Reverse® Shoulder System

Abstracts
At DJO Surgical, our end goal is to help patients reach their greatest potential. 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 shoulder systems that ultimately provide shoulder solutions. DJO Surgical Shoulder 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 heights by providing clinicians solutions to help their patients reach higher.

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.
Reverse shoulder arthroplasty components and surgical techniques that restore glenohumeral motion.

Virani NA, Cabezas A, Gutiérrez S, Santoni BG, Otto R, Frankle M.

Source
Phillip Spiegel Orthopaedic Research Laboratory, Foundation for Orthopedic Research and Education, Tampa, FL, USA

Abstract
BACKGROUND:
Modifications in reverse shoulder arthroplasty (RSA) have been made with the intent of maximizing motion, although there is little objective evidence outlining their benefit. This study investigated the RSA component combinations that impart the greatest effect on impingement-free glenohumeral motion.

METHODS:
A previously validated virtual shoulder model was implanted with RSA components that varied by humeral implant type (inset/onset), glenosphere diameter (30, 36, and 42 mm), glenosphere placement (inferior/neutral), glenosphere center-of-rotation offset (0, 5, and 10 mm), humeral neck-shaft angle (130° and 150°), and humeral offset (zero, five, and ten mm). Motion was simulated in all technique combinations until the point of impingement in abduction, flexion/extension (F/E), and internal/external rotation (IR/ER). Regression analysis was used to rank combinations based on motion.

RESULTS:
Of 216 possible study combinations, 126 constructs (58%) demonstrated no arm-at-side impingement and were included for analysis. Models with the largest motion in abduction, F/E, and IR/ER, respectively, were inset-42-inferior-10-150-zero (107°), inset-36-inferior-10-130-five (146°), and inset-42-inferior-10-130-ten (121°). Humeral neck-shaft angle, glenosphere center-of-rotation offset, glenosphere placement, and glenosphere diameter had a significant effect on motion in all planes tested. Of these variables, humeral neck-shaft angle was most predictive of a change in abduction and F/E motion, whereas glenosphere placement was most predictive of a change in IR/ER motion.

CONCLUSION:
Higher glenosphere center-of-rotation offsets led to an increase in motion in all planes. To maximize motion in abduction, a valgus humeral component should be selected; to maximize F/E, a varus humeral component should be selected; and, to maximize IR/ER, the glenosphere should be placed inferiorly.

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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.

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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, 3.25 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.


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.

LEVEL OF EVIDENCE:
Therapeutic Level IV.

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 of 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.

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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
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young.kwon@nyumc.org

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.

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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 pain 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 SL 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.
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The use of the reverse shoulder arthroplasty for treatment of failed total shoulder arthroplasty.

Walker M, Willis MP, Brooks JP, Pupello D, Mulleri PJ, 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 1.5 (P < .001), and function improved from 2 to 6.5 (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 = .056). 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.


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

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.

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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.

Reverse Shoulder Arthroplasty in the Management of Irreparable Rotator Cuff Tears without Arthritis.

Kevin L. Harreld, MD1; Brian L. Puskas, MD1; Jaron Andersen, MD1; Mark Frankle, MD1

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Extract

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 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, Frankle MA.

Abstract

HYPOTHESIS/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 (109.3 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.

Complications in reverse total shoulder arthroplasty.

Cheung E, Willis M, Walker M, Clark R, Frankle MA.

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.
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.

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Massive rotator cuff tears without arthropathy: when to consider reverse shoulder arthroplasty.

Harreld KL, Puskas BL, Frankle M.

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

Abstract

Massive rotator cuff tears often present a challenge for the treating orthopaedic surgeon. A multitude of surgical approaches have been described to manage this condition, ranging from biceps tenotomy to complex muscle transfers to reverse shoulder arthroplasty. Among these procedures, reverse shoulder arthroplasty is increasingly advocated to relieve pain and restore function; however, the exact role of this arthroplasty procedure continues to be defined, particularly in patients without any evidence of associated glenohumeral arthritis. In this patient population, the reverse shoulder prosthesis is used primarily to address the instability associated with massive rotator cuff tears, as opposed to the more common application of arthroplasty to manage cartilage disease. Currently accepted indications for reverse shoulder arthroplasty include patients with pseudoparalysis and irreparable rotator cuff tears, with or without anterosuperior escape. Surgeons must be aware of conditions that may clinically mimic pseudoparalysis caused by a rotator cuff tear, such as axillary nerve injury, deltoid dehiscence, or cervical radiculopathy. These conditions produce deltoid insufficiency and are unlikely to benefit from a reverse shoulder arthroplasty. Caution is also warranted when considering this procedure in patients with massive rotator cuff tears in whom active forward elevation greater than 90° is preserved. These patients may achieve little benefit in range of motion and pain relief with a reverse shoulder arthroplasty.
® Orthop Trauma 2011;25:318–324

Reverse Shoulder Prosthesis for Acute Four-Part Fracture: Tuberosity Fixation Using a Horseshoe Graft

Jonathan C. Levy, MD* and Brian Badman, MD†

Summary: 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 an 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.

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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 33637, 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 81° 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 S1 to L4 (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.

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 = 0.018). 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.

SUMMARY:
The authors challenge an article by Lèvigne et al concluding that the Constant score and ROM were not affected by scapular notching. This challenge is based primarily on statistical methodology:

- Although several variables were found to be associated with notching, there was limited control for confounding factors to allow the reader to draw a clear conclusion of the effect of each variable on notching.
- Although clinical outcomes were reported to be unaffected by the radiographical appearance of scapular notching, the postoperative results were not segmented by pre-operative diagnosis. This grouping of all patient categories could potentially hide a difference in clinical outcome that could otherwise be determined by segmenting the results by patient indication.
- The only patient outcome measures that were included were the pre-operative and latest follow up.
- 24 percent of patients from the study were lost to follow-up.

In addition, the authors note that current literature supports treating osteolysis in hip, knee, and elbow arthroplasty even in asymptomatic patients. Recent studies in shoulder literature indicate that implant design can reduce the rate of scapular notching, specifically by having a more varus neck-shaft angle, and inferior position of the glenosphere, and a center of rotation lateral to the glenoid.
**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. frankle@pol.net

**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.

**LEVEL OF EVIDENCE:**
Basic Science Study.

**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.
Revision arthroplasty with use of a reverse shoulder prosthesis-allograft composite.
Chacon A, Virani N, Shannon R, Levy JC, Pupello D, Frankle M.

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

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.


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 (0, +5, and +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 μm to 120 μm. 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.

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-stage (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 43.1 degrees (sd 33.5) to 79.5 degrees (sd 43.2) (p = 0.0003), and mean external rotation from 10.2 degrees (sd 18.7) to 25.4 degrees (sd 23.5) (p = 0.0037). There was no statistically significant difference in any outcome between the single-stage and the two-stage group.
Reverse shoulder arthroplasty for the treatment of rotator cuff deficiency.

Cuff D, Pupello D, Vitani 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.


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.
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 19 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, Mighell 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, Siegal S, Saleem A, Mighell 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, and 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.

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. mkharman@bellsouth.net

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 glenesphere, 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 150 μm 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.
The Reverse Shoulder Prosthesis for glenohumeral arthritis associated with severe rotator cuff deficiency. A minimum two-year follow-up study of sixty patients.

Frankle 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.

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, and 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.

Additional publications:
Reverse Total Shoulder Replacement for Arthritis with an Irreparable Rotator Cuff Tear; Frankle, Kumar; Techniques in Shoulder and Elbow Surgery J Orthop Res. 2006 Jan;24(1):112; author reply 112-3.
Re: Shoulder prostheses treating cuff tear arthropathy: a comparative biomechanical study
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