. Deep infection occurred in 3 patients with diabetes mellitus. Antibiotic cement was used in all cases. Six patients were managed with irrigation and debridement and retention of components. Two patients with Staphylococcus aureus infection ultimately required resection arthroplasty. Patients managed with irrigation and debridement, intravenous antibiotics, and retention of components demonstrated good pain relief and function, without evidence of radiographic loosening. Resection resulted in pain relief but poor functional outcomes.

CONCLUSION:
Limited literature is available regarding the management of deep infection in patients with RSA. Component removal after a RSA creates increased bone loss due to a cemented humeral component and glenoid baseplate with several large screws. Five of 7 patients with deep infection had undergone previous shoulder surgery. We recommend that patients should be managed with an initial irrigation and debridement, appropriate intravenous antibiotics, and component retention.

Kinematic analysis of dynamic shoulder motion in patients with reverse total shoulder arthroplasty
Kwon YW, Pinto VJ, Yoon J, Frankle MA, Dunning PE, Sheikhzadeh A.

Source
Division of Shoulder and Elbow Surgery, Department of Orthopaedic Surgery, NYU Hospital for Joint Diseases, New York, NY, USA.

Abstract
BACKGROUND:
Reverse total shoulder arthroplasty (rTSA) has been used to treat patients with irreparable rotator cuff dysfunction. Despite the proven clinical efficacy, there is minimal information regarding the underlying changes to the shoulder kinematics associated with this construct. Therefore, we sought to examine the kinematics of dynamic shoulder motion in patients with well-functioning rTSA.

METHODS:
We tested 12 healthy subjects and 17 patients with rTSA. All rTSA patients were able to elevate their arms to at least 90° and received the implant as the primary arthroplasty at least 6 months before testing. On average, the rTSA patients elevated their arms to 112° ± 12° (mean ± SD) and reported an American Shoulder and Elbow Surgeons outcome score of 90.6 ± 6.3. A 3-dimensional electromagnetic motion capture device was used to detect the dynamic motion of the trunk, scapula, and humerus during bilateral active shoulder elevation along the sagittal, scapular, and coronal planes.

RESULTS:
In both healthy and rTSA shoulders, the majority of the humeral–thoracic motion was provided by the glenohumeral motion. Therefore, the ratio of glenohumeral to scapulothoracic (ST) motion was always greater than 1.62 during elevation along the scapular plane. In comparison to healthy subjects, however, the contribution of ST motion to overall shoulder motion was significantly increased in the rTSA shoulders. This increased contribution was noted in all planes of shoulder elevation and was maintained when weights were attached to the arm.

CONCLUSION:
Kinematics of the rTSA shoulders are significantly altered, and more ST motion is used to achieve shoulder elevation.
Reverse® Shoulder System


Proximal humeral malunion treated with reverse shoulder arthroplasty
Willis M, Min W, Brooks JP, Mulieri P, Walker M, Pupello D, Frankle M.

Source
Tennessee Orthopaedic Alliance, Nashville, TN, USA.

Abstract
BACKGROUND:
The purpose of this study was to determine the outcomes of patients with proximal humeral malunions treated with reverse shoulder arthroplasty (RSA).

MATERIALS AND METHODS:
Sixteen patients were treated with RSA for sequelae of a proximal humeral fracture with malunion. Clinical outcomes (American Shoulder and Elbow Surgeons [ASES] score, Simple Shoulder Test, visual analog scale [VAS] score for pain and function, range of motion, and patient satisfaction) and radiographs were evaluated at a minimum follow-up of 2 years. Wilcoxon signed-rank tests were used to analyze preoperative and postoperative data.

RESULTS:
All patients required alteration of humeral preparation with increased retroversion of greater than 30°. The total ASES score improved from 28 to 63 (P < .001), ASES functional score from 15 to 35 (P = .003), ASES functional score from 15 to 27 (P = .015), VAS pain score from 7 to 3 (P = .003), VAS function score from 0 to 5 (P = .001), and Simple Shoulder Test score from 1 to 4 (P = .0015). Forward flexion improved from 53° to 105° (P = .002), abduction from 48° to 105° (P = .002), external rotation from 5° to 30° (P = .015), and internal rotation from 51 to L3 (P = .005). There were no major complications reported. Postoperative radiographic evaluation showed 2 patients with evidence of notching and 1 patient with proximal humeral bone resorption.

CONCLUSION:
RSA is indicated for treating the most severe types of proximal humeral fracture sequelae. The results of RSA for proximal humeral malunions with altered surgical technique yield satisfactory outcomes in this difficult patient population.


The use of the reverse shoulder arthroplasty for treatment of failed total shoulder arthroplasty
Walker M, Willis MP, Brooks JP, Pupello D, Mulieri P, Frankle MA.

Source
Florida Orthopaedic Institute, Tampa, FL 33637, USA.

Abstract
BACKGROUND:
This study evaluated the outcomes of patients with failed total shoulder arthroplasty (TSA) who were treated with conversion to reverse shoulder arthroplasty (RSA).

MATERIALS AND METHODS:
We performed a retrospective case series of 24 consecutive patients with failed TSA who were treated with conversion to RSA. Twenty-two patients (16 women, 6 men) had a minimum 2-year clinical and radiographic follow-up. The average age at the time of revision was 68 years (range, 51–84 years). Indications for conversion to RSA included failure of TSA from glenohumeral instability in 19, mechanical failure of the humeral or glenoid component in 10, and infection in 2.

RESULTS:
The median total American Shoulder and Elbow Surgeons score improved from 38.5 preoperatively to 67.5 (P < .001). Visual analog scale pain scores decreased from 5 to 15 (P < .001), and function improved from 2 to 65 (P < .001). The median Simple Shoulder Test improved from 1 to 5 (P = .006). Forward flexion improved from 50° to 130° (P < .001), abduction from 45° to 100° (P < .001), and external rotation from 12.5° to 49.5° (P = .016). Internal rotation improved from a spinal level of S2 to L3 (P = .064). Fourteen patients rated their outcome as excellent, 3 as good, 3 as satisfactory, and 2 as unsatisfactory. The overall complication rate was 22.7% (5 of 22).

CONCLUSION:
RSA can be an effective treatment for failed TSA by decreasing pain and improving shoulder function. However, RSA in the revision setting is associated with a higher complication rate.
Complication rates, dislocation, pain, and postoperative range of motion after reverse shoulder arthroplasty in patients with and without repair of the subscapularis


Abstract

BACKGROUND:
Despite improved results with reverse shoulder arthroplasty (RSA), questions still remain regarding certain technical aspects of the operation. One particular area of question is the effect of subscapularis repair on complication rates, dislocation, pain, and overall range of motion. Some authors suggest that when a deltopectoral approach is used, not repairing the subscapularis leads to a higher complication rate, especially for dislocation.

MATERIALS AND METHODS:
From a reverse total shoulder arthroplasty database of 3 surgeons at 1 institution, we identified 55 patients who underwent RSA using the deltopectoral approach without subscapularis repair and 65 patients with subscapularis repair.

RESULTS:
Complications were documented in 11 of 55 shoulders (20%) without subscapularis repair and in 13 of 65 shoulders (20%) with subscapularis repair. Dislocation occurred in 3 shoulders in the nonrepair group and in 2 shoulders in the repair group. These data indicate that nonrepair of the subscapularis did not have a significant effect on the risk of any complication, dislocation, infection, disassociation, or function.

CONCLUSION:
Repairing the subscapularis has no appreciable effect on complication rate, dislocation events, or range of motion gains and pain relief.

Effects of tilt and glenosphere eccentricity on baseplate/bone interface forces in a computational model, validated by a mechanical model, of reverse shoulder arthroplasty

Gutiérrez S, Walker M, Willis M, Pupello DR, Franklin MA.

Abstract

BACKGROUND:
Reverse shoulder arthroplasty is being used with greater frequency for patients with severe rotator cuff deficiency. There are several commercially available reverse shoulder devices, each with different glenosphere options. The purpose of this study was to determine: (1) forces at the baseplate-bone interface in glenospheres with centers of rotation located concentrically and eccentrically to the center of the baseplate; and (2) if baseplate-bone forces can be optimized by altering tilt of the baseplate.

METHODS:
A validated computer model was used to compare concentric glenospheres with neutral offset to eccentrically offset glenospheres (6 mm inferior or 6 mm lateral) in 3 baseplate tilts: 15° inferior, neutral, or 15° superior. A baseplate, simulated bone, screws, and humeral component were modeled, and forces underneath the baseplate were calculated as the arm was abducted through 90° of glenohumeral motion.

RESULTS:
For lateral and concentric glenospheres, inferior tilt provides the most even distribution of forces (mean difference in force between superior and inferior portions of baseplate: 11.3 N and 24.7 N, respectively) and superior tilt provides the most uneven distribution of forces (10.9 N and 78.7 N, respectively). For inferior eccentric glenospheres, inferior tilt provides the most uneven distribution of forces (58.7 N) and neutral tilt provides the most even distribution of forces (27.7 N).

CONCLUSION:
This is the first study to investigate force distribution under the baseplate in inferior eccentric glenospheres. Although inferior tilting of the baseplate is recommended for concentric and laterally offset glenospheres, this same recommendation may be detrimental to inferiorly offset glenospheres and warrants further investigation.
Torsional stability of modular and non-modular reverse shoulder humeral components in a proximal humeral bone loss model

Cuff D, Levy JC, Gutiérrez S, Frankle MA.

Source
Suncoast Orthopaedic Surgery, Venice, FL, USA.

Abstract
HYPOTHESIS/BACKGROUND:
Patients who are treated with reverse shoulder arthroplasty in the setting of proximal humeral bone loss present a technical challenge for humeral component fixation. The purpose of this study was to determine the effect of proximal humeral bone loss on fixation of reverse shoulder humeral implants.

MATERIALS AND METHODS:
Three reverse humeral designs (two modular and one monobloc) were cemented into twenty-four sawbones humeri prepared to simulate intact and proximal humeral bone loss. Torque was applied to the humerus for 1,000 cycles in increments of 2.5 N-m to 25 N-m. Rotational micromotion of the implant was measured.

RESULTS:
There was a significant decrease in rotational micromotion in the intact constructs when compared with the bone loss constructs (we found P < .01 when looking at torsion levels of 5 to 17.5 N-m). In the intact humerus, 10 of 12 implant constructs survived testing. The 2 that failed were modular implants. In the bone loss setting, 7 of 12 implant constructs survived testing. The 5 that failed were also modular implants.

CONCLUSIONS:
This is the first investigation on humeral component fixation in reverse shoulder arthroplasty. The proximal humerus adds stability to the fixation of a cemented humeral implant. Modular components in the presence of proximal humeral bone loss may be at increased risk of mechanical failure. Conversely, non-modular cemented humeral components can withstand greater loads before failure.
Reverse shoulder arthroplasty for the treatment of irreparable rotator cuff tear without glenohumeral arthritis

Mulieri P, Dunning P, Klein S, Pupello D, Frankle M.

Source
Florida Orthopaedic Institute, 13020 North Telecom Parkway, Tampa, FL 33617, USA.

Abstract
BACKGROUND:
The purpose of the present study was to evaluate the indications for, and outcomes of, reverse shoulder arthroplasty in patients with massive rotator cuff tears but without glenohumeral arthritis.

METHODS:
From December 1998 to December 2006, sixty-nine patients (seventy-two shoulders) were managed with reverse shoulder arthroplasty for the treatment of irreparable rotator cuff dysfunction without glenohumeral arthritis. The indications for reverse shoulder arthroplasty were persistent shoulder pain and dysfunction despite a minimum of six months of nonoperative treatment, the presence of at least a two-tendon tear, and Hamada stage-1, 2, or 3 changes in a patient for whom a non-arthroplasty option did not exist. Fifty-eight patients (sixty shoulders) had a minimum of two years of follow-up. Thirty-four shoulders had had no previous surgery (Group A), and twenty-six shoulders had had at least one previous surgical procedure (Group B). Postoperatively, patients were prospectively followed both clinically and radiographically. Survival analysis was performed, with the end points being removal or revision of the implant, radiographic loosening, and declining American Shoulder and Elbow Surgeons score.

RESULTS:
Common characteristics of patients managed with reverse shoulder arthroplasty in this study were pain and (1) <90° of arm elevation at the shoulder without anterosuperior escape (n = 40; 66.6%); (2) <90° of elevation with anterosuperior escape (n = 16; 26.7%); or (3) irreparable rotator cuff tear and pain with >90° of elevation (n = 4; 6.7%). The average duration of follow-up was fifty-two months (range, twenty-four to 101 months). All measured outcomes improved postoperatively. For all patients, the average American Shoulder and Elbow Surgeons score improved from 33.3 to 75.4 (p < 0.0001), the average Simple Shoulder Test score improved from 1.6 to 6.5 (p < 0.0001), the average visual analog score for pain improved from 6.3 to 1.9 (p < 0.0001), the average visual analog score for function improved from 3.2 to 7.1 (p < 0.0001), the average forward flexion improved from 53° to 134° (p < 0.0001), the average abduction improved from 49° to 125° (p < 0.0001), the average internal rotation improved from S1 to L2 (p < 0.0001), and the average external rotation improved from 27° to 51° (p = 0.001). There were a total of twelve complications in eleven patients (prevalence, 20%). The survivorship at a mean of fifty-two months (range, twenty-four to 101 months) was 90.7% for all patients, 91.8% for Group A, and 87% for Group B.

CONCLUSIONS:
When non-arthroplasty options either have failed or have a low likelihood of success, reverse shoulder arthroplasty provides reliable pain relief and return of shoulder function in patients with massive rotator cuff tears without arthritis at the time of short to intermediate-term follow-up.
Reverse shoulder arthroplasty in patients with rheumatoid arthritis

Holcomb JO, Hebert DJ, Mighell MA, Dunning PE, Pupello DR, Pliner MD, Frankle MA.

Source
Henry Ford Wyandotte Hospital, Wyandotte, MI, USA.

Abstract

BACKGROUND:
The purpose of this study was to describe the pathoanatomy of patients diagnosed with rheumatoid arthritis and rotator cuff deficiency and report their outcomes following reverse shoulder arthroplasty.

METHODS:
Twenty-one shoulders were evaluated prospectively. Nine had no prior surgery, 9 had a failed rotator cuff repair, and 3 had a failed arthroplasty. Patients were followed for a minimum of 2 years (average, 36 months). All patients had preoperative radiographs and 19 shoulders had an MRI or CT available for evaluation of muscular and bony deficiency. Radiographs at most recent follow-up were evaluated for loosening and scapular notching.

RESULTS:
All outcome measures improved significantly: ASES scores improved from 28 preoperatively to 82 postoperatively (P < .0001); SST scores improved from 1 to 7 (P < .0001); VAS pain scores improved from 7 to 1 (P < .0001); VAS function scores improved from 3 to 6 (P = .0058); elevation improved from 52° to 126° (P < .0001); abduction improved from 55° to 116° (P = .0002); external rotation improved from 19° to 33° (P = .02); and internal rotation improved from 51 to 4 (P = .02). Twelve patients rated their outcome as excellent, 6 as good, 2 as satisfactory, and 1 as unsatisfactory. Severe glenoid erosion was seen in 10 of the shoulders and 5 of the defects required structural grafting. Three patients (14%) sustained a complication that required reoperation: 2 for infection and 1 for periprosthetic fracture.

CONCLUSIONS:
In patients with rheumatoid arthritis and rotator cuff deficiency, reverse shoulder arthroplasty can provide improvement in function and decreased pain.
Reverse shoulder arthroplasty in the management of irreparable rotator cuff tears without arthritis
Harreld KL, Puskas BL, Andersen J, Frankle, MA.

Source
Florida Orthopaedic Institute, 13020 North Telecom Parkway, Tampa, FL 33637.

Abstract
INTRODUCTION
The ability to provide reliable outcomes in treatment of patients with degenerative rotator cuff tears has become increasingly complicated, as a result of more advanced disease and the increased array of treatment choices.

STEP 1: PREOPERATIVE PLANNING
Develop and communicate with a consistent team of interdisciplinary physicians both preoperatively and postoperatively; utilize advanced imaging modalities to evaluate muscle atrophy as well as glenoid and humeral bone stock.

STEP 2: PATIENT POSITIONING
Place the patient in a beach-chair position, check the abdominal strap, and position yourself facing the axilla.

STEP 3: SURGICAL APPROACH
Develop the subdeltoid and subacromial spaces and take care to avoid vigorous over-retraction of the deltoid.

STEP 4: HUMERAL EXPOSURE AND PREPARATION
Perform the head cut utilizing the 135° resection guide, broach the humerus, and ream the humeral socket.

STEP 5: GLENOID EXPOSURE AND PREPARATION; GLENOSPHERE INSERTION
Ream the inferior surface to bleeding subchondral bone; bleeding subchondral bone on the inferior 50% of the prepared glenoid surface indicates a sufficient depth.

STEP 6: FINAL HUMERAL PREPARATION
At final reaming, the edge of the reamer should sit flush with the cut surface of the humerus.

STEP 7: TRIALING
Proper soft-tissue balance is frequently achieved by positioning the humeral component so that the rim of the socket lies just above the humeral osteotomy site at the anatomic neck.

STEP 8: COMPONENT IMPLANTATION AND CLOSURE
When cementing the humeral component, the socket should match the reamed proximal part of the humerus.
Effects of acquired glenoid bone defects on surgical technique and clinical outcomes in reverse shoulder arthroplasty


Source
Foundation for Orthopaedic Research and Education, Tampa, FL 33637, USA.

Abstract

BACKGROUND:
Reverse total shoulder arthroplasty is the accepted method of treatment for selected shoulder disorders. The purpose of this study was to compare primary reverse shoulder arthroplasty surgical techniques as well as clinical and radiographic outcomes in patients with acquired glenoid bone defects and in those with normal glenoid morphology.

METHODS:
Preoperative three-dimensional computed tomography scans were performed on 216 shoulders in 211 patients undergoing primary reverse shoulder arthroplasty between 2004 and 2007. The glenoids were classified as normal or abnormal on the basis of preoperative radiographs and three-dimensional reconstructions of the scapula. One hundred and forty-three shoulders had been followed for two years. There were eighty-seven normal and fifty-six abnormal glenoids. The surgical techniques that were compared included bone-grafting and glenosphere selection. The clinical outcomes for the two groups were compared with respect to the American Shoulder and Elbow Surgeons score.

RESULTS:
Surgical technique differed between the groups. All fifty-six glenoids with acquired bone defects had center screw placement along an alternative (scapular spine) centerline. A bone graft was used in twenty-two shoulders with acquired glenoid bone defects compared with none of those with normal glenoid morphology (p = 0.016). Shoulders with glenoid defects were treated with larger glenospheres (36 or 40 mm) more often than those with normal glenoids (p < 0.001). No significant difference was detected between the groups with regard to the preoperative or postoperative American Shoulder and Elbow Surgeons scores. Radiographs did not demonstrate failure or resorption of a glenoid bone graft when present. All outcomes improved significantly postoperatively. There were five complications, and one patient was unsatisfied with the result.

CONCLUSIONS:
Glenoid bone defects, when managed with an alteration of surgical technique, including bone-grafting when indicated, are not a contraindication to reverse total shoulder arthroplasty.

Revision reverse shoulder arthroplasty for glenoid baseplate failure after primary reverse shoulder arthroplasty

Holcomb JO, Cuff D, Petersen SA, Pupello DR, Frankle MA.

Source
Shoulder & Elbow Division, Florida Orthopaedic Institute, Tampa, FL 33637, USA.

Abstract

BACKGROUND:
The aim of this study is to document a single surgeon’s experience performing revision reverse shoulder arthroplasty after baseplate failure.

METHODS:
Revision reverse shoulder arthroplasty (RSA) for mechanical failure of the glenoid baseplate after RSA was performed in 14 patients. Clinical and radiographic data were collected preoperatively, prior to baseplate failure, after baseplate failure, and at latest follow-up after revision (average, 33 months).

RESULTS:
When comparing the pre-operative values to post-revision, ASES, forward elevation, and abduction were significantly improved. There was no significant difference in any of the outcome measures when comparing the prefailure data to the post-revision data. The post-revision prosthesis-scapular neck angle (PSNA) showed a significant increase in inferior tilt of the baseplate when compared to pre-failure PSNA (P < .001). Two patients (14%) required a second revision RSA for glenoid baseplate failure (1) and dislocation (1); 1 additional patient developed a postoperative hematoma which resolved without surgery.

CONCLUSION:
Revision RSA for the treatment of glenoid baseplate mechanical failure can restore pain relief and function to the levels gained after the index RSA.
Reverse Shoulder System

Revision arthroplasty with use of a reverse shoulder prosthesis-allograft composite

Source
Florida Orthopaedic Institute, 13020 North Telecom Parkway, Tampa, FL 33617, USA.

Abstract
BACKGROUND:
Patients with disabling pain and loss of shoulder function with associated proximal humeral bone loss following shoulder arthroplasty have limited reliable treatment options. Our objective was to report the results, obtained as part of a prospective outcomes study, of the use of a reverse shoulder prosthesis-allograft composite in these patients.

METHODS:
Between 2002 and 2005, 353 patients treated with a reverse shoulder prosthesis were enrolled in a prospective cohort study. Twenty-five patients received, in addition, a proximal humeral allograft for the management of severe proximal humeral bone loss, and they comprise the study group. The average bone loss measured 53.6 mm (range, 34.5 to 150.3 mm). Patients were followed clinically with use of the American Shoulder and Elbow Surgeons (ASES) score, the Simple Shoulder Test (SST), and a scale with which the patients rated their satisfaction, and they were followed radiographically to detect mechanical failure, loosening, notching, and graft healing. All patients were followed for a minimum of two years (average, 30.2 months).

RESULTS:
The total average ASES score improved from 31.7 points preoperatively to 69.4 points at the time of follow-up (p < 0.0001), and the average SST score improved from 1.4 to 4.5 points (p < 0.0001). Nineteen patients (76%) reported a subjective good or excellent result, five reported a satisfactory result, and one reported that the result was unsatisfactory. The range of motion improved in forward flexion (from 32.7 degrees to 82.4 degrees; p < 0.0001), abduction (from 40.4 degrees to 81.4 degrees; p < 0.0001), and internal rotation. Radiographic evaluation at the time of final follow-up showed incorporation of the allograft in the metaphyseal region in 84% (twenty-one) of the twenty-five patients and incorporation of the allograft in the diaphyseal region in 76% (nineteen) of the patients. Four patients had complications.

CONCLUSIONS:
Use of a reverse shoulder prosthesis-proximal humeral allograft composite for the treatment of shoulder dysfunction following arthroplasty associated with substantial proximal humeral bone loss has shown promising early results. The allograft may restore proximal humeral bone stock, thereby helping to maintain the height of the prosthesis bone construct and thus deltoid tension. Additional, long-term studies are needed to evaluate the longevity of this construct.
Reverse® Shoulder System


Reverse shoulder arthroplasty for the treatment of rotator cuff deficiency
Cuff D, Pupello D, Virani N, Levy J, Frankle M.

Source
Florida Orthopaedic Institute, 13020 North Telecom Parkway, Tampa, FL 33637, USA.

Abstract
BACKGROUND:
Early designs of reverse shoulder arthroplasty components for the treatment of glenohumeral arthritis associated with severe rotator cuff deficiency in some cases have been associated with mechanical failure. The purpose of this study was to perform a prospective outcomes study of reverse shoulder arthroplasty performed with use of 5.0-mm peripheral locking screws for baseplate fixation and a lateralized center of rotation for the treatment of a rotator cuff deficiency.

METHODS:
From February 2004 to March 2005, 112 patients (114 shoulders) were treated with a reverse shoulder arthroplasty as part of a United States Food and Drug Administration Investigational Device Exemption study. Ninety-four patients (ninety-six shoulders) were available for a minimum follow-up of two years. Of the ninety-six shoulders, thirty-seven had a primary rotator cuff deficiency, thirty-three had a previous rotator cuff operation, twenty-three had a previous arthroplasty, and three had a proximal humeral nonunion. The patients were prospectively followed clinically (the American Shoulder and Elbow Surgeons [ASES] score, the Simple Shoulder Test [SST], and self-reported satisfaction) and radiographically (mechanical failure, loosening, and notching). Patients were videotaped while performing a standard active range-of-motion protocol before and after treatment. These videos were then analyzed in a blinded fashion by three independent observers using a digital goniometer.

RESULTS:
At two years, the average total ASES scores had improved from 30 preoperatively to 77.6; the average ASES pain scores, from 15 to 41.6; and the average SST scores, from 1.8 to 6.8 (p < 0.0001 for all). Blinded analysis of range of motion showed that average abduction improved from 61 degrees preoperatively to 109.5 degrees (p < 0.0001); average flexion, from 63.5 degrees to 118 degrees (p < 0.0001); and average external rotation, from 13.4 degrees to 28.2 degrees (p < 0.0001). The patients rated the outcome as excellent in fifty-three shoulders (55%), good in twenty-six (27%), satisfactory in eleven (12%), and unsatisfactory in six (6%). There was no evidence of mechanical failure of the baseplate or scapular notching in any of the patients. Six of the ninety-four patients in this study had a complication.

CONCLUSIONS:
Recent advances in reverse shoulder arthroplasty have allowed for improvement in patient outcomes while minimizing early mechanical failure and scapular notching and decreasing the overall complication rate at short-term follow-up.


The treatment of deep shoulder infection and glenohumeral instability with debridement, reverse shoulder arthroplasty and postoperative antibiotics
Cuff DJ, Virani NA, Levy J, Frankle MA, Derasari A, Hines B, Pupello DR, Cancio M, Mighell M.

Source
Florida Orthopaedic Institute, 13020 N Telecom Parkway, Tampa, Florida 33637, USA.

Abstract
We retrospectively reviewed 21 patients (22 shoulders) who presented with deep infection after surgery to the shoulder, 17 having previously undergone hemiarthroplasty and five open repair of the rotator cuff. Nine shoulders had undergone previous surgical attempts to eradicate their infection. The diagnosis of infection was based on a combination of clinical suspicion (16 shoulders), positive frozen sections (> 5 polymorphonuclear leukocytes per high-power field) at the time of revision (15 shoulders), positive intra-operative cultures (18 shoulders) or the pre-operative radiological appearances. The patients were treated by an extensive debridement, intravenous antibiotics, and conversion to a reverse shoulder prosthesis in either a single- (10 shoulders) or a two-stage (12 shoulders) procedure. At a mean follow-up of 43 months (25 to 66) there was no evidence of recurrent infection. All outcome measures showed statistically significant improvements. Mean abduction improved from 36.1 degrees (sd 27.8) pre-operatively to 75.7 degrees (sd 36.0) (p < 0.0001), the mean forward flexion from 41.1 degrees (sd 31.5) to 79.5 degrees (sd 41.2) (p < 0.0003), and mean external rotation from 10.2 degrees (sd 18.7) to 25.4 degrees (sd 21.5) (p < 0.0037). There was no statistically significant difference in any outcome between the single-stage and the two-stage group.
Center of rotation affects abduction range of motion of reverse shoulder arthroplasty
Gutiérrez S, Levy JC, Frankle MA, Lee WE 3rd, Keller TS, Maitland ME.

Source
Musculoskeletal Research Foundation, Florida Orthopaedic Institute, Temple Terrace, FL 33637, USA.

Abstract
Although clinical outcomes of the reverse shoulder replacement have noted improvements in pain and function, evaluation of these outcomes reveals concerns regarding progressive scapular notching and variability of functional improvements in range of motion. Therefore, an apparatus was designed to examine differences in abduction range of motion for seven configurations of reverse shoulder arthroplasty. An electronic goniometer was used to measure abduction range of motion, and digital video analysis was used to determine impingement points. Finally, a correlation analysis between range of motion and the effect of changing the center of rotation of the glenosphere was performed. As the center of rotation was moved more lateral from the glenoid, abduction range of motion increased. The greatest range of motion was 97° ± 0.9° using a glenoid component with a center of rotation offset 10 mm ± 0.4 mm from the glenoid. The smallest range of motion was 67° ± 1.8° using a glenosphere with a center of rotation offset 0.5 mm ± 0.1 mm from the glenoid surface. Range of motion always was limited by impingement points on the scapula. Inferiorly, adduction was limited by impingement on either the inferior scapular border or the glenoid. Superiorly, abduction was limited by impingement on the acromion. A positive linear correlation was found between abduction range of motion and center of rotation offset relative to the glenoid.

Biomechanical comparison of component position and hardware failure in the reverse shoulder prosthesis

Source
Musculoskeletal Research Foundation, Florida Orthopaedic Institute, Temple Terrace, FL 33637, USA.

Abstract
There has been renewed interest in reverse shoulder arthroplasty for the treatment of glenohumeral arthritis with concomitant rotator cuff deficiency. Failure of the prosthesis at the glenoid attachment site remains a concern. The purpose of this study was to examine glenoid component stability with regard to the angle of implantation. This investigation entailed a biomechanical analysis to evaluate forces and micromotion in glenoid components attached to 12 polyurethane blocks at -15 degrees, 0 degrees, and +15 degrees of superior and inferior tilt. The 15 degrees inferior tilt had the most uniform compressive forces and the least amount of tensile forces and micromotion when compared with the 0 degrees and 15 degrees superiorly tilted baseplate. Our results suggest that implantation with an inferior tilt will reduce the incidence of mechanical failure of the glenoid component in a reverse shoulder prosthesis.
Reverse® Shoulder System


Use of the reverse shoulder prosthesis for the treatment of failed hemiarthroplasty in patients with glenohumeral arthritis and rotator cuff deficiency.
Levy JC, Virani N, Pupello D, Frankle M.

Source
Orthopaedic Institute at Holy Cross, Fort Lauderdale, Florida 33308, USA.

Abstract
We report the use of the reverse shoulder prosthesis in the revision of a failed shoulder hemiarthroplasty in 18 shoulders in 18 patients (7 men, 11 women) with severe pain and loss of function. The primary procedure had been undertaken for glenohumeral arthritis associated with severe rotator cuff deficiency. Statistically significant improvements were seen in pain and functional outcome. After a mean follow-up of 44 months (24 to 89), mean forward flexion improved by 26.4 degrees and mean abduction improved by 35 degrees. There were six prosthesis-related complications in six shoulders (32%), five of which had severe bone loss of the glenoid, proximal humerus or both. Three shoulders (16%) had non-prosthesis related complications. The use of the reverse shoulder prosthesis provides improvement in pain and function for patients with failure of a hemiarthroplasty for glenohumeral arthritis and rotator cuff deficiency. However, high rates of complications were associated with glenoid and proximal humeral bone loss.


The use of the reverse shoulder prosthesis for the treatment of failed hemiarthroplasty for proximal humeral fracture
Levy J, Frankle M, Mighele M, Pupello D.

Source
Florida Orthopaedic at the Florida Orthopaedic Institute, Temple Terrace, FL 33637, USA.

Abstract
BACKGROUND:
Humeral hemiarthroplasty is an established treatment for patients with selected fractures of the proximal part of the humerus. However, a subset of patients have development of glenoid arthritis and rotator cuff deficiency due to tuberosity failure. To date, there has been no reliable salvage procedure for this problem.

METHODS:
Over a period of five years, twenty-nine patients (twenty-five women and four men) with a mean age of sixty-nine years (range, forty-two to eighty years) were managed with removal of a hemiarthroplasty prosthesis and revision with a Reverse Shoulder Prosthesis alone or in combination with a proximal humeral allograft. Patients were followed clinically and radiographically for an average of thirty-five months. All patients were evaluated with use of the American Shoulder and Elbow Surgeons score; the Simple Shoulder Test; range-of-motion measurements, including abduction, forward flexion, and external rotation; and a rating scale for overall satisfaction with the outcome of the surgery. Patients were assessed preoperatively and at all follow-up points beginning at three months postoperatively.

RESULTS:
The average total American Shoulder and Elbow Surgeons score improved from 22.3 preoperatively to 52.1 at the time of the last follow-up (p < 0.001). The average American Shoulder and Elbow Surgeons pain score improved from 12.2 to 34.4 (p < 0.001), and the average American Shoulder and Elbow Surgeons function score improved from 10.1 to 17.7 (p = 0.058). The average Simple Shoulder Test score improved from 0.9 to 2.6 (p = 0.004). Forward flexion improved from 38.1 degrees to 72.7 degrees (p < 0.001), and abduction improved from 34.1 degrees to 70.4 degrees (p < 0.001). The overall complication rate was 28% (eight of twenty-nine). At the time of the latest follow-up, sixteen patients rated the outcome as good or excellent, seven rated it as satisfactory, and six were dissatisfied. Four of the six patients who were dissatisfied had been managed with a Reverse Shoulder Prosthesis alone.

CONCLUSIONS:
The Reverse Shoulder Prosthesis offers a salvage-type solution to the problem of failed hemiarthroplasty due to glenoid arthritis and rotator cuff deficiency following tuberosity failure. The early results reported here are promising. In cases of severe proximal humeral bone deficiency, augmentation of the Reverse Shoulder Prosthesis with a proximal humeral allograft may improve patient satisfaction.


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
Frankle M, Levy JC, Pupello D, Siegel S, Saleem A, Mighele M, Vasey M.

Source
Florida Orthopaedic Institute, 13020 Telecom Parkway North, Temple Terrace, FL 33637, USA.
Abstract

BACKGROUND:
Patients who have pain and dysfunction from glenohumeral arthritis associated with severe rotator cuff deficiency have few treatment options. The goal of this study was to retrospectively evaluate the short-term results of arthroplasty with use of the Reverse Shoulder Prosthesis in the management of this problem.

METHODS:
We report the results for sixty patients (sixty shoulders) with a rotator cuff deficiency and glenohumeral arthritis who were followed for a minimum of two years. Thirty-five patients had no previous shoulder surgery, whereas twenty-three had had either an open or arthroscopic rotator cuff repair, one had had a subacromial decompression, and one had had a biceps tendon repair. All patients were assessed preoperatively and postoperatively with the American Shoulder and Elbow Surgeons scoring system for pain and function and with visual analog scales for pain and function. They were also asked to rate their satisfaction with the outcome. The shoulder range of motion was measured preoperatively and postoperatively.

RESULTS:
The average age of the patients was seventy-one years. The average duration of follow-up was thirty-three months. All measures improved significantly (p < 0.0001). The mean total score on the American Shoulder and Elbow Surgeons system improved from 34.3 to 68.2, the mean function score, from 16.1 to 29.4, and the mean pain score, from 18.2 to 38.7. The score for function on the visual analog scale improved from 2.7 to 6.0, and the score for pain on the visual analog scale improved from 6.3 to 2.2. Forward flexion increased from 55.0 degrees to 105.1 degrees, abduction increased from 41.4 degrees to 101.8 degrees. Forty-one of the sixty patients rated the outcome as good or excellent; sixteen were satisfied, and three were dissatisfied. There were a total of thirteen complications in ten patients (17%). Seven patients (12%) had eight failures, requiring revision surgery to another Reverse Shoulder Prosthesis in five patients (one shoulder had two revisions) and revision to a hemiarthroplasty in two patients because of deep infection.

CONCLUSIONS:
The data from this study suggest that arthroplasty with the Reverse Shoulder Prosthesis may be a viable treatment for patients with glenohumeral arthritis and a massive rotator cuff tear. However, future studies will be necessary to determine the longevity of the implant and whether it will provide continued improvement in function.


The Reverse Shoulder Prosthesis for glenohumeral arthritis associated with severe rotator cuff deficiency. A minimum two-year follow-up study of sixty patients
Frankie M, Siegal S, Pupello D, Saleem A, Mighell M, Vasey M.

Source
Florida Orthopaedic Institute, 13020 Telecom Parkway North, Temple Terrace, Florida 33637, USA.

Abstract

BACKGROUND:
Patients who have pain and dysfunction from glenohumeral arthritis associated with severe rotator cuff deficiency have few treatment options. The goal of this study was to retrospectively evaluate the short-term results of arthroplasty with use of the Reverse Shoulder Prosthesis in the management of this problem.

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CONCLUSIONS:
The data from this study suggest that arthroplasty with the Reverse Shoulder Prosthesis may be a viable treatment for patients with glenohumeral arthritis and a massive rotator cuff tear. However, future studies will be necessary to determine the longevity of the implant and whether it will provide continued improvement in function.
Initial glenoid component fixation in “reverse” total shoulder arthroplasty: a biomechanical evaluation
Harman M, Frankle M, Vasey M, Banks S.

Source
Orthopaedic Research Laboratory, The BioMotion Foundation, West Palm Beach, FL 33480, USA.

Abstract
In patients with rotator cuff arthropathy, a “reverse” shoulder prosthesis resists glenohumeral subluxation and offers the potential for improved function. However, premature mechanical failure due to loosening is a concern with these devices. This in vitro study evaluates initial glenoid component fixation of 2 uncemented “reverse” prostheses during physiologic loading and determines the relationship among lateral offset of the glenosphere, fixation method, and motion. To simulate an excellent glenoid bone stock, a polyurethane foam bone with similar material properties to that of the glenoid cancellous bone was used. Both lateral offset and peripheral screw type affected the magnitude of baseplate motion. Baseplate motion for Delta III components and Reverse Shoulder Prosthesis (RSP) components fixed with 5.0-mm captured screws were below the ISO mum of motion generally accepted as the threshold for bone ingrowth. Stable fixation was achieved for the RSP-neutral components despite a substantially (69%) greater moment at the baseplate-foam interface compared with the Delta III. Obtaining similar results in vivo is partially dependent on surgical placement of the peripheral screws and the patient’s glenoid bone stock.
Factors predicting postoperative range of motion for anatomic total shoulder arthroplasty
Levy JC, Ashukem MT, Formaini NT.

Source
Holy Cross Orthopedic Institute, 5597 N Dixie Hwy, Fort Lauderdale, FL 33334, USA.

Abstract
BACKGROUND:
Total shoulder arthroplasty (TSA) has repeatedly been shown to be an effective and durable treatment option for end-stage arthritis with good long-term survival. Whereas pain relief is typically the primary goal, improvements in range of motion are typically expected as well. The factors that influence postoperative motion have not been well characterized. The purpose of the study was to examine the factors that influence ultimate postoperative motion after TSA.

METHODS:
A retrospective review was conducted of prospectively collected data of 230 patients with minimum 1-year follow-up after TSA for end-stage arthropathy with an intact rotator cuff. Analysis was focused on factors that may correlate with postoperative measured forward flexion, abduction, external rotation, and internal rotation. Included in this analysis was perception of motion, age, body mass index (BMI), comorbidities (smoking, diabetes, osteoporosis, hypercholesterolemia, inflammatory arthritis, and thyroid disease), and number of comorbidities.

RESULTS:
Preoperative motion in all directions was predictive of postoperative motion for forward flexion ($R = 0.235; P < .001$), abduction ($R = 0.363; P < .001$), external rotation ($R = 0.325; P < .001$), and internal rotation ($R = 0.213; P = .002$). BMI and diabetes both negatively correlated with internal rotation ($R = -0.134, P = .40$ and $R = -0.196, P = .003$, respectively). Individual and total number of comorbidities were not predictive of postoperative motion. The patient’s perception of preoperative motion also did not correlate with postoperative motion.

CONCLUSIONS:
Preoperative range of motion before TSA is most predictive of final motion achieved. Individual and total number of comorbidities are not predictive of postoperative motion. Patients with high diabetes and increased BMI have limited postoperative internal rotation.

Observation of initial postoperative radiolucent lines using a modern pegged glenoid design
Everding NG, Levy JC, Formaini NT, Blum S, Gil CG, Verde K.

Source
Holy Cross Orthopedic Institute, 5597 N Dixie Hwy, Fort Lauderdale, FL 33334, USA.

Abstract
PURPOSE:
Glenoid component loosening remains a common mode of failure for total shoulder arthroplasty and has inspired improvements in implant design, instrumentation and surgical technique. The purpose of this manuscript is to evaluate the incidence of radiolucent lines and glenoid seating on initial post-operative radiographs using a modern pegged glenoid design, instrumentation, and surgical technique.

METHODS:
We performed a retrospective analysis of a consecutive series of 100 pegged-glenoid total shoulder replacements. In cases of excessive glenoid version, the glenoid was asymmetrically reamed to recreate more normal version. Initial post-operative radiographs were evaluated for the presence of radiolucent lines and completeness of glenoid seating. The pre-operative glenoid version measured on axial CT scans was used to compare differences in version amongst those with complete and incompletely seated glenoids.

RESULTS:
The rate of radiolucent lines observed on post-operative radiographs was 0%. Complete glenoid seating (Grade A) was observed in 81 patients (observer 1) and 82 patients (observer 2). Measurements of pre-operative CT scans found a higher percentage of abnormal glenoid version for incompletely seated glenoids (47%) than completely seated glenoids (34%) but no significant difference ($p=0.327$). The mean pre-operative glenoid retroversion for incompletely seated glenoids was $12.1^\circ$ and $9.1^\circ$ for completely seated glenoids ($p=0.263$).

CONCLUSIONS:
Modern surgical techniques, surgical instrumentation, and peg glenoid design has facilitated the ability to eliminate radiolucent lines on initial post-operative radiographs with high rates of complete seating of glenoid components. Incomplete seating may be related to incomplete correction of glenoid version.
Functional internal rotation after shoulder arthroplasty: a comparison of anatomic and reverse shoulder arthroplasty
Triplet JJ, Everding NG, Levy JC, Moor MA.

Abstract
BACKGROUND:
Recovery of functional internal rotation after primary shoulder arthroplasty is essential to perform many important activities of daily living. Functional internal rotation is typically reported as it relates to clinical examination findings of motion (posterior reach) and lift-off or belly-press tests. A more detailed evaluation of functional recovery of internal rotation after primary anatomic total shoulder arthroplasty (TSA) and reverse shoulder arthroplasty (RSA) is needed.

METHODS:
A retrospective review of patients treated with primary TSA (n = 132) and RSA (n = 91) with a minimum 2-year follow-up was performed. Subanalysis of revision RSA (n = 24) and primary RSA was performed. Active range of motion, subjective internal rotation motion, manual internal rotation strength, and specific questions related to internal rotation function isolated from the Simple Shoulder Test (SST) and American Shoulder and Elbow Surgeons (ASES) functional questionnaires were reviewed.

RESULTS:
Compared with RSA, TSA patients could more likely reach the small of the back (SST) and wash the back/fasten bra (ASES). Active internal rotation motion, SST score, ASES score, and subjective internal rotation were greater after TSA. No significant difference was observed with respect to managing toileting between cohorts. Revision RSA patients were less likely to be able to wash the back/fasten bra (ASES) and easily manage toileting (ASES) compared with primary RSA patients.

CONCLUSION:
Primary anatomic shoulder arthroplasty yields greater functional internal rotation than does primary RSA, with either procedure being effective at managing toileting. Patient education regarding activities of daily living related to internal rotation can be predicted.

Anatomic and Reverse Total Shoulder Arthroplasty in Patients Older Than 80 Years.
Triplet JJ, Everding NG, Levy JC, Formaini NT, O’Donnell KP, Moor MA, Virraroeo LD.

Abstract
Anatomic total shoulder arthroplasty (TSA) and reverse total shoulder arthroplasty (RSA) are routinely performed in patients older than 80 years. Often unaware of the differences between the 2 procedures, patients may expect similar outcomes from these procedures. This article reports the outcomes of primary TSA and RSA in patients older than 80 years, with attention directed toward differences in outcomes between the procedures. The authors evaluated a consecutive series of patients who were at least 80 years old and were treated with primary shoulder arthroplasty and had a minimum follow-up of 2 years. Of these patients, 18 underwent primary TSA for osteoarthritis and 33 underwent primary RSA for rotator cuff tear arthropathy. Pain scores, function scores, and range of motion were evaluated preoperatively and at final follow-up. Perioperative and postoperative complications, transfusion rates, length of stay, and subjective satisfaction with the outcome were reported. In these patients, TSA and RSA were similarly effective in improving pain scores, functional scores, and range of motion measurements. Patients who had TSA reported significantly greater satisfaction with surgery and had superior American Shoulder and Elbow Society total and function scores, forward elevation, and external rotation, but similar net improvement from preoperative levels. Although no significant differences were shown in complications, length of stay, or re-operation for transfusion, patients treated with RSA had higher rates of transfusion and postoperative complications. Both procedures were similarly effective treatments for patients older than 80 years and showed similar improvements in pain, function, and motion. Patients undergoing RSA were less likely to have good to excellent results, with higher complication and transfusion rates.
Discovery Elbow System: clinical and radiological results after 2- to 10-year follow up.

Source
Oulu University Hospital, University of Oulu, PL 21, 90029 OYS Oulu, Finland

Abstract

BACKGROUND:
Discovery Elbow System (DES) is a semiconstrained prosthesis, mainly used for patients with rheumatoid arthritis (RA).

METHODS:
Records from 79 patients with RA (90 DES arthroplasties) were reviewed; 47 patients with 55 DES elbows were re-examined. Range of motion (ROM) of both elbows, upper limb function, and quality of life (Disabilities of the Arm, Shoulder, and Hand [DASH] score, Mayo Elbow Performance Score [MEPS], and the RAND-36 Item Health Survey [RAND-36]) were assessed. Cementing quality was assessed, and radiolucent lines measured from plain radiographs. Mean follow-up was 64 (range 24–123) months.

RESULTS:
Pre-operatively to post-operatively, mean elbow flexion improved from 120° to 146° (p<0.001) and mean extension lag improved from 29° to 24° (p = 0.02), respectively. At follow-up, mean supination was 66°, mean pronation was 69°, and mean grip strength was 14 kg. Grip strength and ROM (except supination) were similar between the DES elbow and contralateral un-operated elbow. Mean post-operative MEPS was 93 points (excellent, n = 38; good, n = 14; fair, n = 2; and poor, n = 1). Mean DASH score was 43 points. The RAND-36 showed that physical functioning, physical role functioning, bodily pain, and general health were lower than the Finnish reference values. Primary cementing was challenging, and radiolucent lines appeared during follow-up. Four prostheses were revised because of aseptic loosening (n = 3) and periprosthetic fracture (n = 1).

CONCLUSION:
DES provides significant improvement in patient’s flexion-extension arc. Cementing of the elbow prosthesis was challenging; radiolucent lines appeared during the 5-year follow-up, but their clinical relevance remains unclear. First-generation locking screws may loosen over time.

Total elbow arthroplasty: a prospective clinical outcome study of Discovery Elbow System with a 4-year mean follow-up
Alizadehkhaiyat O, Al Mandhari A, Sinopidis C, Wood A, Frostick S.

Source
Royal Liverpool University Hospital, Liverpool L69 3GA, UK

Abstract

BACKGROUND:
Total elbow arthroplasty (TEA) is increasingly used for the treatment of advanced elbow conditions to reduce pain and improve function. However, TEA is still associated with a higher complication rate than total hip and knee arthroplasty despite advances in the design and surgical techniques. This prospective clinical study reports the outcome of the Discovery Elbow System (Biomet, Warsaw IN, USA), which has been in clinical use in the United Kingdom since 2003.

METHODS:
The study included a total of 100 Discovery Elbows (April 2003 to January 2010) with a minimum 2-year follow-up, including 75 primary and 25 revisions (60% women and 40% men; mean age, 62 years). Outcome was assessed by means of the Liverpool Elbow Score, pain experience, patient satisfaction, range of motion, and radiographic imaging.

RESULTS:
The mean follow-up period was 48.5 months (range, 24-108 months). The Liverpool Elbow Score improved from 3.79 to 6.16 (P < 0.001). The percentage of pain-free patients was substantially increased from 7% preoperatively to 64% at the final follow-up. The patient satisfaction rate was over 90%. The flexion-extension arc and pronation-supination arc increased from 72° to 91° and from 86° to 111°, respectively (P < 0.001). Major postoperative complications included deep infection (2%), progressive aseptic loosening requiring revision (primary, 5%; revision 12%), persistent ulnar neuropathy (2%), and periprosthetic fracture (primary, 6.8%; revision, 8%).

CONCLUSION:
The Discovery Elbow System resulted in improved function, reduced pain, and high patient satisfaction. Long-term results are required to assess the survivorship of this system.
Medium-term clinical results of a linked total elbow replacement system

Large R, Tambe A, Cresswell T, Espag M, Clark DI.

Source
Royal Derby Hospital, Uttoxeter New Road, Derby DE22 3NE, UK.

Abstract
Medium-term results of the Discovery elbow replacement are presented. We reviewed 51 consecutive primary Discovery total elbow replacements (TERs) implanted in 48 patients. The mean age of the patients was 69.2 years (49 to 92), there were 19 males and 32 females (37%:63%) The mean follow-up was 40.6 months (24 to 69). A total of six patients were lost to follow-up. Statistically significant improvements in range movement and Oxford Elbow Score were found (p < 0.001). Radiolucent lines were much more common in, and aseptic loosening was exclusive to, the humeral component. Kaplan–Meier survivorship at five years was 92.2% (95% CI 74.5% to 96.4%) for aseptic loosening. In four TERs, periprosthetic infection occurred resulting in failure. A statistically significant association between infection and increased BMI was found (p = 0.0268). Triceps failure was more frequent after the Mayo surgical approach and TER performed after previous trauma surgery. No failures of the implant were noted.

Our comparison shows that the Discovery has early clinical results that are similar to other semi-constrained TERs. We found continued radiological surveillance with particular focus on humeral lucency is warranted and has not previously been reported. Despite advances in the design of total elbow replacement prostheses, rates of complication remain high.


A prospective multicenter clinical study of the Discovery elbow

Hastings H, Lee DH, Pietrzak WS.

Source
Biomet Inc, 1691 S Meadow Dr. Warsaw, IN, 46581, USA.

Abstract
BACKGROUND:
Semiconstrained total elbow arthroplasty is used to improve elbow function and reduce pain. Although effective, high complication rates exist, with the polyethylene bushing especially susceptible to failure. The Discovery Elbow System (Biomet Inc, Warsaw, IN, USA) contains a spherical bearing designed to minimize polyethylene wear. This prospective, multicenter clinical study investigated the 4-year (mean) outcomes of this elbow.

METHODS:
From 2002 to 2009, 92 patients (71 women, 21 men; mean age, 63.9 years; range, 33.4-88.7 years) received 99 Discovery elbows at 4 centers. The study cohort was limited to 46 elbows with complete preoperative and minimum 2-year clinical (modified American Shoulder and Elbow Surgeons elbow score) and radiographic follow-up.

RESULTS:
Mean follow-up was 4.1 years (range, 2.5-9.9 years). All American Shoulder and Elbow Surgeons elbow score components improved significantly (P < .001). Mean flexion-extension arcs increased from 81° to 121° and pronation-supination arcs from 134° to 163° (P < .001). Loose locking screws in 2 elbows (first-generation screws), a loose polyethylene bearing in 1 (history of falls), and a condyle/bearing in 1 (deep infection) were exchanged. Among the 46 elbows, gross survivorship was humeral/ulnar components, 100%; condyles, 97.8%; bearings, 95.7%; and screws, 95.7%. One humeral component (2.2%) was radiographically loose but not revised. An additional elbow (elbow 47) that did not meet the criteria for inclusion (<2 years of follow-up) was revised due to a loose humeral component and was reported separately.

CONCLUSION:
The Discovery elbow increased function and decreased pain with high survivorship at a mean of 4.1 years.
Discovery Elbow System: 2- to 5-year results in distal humerus fractures and posttraumatic conditions: a prospective study on 24 patients
Giannicola G, Scacchi M, Polimanti D, Cinotti G.

Source
American Society for Surgery of the Hand, 822 W Washington Blvd, Chicago, IL 60610, USA.

Abstract
PURPOSE:
To prospectively evaluate preliminary results of the Discovery Elbow System (DES) used for acute distal humerus fractures and posttraumatic conditions.

METHODS:
We analyzed 24 patients (9 men and 15 women), with a mean age of 69 years (range, 45-89 y). Ten had comminuted distal humerus fractures (group I), and 14 had severe posttraumatic arthritis, chronic instability, or nonunion (group II). Clinical and radiographic evaluations were performed. The preoperative (group II) and postoperative (both groups) evaluations were assessed with the Mayo Elbow Performance Score and Mayo Elbow Performance Index, the Quick Disabilities of the Arm, Shoulder, and Hand score, and the modified American Shoulder and Elbow Surgeons score. Patient satisfaction was evaluated on a 4-point scale.

RESULTS:
Mean follow-up was 41 months (range, 29-63 mo). At the last evaluation, average flexion, extension, pronation, and supination were 136°, 17°, 80°, and 83°, respectively. The average Mayo Elbow Performance Score, Quick Disabilities of the Arm, Shoulder, and Hand score, and the modified American Shoulder and Elbow Surgeons score were 96, 20, and 84, respectively, and without significant intergroup differences. According to the Mayo Elbow Performance Index, there were 20 excellent, 3 good, and one fair result. Twenty patients were very satisfied or satisfied with the outcome. A significant increase in the functional scores was observed in group II compared with preoperative results. Radiological evaluation showed one patient with progressive radiolucency and 1 with a nonprogressive radiolucency at the final follow-up. No mechanical failures were observed. Two transient ulnar neuropathies, one wound infection, and one epicondyle fracture were observed.

CONCLUSIONS:
The DES yielded promising 2- to 5-year results in the treatment of acute fractures and posttraumatic conditions regarding pain relief, functional improvement, and patient satisfaction, achieving excellent results in most cases. The DES may represent an effective linked-implant option for total elbow replacement in such patients. However, long-term studies are needed.

Total elbow arthroplasty for the treatment of insufficient distal humeral fractures. A retrospective clinical study and review of the literature
Chalidis B, Dimitriou C, Papadopoulos P, Giannoudis PV.

Source
LGU University Hospital, Clarendon Wing, Great George St. Leeds, LS1 3EX, UK.

Abstract
Treatment of complex distal humeral fractures in older patients with osteopenic bone remains a major surgical challenge. We report the results of 11 patients over 75 years of age who underwent semiconstrained sloppy-hinge total elbow arthroplasty (TEA) due to comminuted intraarticular fractures of the distal humerus. There were 9 women and 2 men with a mean age of 79.6 years. The mean duration of follow up was 2.8 years. According to AO classification, there were 8 type C3 and 3 type C2 fractures. The mean time from injury to operation was 4.3 days and the mean length of hospital stay was 9.8 days. The elbow flexion/extension and forearm pronation/supination arc of motion averaged 107° and 121° respectively. The mean Mayo Elbow Performance Score (MEPS) was 90 points, equivalent to excellent result. One patient sustained a periprosthetic humeral fracture and signs of non-progressive radiolucency were found in 8 out of the 11 elbows. Our search in the English and International literature revealed 9 other clinical studies describing the results of TEA in 167 patients with 168 distal humeral fractures. The mean age of patients varied from 69 to 84.6 years and the average follow up from 17.8 months to 7 years. The mean MEPS among the studies was between 85 and 95 points. Wound infection was diagnosed in 9 cases (5.4%) but component removal and subsequent reimplantation was only applied in 3 elbows (1.8%). Partial ulnar nerve lesions were reported in 11 patients (6.5%) and reflex sympathetic dystrophy was developed in 5 patients (3%). In 3 elbows (1.8%) a periprosthetic fracture after a fall was recorded. Radiolucent lines between the cement mantle and bone interface were described in 24 cases (14.3%) but the majority of them (17 cases) were stable and asymptomatic. In conclusion, TEA constitutes a viable treatment option for the complex distal humeral fractures in elderly and medically compromised patients. Careful patient selection and regular follow up evaluation are mandatory for achieving an optimal result and eliminating the risks of mismanagement and early implant failure.
Results after 562 total elbow replacements: a report from the Norwegian Arthroplasty Register
Fevang B-T, Lie S, Havelin LI, Skredderstuen A, Furnes O.

Source
Haukeland University Hospital, Møllendalshaikken 11, 5021 Bergen, Norway.

Abstract
BACKGROUND:
The aim of this study was to give results of elbow arthroplasty for a relatively large population and compare different prosthesis brands and different patient subgroups.

METHODS:
Between 1994 and 2006, 562 total elbow replacement operations were reported to the Norwegian Arthroplasty Register. Revisions of prostheses were shown using Kaplan-Meier failure curves, and risk of revision was calculated using Cox regression analysis.

RESULTS:
The overall 5- and 10-year failure rates were 8% and 15%, respectively. There were only minor differences between the different implants. Patients who developed traumatic arthritis after fracture had the worst prognosis compared with inflammatory arthritis (P = .005). Risk of revision was also increased when the ulnar component was inserted without cement (P = .02.)

CONCLUSIONS:
Good results in terms of prosthesis survival were obtained with total elbow arthroplasty, although results were worse than for knee- and hip arthroplasties. The best results were achieved in patients with inflammatory arthritis.
Surgical Techniques


Accuracy of patient-specific instrumentation in anatomic and reverse total shoulder arthroplasty
Dallalana RJ, McMahon RA, East B, Geraghty L.

Source
Park Clinic Orthopaedics, Suite 7/166 Gipps Street, East Melbourne, Victoria 3002, Australia.

Abstract
PURPOSE:
Glenoid component malposition is associated with poor function and early failure of both anatomic and reverse total shoulder arthroplasty. Glenoid positioning is challenging particularly in the setting of bone loss or deformity. Recently, the use of computer assistance has been shown to reduce implantation error. The aim of this study is to evaluate the accuracy of patient-specific instrumentation in cases of anatomic and reverse shoulder replacement in vivo.

METHODS:
Twenty patients underwent total shoulder arthroplasty using a computed tomography (CT)-based patient-specific instrumentation (PSI) system, ten anatomic and ten reverse. Preoperative three-dimensional digital templating of glenoid component position was undertaken and surgery then performed using a custom-made guide. Postoperative CT scans were used to compare final implanted component position to the preoperatively planned position in the same patient.

RESULTS:
Final component position and orientation closely reflected the preoperatively template position. Mean deviation in the glenoid version from planned was 1.8° ± 1.9° (range, 0.1°–7.3°). Mean deviation in inclination was 1.3° ± 1.0° (range, 0.2°–4.5°). Mean deviation in position on the glenoid face was 0.5 ± 0.3 mm (range, 0.0–1.3 mm) in the anteroposterior plane and 0.8 ± 0.5 mm (range, 0.0–1.9 mm) in the superoinferior plane. Actual achieved version was within 7° of neutral in all cases except for one where it was deliberately planned to be outside of this range.

CONCLUSION:
PSI in both anatomic and reverse shoulder arthroplasty is highly accurate in guiding glenoid component implantation in vivo. The system can reliably correct bony deformity.

Tuberosity healing after reverse shoulder arthroplasty for acute proximal humerus fractures: the “black and tan” technique
Formaini NT, Everding NG, Levy JC, Rosas S.

Source
Holy Cross Orthopedic Institute, 5597 N Dixie Hwy, Fort Lauderdale, FL 33334, USA.

Abstract
BACKGROUND:
Reverse shoulder arthroplasty has seen increased use for management of complex proximal humeral fractures in the elderly. Recent evidence has shown that tuberosity healing leads to improved active range of motion and functional outcomes. The purpose of this study was to report on the radiographic and clinical outcomes of a consecutive series of patients having undergone reverse shoulder arthroplasty for fracture utilizing the “black and tan” method—a hybrid cementation-impaction grafting technique that uses autogenous cancellous bone graft to create an interface between the proximal cement mantle and the area of tuberosity repair.

METHODS:
Twenty-five patients (average age, 77 years; range, 63–88 years) were included in the analysis with a mean follow-up of 17 months. All patients underwent reverse shoulder arthroplasty for a complex proximal humerus fracture using the black and tan technique.

RESULTS:
The tuberosity healing rate was 88.4%. At final follow-up, mean active elevation was 117° ± 23°, mean abduction was 86° ± 16°, and mean external rotation was 29° ± 18°. External rotation strength averaged 4.9 ± 0.2. The Simple Shoulder Test and Single Assessment Numeric Evaluation scores averaged 7 and 76, respectively. The mean American Shoulder and Elbow Surgeons total score was 71; visual analog scale score for pain, 2; and visual analog scale score for function, 7. Of the 25 patients, 21 (84%) rated their satisfaction with the surgery as excellent or good.

CONCLUSIONS:
The black and tan technique together with standard suture repair and an implant with features that support tuberosity repair results in a high tuberosity healing rate with restoration of external rotation after reverse shoulder arthroplasty for fracture.
Avoiding cement bone necrosis effect on tuberosity healing: the "black-and-tan" technique

Levy JC.

Source
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Abstract
Tuberosity healing in the setting of shoulder arthroplasty for fracture has been shown to have significant effects on functional shoulder outcomes. Although surgical techniques have been developed to encourage anatomic tuberosity healing, the thermal effects of cement on bone can limit successful healing. The technique described in this manuscript utilizes a bone graft interface between the cement and the tuberosities, which helps create an interface of bone for successful tuberosity healing. Bone graft taken from the humeral head and impacted bone from the intramedullary canal of the humeral shaft is placed as a compressed layer of bone above the cement line, creating a "black-and-tan" interface. This technique can be used with both hemiarthroplasty and reverse shoulder arthroplasty when treating complex proximal humerus fractures.

Reverse shoulder prosthesis for acute four-part fracture: tuberosity fixation using a horseshoe graft

Levy JC, Badman, B.

Source
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Abstract
Results of hemiarthroplasty for complex four-part proximal humerus fractures in the elderly have been unreliable. Although patients often achieve pain relief, return of above-shoulder level function can be challenging, because tuberosity nonunion, malunion, and/or resorption is quite common. The reverse shoulder replacement has been advocated as a reliable alternative for these patients. Preliminary studies have suggested that tuberosity healing is critical for achieving external rotation strength after reverse shoulder arthroplasty. We describe a technique of tuberosity repair using a wedge horseshoe graft, which can provide improved surface area for tuberosity healing. A clinical series of seven patients treated with this technique is reported with a minimum follow-up of 12 months (range, 12–23 months). The tuberosity union rate was 86% (six of seven patients). Average active forward elevation was 117° (range, 95°–150°), and active external rotation was 19° (range 0°–30°). Visual analog scale pain scores averaged 0.6 (range, 0–1), visual analog scale function averaged 8.7 (range, 7–10), mean American Shoulder and Elbow Surgeons pain was 47.1 (range, 45–50), and mean American Shoulder and Elbow Surgeons function was 39.2 (range, 31–50). Subjective satisfaction ratings were excellent for four patients, and good for two, and satisfactory for one. No patients were unsatisfied with their outcomes. The horseshoe graft technique provides a reliable means for anatomic restoration of the tuberosities, facilitating the return of shoulder function in elderly patients with complex four-part proximal humerus fractures treated with a reverse total shoulder.
Background Information


How reverse shoulder arthroplasty works
Walker M, Brooks J, Willis M, Frankle M.

Source
Florida Orthopaedic Institute, 13020 Telecom Parkway North, Tampa, FL 33637, USA.

Abstract
BACKGROUND:
The reverse total shoulder arthroplasty was introduced to treat the rotator cuff-deficient shoulder. Since its introduction, an improved understanding of the biomechanics of rotator cuff deficiency and reverse shoulder arthroplasty has facilitated the development of modern reverse arthroplasty designs.

QUESTIONS/PURPOSES:
We review (1) the basic biomechanical challenges associated with the rotator cuff-deficient shoulder; (2) the biomechanical rationale for newer reverse shoulder arthroplasty designs; (3) the current scientific evidence related to the function and performance of reverse shoulder arthroplasty; and (4) specific technical aspects of reverse shoulder arthroplasty.

METHODS:
A PubMed search of the English language literature was conducted using the key words reverse shoulder arthroplasty, rotator cuff arthropathy, and biomechanics of reverse shoulder arthroplasty. Articles were excluded if the content fell outside of the biomechanics of these topics, leaving the 66 articles included in this review.

RESULTS:
Various implant design factors as well as various surgical implantation techniques affect stability of reverse shoulder arthroplasty and patient function. To understand the implications of individual design factors, one must understand the function of the normal and the cuff-deficient shoulder and coalesce this understanding with the pathology presented by each patient to choose the proper surgical technique for reconstruction.

CONCLUSIONS:
Several basic science and clinical studies improve our understanding of various design factors in reverse shoulder arthroplasty. However, much work remains to further elucidate the performance of newer designs and to evaluate patient outcomes using validated instruments such as the American Society for Elbow Surgery, simple shoulder test, and the Constant-Murley scores.


Complications in reverse total shoulder arthroplasty
Cheung E, Willis M, Walker M, Clark R, Frankle MA.

Source
Department of Orthopaedic Surgery, Stanford University Medical Center, Redwood City, CA, USA.

Abstract
Reverse total shoulder arthroplasty was initially used to manage complex shoulder problems. Indications have been expanded to include rotator cuff arthropathy, massive rotator cuff tear, failed shoulder arthroplasty, and increased use of primary reverse total shoulder arthroplasty has led to reports of associated problems unique to the procedure. The most common complications include neurologic injury, periprosthetic fracture, hematoma, infection, scapular notching, dislocation, mechanical baseplate failure, and acromial fracture. Little information has been published regarding best practices for managing these complications.
Glenoid morphology in reverse shoulder arthroplasty: classification and surgical implications
Frankle MA, Teramoto A, Luo ZP, Levy JC, Pupello D.

Source
Florida Orthopaedic Institute, Tampa, FL 33637, USA.

Abstract
BACKGROUND:
A great challenge in reverse shoulder arthroplasty is the wide variation in glenoid morphology that adds uncertainties in glenoid component placement. The purpose of this study was to classify glenoid morphology and examining its effect on possible glenoid component fixation.

MATERIALS AND METHODS:
The morphology of 216 glenoids was classified into normal and abnormal with subgroups defined by erosion sites. Six anatomic and 2 surgical parameters were compared among the classified groups. Plain radiographs or 2-dimensional (2D) computed tomography (CT) scans showed 62.5% of glenoids were normal and 37.5% were abnormal, with further subclassification of abnormal in posterior (17.6%), superior (9.3%), global (6.5%), and anterior (4.2%) erosions using 3D CT models.

RESULTS:
The standard centerline became significantly shorter in abnormal (19.6 +/- 9.1 mm) than in normal (28.6 +/- 4.1 mm, P < .0001) glenoids. Alternatively, the spine centerline provided longer bony distance in abnormal glenoids (34.9 +/- 17.0 mm). Abnormal glenoid morphology also reduced peripheral screw placement area by 42% and limited it to the anterior and inferior quadrants.

DISCUSSION:
Glenoid morphology of the rotator cuff deficient shoulder can be reliably classified using this classification system consisting of normal and abnormal, which included 4 subgroups of posterior, superior, global, and anterior erosions.

CONCLUSIONS:
Abnormal glenoid morphology was shown to have a significant effect on anatomical and surgical factors which can necessitate adjustments in surgical technique for reverse shoulder arthroplasty.

Arc of motion and socket depth in reverse shoulder implants
Gutiérrez S, Luo ZP, Levy J, Frankle MA.

Source
The Phillip Spiegel Orthopaedic Research Laboratory at the Foundation for Orthopaedic Research and Education (FORE), 13020 N. Telecom Parkway, Tampa, FL 33637, USA.

Abstract
BACKGROUND:
Reverse shoulder arthroplasty relies on its congruent ball/socket joint to restore shoulder function. For a simple ball/socket joint, as shown in total hip arthroplasty, range of motion decreases with the increase of articular constraint. We challenge here that this intuitive concept might not be held in reverse shoulder arthroplasty because of the effect of multiple concurrent factors.

METHODS:
Abduction impingement-free arc of motion in reverse shoulder arthroplasty was examined with a virtual computer model. Six articular constraints, defined by normalized socket depths, were simulated. Four concurrent factors: glenosphere diameter, lateral offset of glenosphere from the glenoid surface, humeral neck-shaft angles, and locations of the glenosphere on the glenoid surface, were also studied, which composed a total of 81 combinations and 486 individual conditions.

FINDINGS:
Three distinct classes of arc of motion relative to the articular constraint were revealed: I--arc of motion decreased with increased constraint (57%), II--arc of motion with a complex relationship to constraint (37%), and III--arc of motion increased with increased constraint (6%).

INTERPRETATION:
Classes II and III were counter-intuitive which could be caused by impingement on the acromion associated primarily with superior positioning. Surgeons may need to be aware of it when the glenoid component has to be placed superiorly. The detailed motion/constraint relationship will further help engineers improve the design in reverse shoulder arthroplasty.
Hierarchy of stability factors in reverse shoulder arthroplasty
Gutierrez S, Levy JC, Lee WE 3rd, Luo ZP.

Source
Florida Orthopaedic Institute, Tampa, FL 33637, USA.

Abstract
Reverse shoulder arthroplasty is being used more frequently to treat irreparable rotator cuff tears in the presence of glenohumeral arthritis and instability. To date, however, design features and functions of reverse shoulder arthroplasty, which may be associated with subluxation and dislocation of these implants, have been poorly understood. We asked: (1) what is the hierarchy of importance of joint compressive force, prosthetic socket depth, and glenosphere size in relation to stability, and (2) is this hierarchy defined by underlying and theoretically predictable joint contact characteristics?

We examined the intrinsic stability in terms of the force required to dislocate the humerosocket from the glenosphere of eight commercially available reverse shoulder arthroplasty devices. The hierarchy of factors was led by compressive force followed by socket depth; glenosphere size played a much lesser role in stability of the reverse shoulder arthroplasty device. Similar results were predicted by a mathematical model, suggesting the stability was determined primarily by compressive forces generated by muscles.

Range of impingement-free abduction and adduction deficit after reverse shoulder arthroplasty. Hierarchy of surgical and implant-design-related factors
Gutiérrez S, Comiskey CA 4th, Luo ZP, Pupello DR, Frankle MA.

Source
Florida Orthopaedic Institute Research Foundation, 13020 North Telecom Parkway, Tampa, FL 33637, USA.

Abstract
BACKGROUND:
Evaluations of functional outcomes of reverse shoulder arthroplasty have revealed variable improvements in the range of motion and high rates of scapular notching. The purpose of this study was to systematically examine the impact of surgical factors (location of the glenosphere on the glenoid and tilt angle of the glenosphere on the glenoid) and implant-related factors (implant size, center-of-rotation offset, and humeral neck-shaft angle) on impingement-free abduction motion.

METHODS:
A computer model was developed to virtually simulate abduction/adduction motion and its dependence on five surgical and implant-related factors. Three conditions were tested for each factor, resulting in a total of 243 simulated combinations. The overall motion was determined from 0 degrees of abduction until maximum abduction, which would be limited by impingement of the humerosocket on the scapula. In those combinations in which 0 degrees of abduction could not be achieved, the adduction deficit was recorded.

RESULTS:
The largest average increase in the range of impingement-free abduction motion resulted from a more lateral center-of-rotation offset: the average increase was 31.9 degrees with a change in the center-of-rotation offset from 0 to 10 mm, and this change resulted in an increase in abduction motion in eighty of the eighty-one combinations. The position of the glenosphere on the glenoid was associated with the second largest average increase in abduction motion (28.1 degrees when the glenosphere position was changed from superior to inferior, with the change resulting in an increase in seventy-one of the eighty-one combinations). These factors were followed by glenosphere tilt, humeral neck-shaft angle, and prosthetic size in terms of their effects on abduction motion. The largest effect in terms of avoiding an adduction deficit was provided by a humeral neck-shaft angle of 130 degrees (the deficit was avoided in forty-nine of the eighty-one combinations in which this angle was used), followed by an inferior glenosphere position on the glenoid (deficit avoided in forty-one combinations), a 10-mm lateral offset of the center of rotation, inferior tilt of the glenosphere, and a 42-mm-diameter prosthetic size.

CONCLUSIONS:
An understanding of a hierarchy of prosthetic design and implantation factors may be important to maximize impingement-free abduction motion as well as to avoid inferior impingement.
Evaluation of abduction range of motion and avoidance of inferior scapular impingement in a reverse shoulder model


Source
Florida Orthopaedic Institute Research Foundation, Temple Terrace, FL 33637, USA.

Abstract
The purpose of this study was to determine the effects of prosthetic design and surgical technique of reverse shoulder implants on total abduction range of motion and impingement on the inferior scapular neck. Custom implants in three glenosphere diameters (30, 36, and 42 mm), with 3 different centers of rotation offsets (+10 mm), were placed into a Sawbones scapula (Pacific Research Laboratories, Vashon, WA) in 3 different positions: superior, center, and inferior glenoid. Humeral sockets were manufactured with a 130 degrees, 150 degrees, and 170 degrees neck-shaft angle. Four independent factors (glenosphere diameter, center of rotation offset, glenosphere position on the glenoid, and humeral neck-shaft angle) were compared with the 2 dependent factors of range of motion and inferior scapular impingement. Center of rotation offset had the largest effect on range of motion, followed by glenosphere position. Neck-shaft angle had the largest effect on inferior scapular impingement, followed by glenosphere position. This information may be useful to the surgeon when deciding on the appropriate reverse implant.

In vitro and finite element analysis of glenoid bone/baseplate interaction in the reverse shoulder design

Virani NA, Harman M, Li K, Levy J, Pupello DR, Frankle MA.

Source
Florida Orthopedic Institute Research Foundation, Tampa, FL, USA.

Abstract
We developed biomechanical and finite element models, using high-strength polyurethane foam blocks, to represent the glenoid bone/baseplate junction to determine if increasing the distance between the glenoid bone and the center of rotation of the glenosphere increases baseplate motion during static loading in the reverse shoulder design. Although there was a general trend toward increased baseplate motion with increasing distance from the glenoid to the center of rotation, in vitro mechanical testing revealed no significant difference between the 7 glenosphere types tested, with average baseplate motion during 1000 load cycles ranging from 90 mum to 120 mum. Results from the finite element analysis strongly correlated with the in vitro mechanical testing. The magnitude of baseplate motion occurring in a modeled representation of bone under simulated physiologic loading conditions was similar for the 7 reverse shoulder glenoid components tested in this study.