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1  BONE GRAFTING AND IMPLANTATION OF GLENOID COMPONENT AS A ONE STAGE PROCEDURE AT REVISION SURGERY?
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Aim: Huge defects of the glenoid bone stock after glenoid component loosening may raise the question how to deal with such a glenoid at revision surgery. Patients and Methods: Out of 24 patients with glenoid problems the glenoid component was loose in 12. According to the classification of Antuna et al 2 have shown a central moderate, 6 a central severe, and 4 a combined severe central and peripheral defect of the glenoid at revision surgery. In the 2 cases with a moderate central defect re-implantation of a glenoid component by cementation was performed. In the 6 cases with severe central defect and intact glenoid wall bone grafting and re-implantation of a glenoid component as a one stage procedure was carried out. Bone grafting was performed by impaction of autologous bone chips at the bottom of the defect and impaction of a cortico-cancellous bone block into the glenoid wall. The bone block was then prepared for a keeled glenoid component which was cemented. Of the 4 cases with a severe combined defect grafting without glenoid component was performed in 2 and a change toward a bipolar prosthesis without glenoid component in the others. Results: After on average 62 months (range, 18-96) no clinical or radiological loosening was observed. According to the Constant score improvement from pre-operative to FU was from on

2  TEST-RETEST RELIABILITY OF ISOLATED SUBSCAPULARIS MUSCLE STRENGTH MEASURES
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Study Design: Test-retest reliability. Objectives: (1) To determine the test-retest reliability of measuring isolated subscapularis muscle strength using a hand-held dynamometer (HHD) while in the belly-press test. (2) To compare the test-retest reliability of the HHD with that of the isokinetic dynamometer (IKD).

Background: The subscapularis muscle plays a critical role in normal glenohumeral joint function. Subscapularis tendon tears, whether from trauma, degeneration, or surgical complication, are becoming increasingly recognized as a possible cause of shoulder pain and disability. Although recent evidence suggests that the subscapularis muscle can be isolated and its strength can be measured while in the belly-press test position limited information exists assessing the reliability of any isolated rotator cuff measure. Methods and Measures: 41 healthy subjects, 20 male (25 ± 2 years; range, 21-29 years) and 21 female (24 ± 2; 20-27 years) and 24 patients with varying shoulder pathologies 14 male (24 ± 6; 18-41 years) and 10 female (24 ± 5; 18-36 years) were assessed on two occasions, 1 week apart, by one rater with an HHD in both healthy subjects and patients and with an IKD in healthy subjects only. The mean of three maximum voluntary isometric contraction (MVIC) forces was measured in Newtons (N). Intraclass correlation coefficients (ICCs2,1) were used to estimate relative test-retest reliability and standard error of measurements (SEMs) as well as minimal detectable changes with a 95% confidence level (MDC95) were used to estimate absolute reliability. Results: ICCs (1-sided 95% lower confidence interval [CI] limit) for the HHD in the dominant and non-dominant or symptomatic and asymptomatic shoulders were .92 (.80) and .87 (.71) for healthy males, .87 (.71) and .86 (.68) for healthy females, .97 (.92) and .96 (.86) for male patients, and .87 (.57) and .94 (.80) for female patients. Similarly MDC95 were ±21.5 N, ±28.1 N, ±11.2 N, ±12.8 N, ±15.1 N, ±16.5 N, ±11.7 N, and ±8.5 N, respectively. ICCs for the IKD ranged from .67 (.34) to .81 (.59). Mean MVIC forces were significantly greater for the non-dominant than the dominant subscapularis in both male and female healthy subjects. Mean ± SD male and female dominant versus non-dominant MVIC forces were 97 ± 23 N versus 103 ± 22 N and 62 ± 11 N versus 64 ± 10 N, respectively. Conclusions: The HHD displayed excellent test-retest reliability for measuring isolated subscapularis strength in both younger and active healthy subjects and younger patients with varying shoulder limitations. The IKD showed moderate test-retest reliability. Clinicians should utilize an HHD when assessing isolated subscapularis strength in the belly-press test position. In addition, they should be aware of possible underlying differences in subscapularis muscle force production between the dominant and non-dominant shoulder.

Key Words: Minimal detectable change, reliability, belly-press test, hand-held dynamometer, subscapularis.

3  CENTRAL AXIS/ANATOMICALLY DESIGNED PRECISI FIT RADIAL HEAD PROSTHETIC ARTHROPLASTY
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Replacement arthroplasty of the radial head is indicated when fracture, deformity and/or arthrosis of the radiocapitellar joint is
accompanied by posterolateral or axial instability. Collateral ligament instability derived from trauma or longstanding attenuation in conjunction with loss of axial support results in instability of the elbow and dysfunction. In the face of trauma restoration of columnar support at the radiocapitellar joint relies on the ability to reconstruct the radial head and neck. When this is impossible or following a failed attempt to do so, the result is pain, dysfunction and loss of control. With loss of the interosseous ligament, integrity longitudinal instability results in dysfunction more distally at the wrist as well as instability at the elbow. Silastic prosthetic replacement has been shown to be inadequate while soft tissue reconstruction alone is both difficult and unpredictable. Restoration of columnar support through replacement of the radial head has been effective in restoring stability but has relied upon standard sized prostheses, which do not always conform with anatomy. The authors have developed a radial head prosthesis system which closely approximates the native anatomy in terms of intramedullary fit, reestablishment of radial head height, and diameter accommodation to be able to adequately close soft tissue capsular and ligamentous structures without "overstuffing" the proximal radioulnar joint. The modular implant utilizes the concept of a central axis of forearm pronation and supination establishing a neck cut perpendicular to this long axis rather than perpendicular to the anatomic neck. This allows the replaced head to sit opposed to the capitellum at all times during pronation and supination. The radial head itself is sized to restore appropriate length longitudinally but is downsized at least 2 mm to allow adequate soft tissue closure, preventing overstuffing. A variety of sizes of stem and head length and width are provided in the "emergency trauma tray" with spacers of 1 mm and 2 mm to provide up to the 3 mm additional length as needed. For reconstruction cases, custom implants are measured and designed through markers placed on standardized x-rays and are constructed within five working days to provide an anatomic replacement exactly fitting the patient's anatomy. The prosthetic head is easily removed from the stem for trial and sizing purposes. Each implant comes with its own set of instruments for exposure, broaches and inserters. Twenty-three patients with both acute and chronic pathology at the proximal radio-ulna and radio-capitellar joints with instability have been managed with this anatomic modular system. No patients have required revision. All have remained stable and pain relief has been significant with a decrease in a pain visual analog scale from an average of 8.5 to 1.2 and an increase in the arc of pronation and supination from 50° to 160°. There have been no infections. One patient has shown some lucency about the radial stem but clinically has had no symptoms of pain, instability or loosening. This system which attempts to re-create functional anatomy has proven to be effective in restoring stability while simplifying the surgical technique through use of user-friendly implants and surgical instrumentation.

4 THE IN VIVO ULTRASONIC EVALUATION OF "INERTIAL" AND "EXTERNAL" SHOULDER "IMPEIGNANCE"
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Introduction: Functional and pathologic relationships between the supraspinatus tendon, the coracohumeral arch and posterior-superior glenoid are important when managing "inertial" and "external" shoulder "impingement." Studies have been performed, most in vitro utilizing cadaveric models, to evaluate these relationships. This study presents the use of ultrasound to evaluate these relationships in vivo.

Materials/Methods: Fifty overhead athletes' shoulders (30 males, 20 females, mean age 19.25 [range 16-22]) were evaluated utilizing a linear scanning ultrasound. The relationship between the supraspinatus/acromion was evaluated during dynamic elevation, and between the supraspinatus/posterior superior glenoid during external rotation/abduction.

Results: During shoulder elevation the greater tuberosity cleared under the acromion at a mean: 65.4 degrees dominant (range 60-70), 65.5 degrees non-dominant extremity (range 61-70). During abduction/external rotation the supraspinatus abutted the posterior-superior glenoid at mean: elevation angle 82.4 degrees (range 74-87), in the mean 15.3 degrees (range 7-28) posterior scapular plane at a mean ER of 108.8 degrees (range 97-131) in the dominant and 83.1 degrees (range 72-87), 16 degrees (range 7-27), 104.9 degrees (range 94-119) in the non-dominant extremity.

5 ARTHROSCOPIC ROTATOR CUFF REPAIR: DOES DOUBLE ROW FIXATION INCREASE INITIAL FIXATION STRENGTH AND/OR FOOTPRINT RESTORATION?
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Objective: Arthroscopic rotator cuff repairs fixed with a single row of anchors have been shown to have a high re-tear rate. Many clinicians have begun to implement double row anchor fixation in an effort to increase the strength of the repair and restoration of the normal attachment to bone ("footprint"). Recent studies have shown increases in ultimate load with double row fixation; however, they have evaluated small isolated portions of the rotator cuff and not the overall complex. The objective of this study was to evaluate the biomechanical properties and footprint restoration after single and double row repairs using a cadaveric model with inclusion of the entire surrounding rotator cuff complex.

Methods: A cyclic loading and load-to-failure protocol was performed on sixteen fresh cadaveric rotator cuff complexes using a materials testing machine. The biomechanical properties were determined for three rotator cuff repairs: single row fixation (n=5) and two different double row fixation (n=11) techniques. The intact rotator cuff was preconditioned, a 3 cm tendon, preconditioned and randomly repaired with one of the selected repairs. The repaired rotator cuff tendon attachment site was recorded, cyclically loaded from 20 to 100 N for 100 cycles, allowed to recover for 45 minutes and subsequently loaded to failure. The footprint restoration, cyclic creep, ultimate load and stiffness of all three repairs were compared with an unpaired Student's t-test with significance set at p<0.05.

Results: The double row repairs increased restoration of the footprint at 90% of normal compared to 40% for the single row (p<0.05). All repairs exhibited small amounts of cyclic creep (single row: 0.50±0.04 mm; double row A: 0.65±0.28 mm; double row B: 0.38±0.29 mm) with no significant differences (p>0.05) between any of the groups. Similarly, no differences were detected between any of the three repairs for the ultimate load (744±70 N; 996±228 N and 794±350) and stiffness (100±6 N/mm, 100±13 N/mm and 89±33 N/mm), respectively.

Conclusions: Both double row repairs examined in this study provide an increased footprint for tendon-to-bone healing compared to the single row. The small amount of cyclic creep suggests all repairs could withstand earlier rehabilitation without compromising stability. Contradicting recent studies, the addition of another row of anchors does not increase the initial biomechanical properties of the repaired tendon with a double row; however, this difference can be attributed to the inclusion of surrounding soft tissue structures during testing.

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though this testing setup provides a more realistic simulation of the clinical setting before repair and during failure, the low number of cycles could only mimic an acute injury setting. The effect of increasing the number of cycles on the surrounding tissues should be further investigated to clarify how its properties affect the overall properties of the complex. Increasing the number of cycles could condition the surrounding tissues and simulate a chronic rotator cuff state after overuse. Even though no differences were detected for initial fixation, the increased restoration of the footprint could lead to increased tendon-to-bone healing with the possibility of improved biomechanical properties. In the future, optimization of the double row suture anchor repair technique should be evaluated in an animal model to assess the effects of healing and attachment site repair.

6 FAILURE STRENGTH OF ARTHROSCOPIc BICEPS TENODESIS REPAIRS

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Objective: Arthroscopic biceps tenodesis has become a popular technique in the management of end-stage pain and degeneration of the proximal biceps tendon. Keyhole fixation with an interference screw has the disadvantage of creating a defect in the proximal humerus that can serve as a “stress-riser.” In order to circumvent this risk, other techniques including soft tissue fixation to the transverse humeral ligament and anchor fixation to the bicipital groove have been utilized. To date there is little biomechanical data on the initial strength of these repairs. Therefore, the objective of this study was to evaluate the biomechanical properties of these two arthroscopic biceps tenodesis techniques.

Methods: A load-to-failure protocol was performed on six fresh cadaveric humeri with the isolated biceps tendon intact using a materials testing machine. The biomechanical properties were determined for two biceps tenodesis fixations: suture anchor attachment to the bicipital groove (n=3) and the percutaneous intra-articular transtendon tenodesis (PITT) attachment to the transverse humeral ligament (n=3). The intact biceps tendon was grasped with a custom sinusoidal clamp and attached via a universal joint to the crosshead of a materials testing machine while the humerus was fixed to the testing base. A uniform load was applied parallel to the humeral shaft. A preload of 5 N was applied to the intact tendon to find a reference position for the tendon before repair. After repair, the proximal end of the tendon was detached from its insertion and a load-to-failure protocol was performed. The ultimate load and stiffness of both repairs were determined from the load-displacement curves and compared with an unpaired Student’s t-test with significance set at p<0.05. Results: The suture anchor and PITT techniques had ultimate loads of 185±35 N and 150±17 N and stiffness of 22.8±6.1 N/mm and 14.4±3.0 N/mm, with no statistical difference between techniques, respectively (p>0.05). During loading, both repairs had typical load-displacement curves into the linear region of the curve followed by a constant increase in displacement until the suture pulled through the tendon. In every case, failure occurred with the suture pulling through the substance of the biceps tendon. Conclusions: The suture anchor and PITT techniques exhibited satisfactory initial strength with no statistical difference between the two groups. These findings along with the consistent pullout of the suture through the tendon during failure suggests that the most important factor for initial strength is not dependent on the attachment site but dependent on the quality of the biceps tendon. This may be important when considering post-operative rehabilitation.
**8** ANTERIOR INFERIOR BONE GRAFTING CAN RESTORE STABILITY IN OSSEOUS GLENOID DEFECTS

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**Introduction:** Glenohumeral instability associated with a significant osseous defect of the glenoid is often treated with bone graft to restore the glenoid concavity. The purpose of this study is to investigate the effects on the intrinsic stability provided by the glenoid of (1) a standardized anteroinferior glenoid defect and (2) different heights and configurations of anteroinferior glenoid bone graft. **Methods:** Using a tipping device to measure the balance stability angle, the anteroinferior stability provided by the glenoid concavity was assessed in each of four fresh frozen, grossly normal cadaver glenoids in (1) the unaltered state, (2) after creating a standardized defect of a magnitude reported by other investigators to be sufficient to require a bone graft, and (3) after a succession of steps varying the bone graft height and contour. **Results:** The anteroinferior glenoid defect significantly diminished the anteroinferior stability angle (from 26°+- 2 deg to 14°+- 2 deg, p < 0.006). Well contoured grafts of heights of 0, 2, 4, 6 and 8 mm above the surface of the glenoid each significantly restored the lost stability, with greater stability angles for the higher grafts (stability angles of 22°+- 1 deg, 26°+- 2 deg, 31°+- 3 deg, 35°+- 3 deg, and 46°+- 4 deg respectively). Less well contoured grafts provided less stability. Eight millimeter grafts caused posterior displacement of the head. **Conclusions:** A bony defect can significantly compromise the anteroinferior stability provided by the glenoid concavity. The lost intrinsic stability can be restored by bone grafting. The effectiveness of the graft in restoring the lost stability is related to both its height and to the extent to which it is contoured.

**9** A PROSPECTIVE ANALYSIS OF THE SAFETY AND EFFICACY OF INTERSCALENE BRACHIAL PLEXUS BLOCK ANESESTHESIA FOR SHOULDER SURGERY

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**Introduction:** The success and complications associated with interscalene brachial plexus block (IBPB) anesthesia for shoulder surgery have been reviewed in recent retrospective reports with wide variability in results and differing conclusions. Numerous prior case reports have documented significant complications related to IBPB anesthesia. Some reports generally conclude that the success of IBPB is less than optimal. Further, those reports conclude that IBPB should not be performed on patients who are heavily sedated or under general anesthesia because of the risk of undetectable intraneural injection of local anesthetic. This prospective study was undertaken to study the safety and efficacy of IBPB performed on patients after induction of general anesthesia. **Methods:** Following IRB approval, 500 consecutive consenting patients undergoing a variety of open and arthroscopic shoulder surgeries were enrolled in this study. For inclusion, the IBPB had to be performed by an anesthesiologist skilled and experienced in IBPB after the patient had been administered general anesthesia. Blocks were performed with an insulated needle, and a nerve stimulator was utilized to determine appropriate needle placement. Stimulation of the biceps brachia muscle, without stimulation of the phrenic nerve, with the current produced by the nerve stimulator set below 0.5 milliamps was required. Bupivacaine 0.5% with epinephrine 1:200,000 (40 ml) was instilled. Aspiration was performed after every 0.5 ml of injected fluid to ensure the absence of blood in the aspirate. Corticosteroid (Kenalog 25 mg) was randomly added to the anesthetic injection in some patients, while others received anesthetic without steroid. Adverse events were noted and followed, and the success and duration of each block was documented. **Results:** Mean time required for the performance of the blocks (positioning and preparation of the head/neck, needle placement, and instillation) was 5.5 minutes. Mean current for nerve stimulation was 0.30 milliamps. The block was successful in 490 (98%) of the 500 cases. Overall mean block duration for all patients was 26 hours. Mean duration of analgesia for blocks performed without steroid was 20 hours. Mean duration for blocks performed with steroid was 28 hours. Immediate post-operative adverse side effects occurred in 54 patients (11%), including: Horner’s syndrome in 37 patients, mild subjective dyspnea due to phrenic nerve dysfunction in 7, severe subjective dyspnea in 3, and hoarseness due to recurrent laryngeal nerve dysfunction in 7. No patient suffered a pneumothorax. No treatment was required for the side effects of the IBPB. One block was aborted after instillation of 20 ml of Bupivacaine (without steroid) due to aspiration of blood during the routine intrablock aspiration check. That patient experienced 19 hours of post-injection analgesia. Nine patients noted persistent hypesthesia and/or paresthesia in the distal portion of the upper extremity after resolution of the analgesic effect of the IBPB. These symptoms resolved in less than one week in 4 patients. The remaining 5 patients had hypesthesia/paresthesia lasting longer than 2 weeks, but all noted spontaneous resolution between 2 weeks and 3 months post-IBPB. No patient had lasting sensory symptoms and no patient experienced persistent motor deficits. **Conclusion:** IBPB performed on patients under general anesthesia was found to be safe (no serious or permanent complications) and effective (98% success). It provided a satisfactory duration of effective analgesia (26 hours). Minor short-lasting adverse side effects occurred in 11% of patients, and temporary minor neurologic adverse events occurred in 2%.

**10** GEOMETRIC RATIONAL TO ANATOMIC REPLACEMENT OF THE PROXIMAL Humerus: HOW MUCH PROSTHETIC GEOMETRY IS NECESSARY?

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**Introduction:** It is now generally accepted that prosthetic replacement of the humerus should strive for near anatomic restoration of the anatomy. Anatomic replacement of an anatomic surface restores (1) normal soft tissue tension across the glenohumeral joint, (2) replicates the original position of the center of rotation, and (3) allows for an arc of motion within the normal range. The biomechanical data are now clear that altering the size and position of the articular surface alters the kinematics and forces across the joint. The following study evaluated a range of fictitious prosthetic scenarios looking to answer: How much prosthetic geometry is needed to achieve a minimum standard of anatomic reconstruction? This minimum standard was defined as a reconstruction that re-positioned the center of rotation within 4 mm of the original, using an articular surface with a surface arc within 20° of the original for 95% of all specimens. **Methods:** Mean data from an anatomic study of normal cadaveria were used to construct four prosthetic scenarios. These scenarios were based on a posterior-inferior inclination angle of 42 degrees using an optimization algorithm that has been applied in previous studies. For all scenarios, stem sizes and the relationship between stem size and offset were kept the same. The gap created by the taper and collar was considered negligible. Four prosthetic heads with a radius of curvature of 20, 22, 24, and 26 mm were available in each scenario, as was an offset mechanism that allowed for a centered position of the head and one with universal offset that was 4 mm displaced from the center of the taper lock. The scenarios differed in the available head heights, inclination angle(s) and eccentric offset of the taper.
mechanism. In the simplest scenario (1), only one head height that was 75% of the RC and one inclination angle of 42° was available. In scenario 2, three head thicknesses were allowed per radius of curvature, taken at 75%, +/− 10% or 65%, 75% and 85% of RC. In scenario 3, three head thicknesses were allowed, two inclination angles of 42° and 48°, and three offset mechanisms of the taper offset (centered, 2 mm and 4 mm). In scenario 4, five head thicknesses (55%, 65%, 75%, 85% and 95% of RC), six inclination angles (36, 39, 42, 45, 48 and 51°) and five offset mechanisms (centered, 1, 2, 3, and 4 mm from the taper lock) were allowed. These scenarios were compared to previously published data on second generation prosthetic systems and the one third generation system (Tornier Aequalis).

Results:
Scenario 1: The mean displacement of the center of rotation (DCR) was 2.6 mm, that for the articulation point (DAP) was 2.0 mm and the mean reduction of surface arc (DSA) was 10°. The maximum DCR and DSA encountered in this scenario was 7.7 mm and 25°, respectively. This compares with a mean DCR of 9.7 (+/− 5.3) mm and DSA of 32° (+/− 7°) found in a previous analysis of select second generation systems, and a mean DCR of 2.1 (+/− 1.0) mm and DSA of 12° (+/− 7°) for the Tornier Aequalis. Scenario 2: The mean DCR was 2.2 mm (range 0.4 to 6.9), DAP was 1.9 mm (range 0.2 to 6.9) and DSA was 6° (range 4 to 20). Scenario 3: The mean DCR was 1.6 mm (range 0.3 to 4.1), DAP was 1.3 mm (range 0.2 to 4.2) and DSA was 7° (range 4 to 23). Scenario 4: The mean DCR was 1.3 mm (range 0.4 to 4.1), DAP was 1.0 mm (range 0.2 to 4.1) and DSA was 6° (range 6 to 23). (DCR – displacement of center of rotation, DAP – displacement of articulation point, DSA – loss of articular surface arc.)

Conclusions: In this abstract analysis, even the simplest prosthetic system with only one inclination angle (42°) and four available prosthetic heads allowed for replication of normal anatomy within a range comparable to existing third generation prosthetic systems. Two inclination angles with three head heights (12 head sizes) and three offset positions enabled the algorithm to meet the stringent criteria of this study in 95% of the specimens. Additional inclination angles, head heights and offset options did not substantially improve the results. The computer optimization algorithm demonstrated ways in which optimal anatomic reconstruction is sometimes best achieved with a head resection at a different inclination angle than that of the anatomic neck.

11 CORRECTIVE SURGICAL NECK OSTEOTOMY FOR VARUS MALUNION OF THE PROXIMAL HUMERUS
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Introduction: Although the outcome of non-operative treatment of displaced proximal humerus fractures is often limited, it is uncommon for patients to require or undergo operative reconstruction. Reconstructive arthroplasty is typically performed for post-traumatic arthritis. Shoulders with extra-articular malunion and an intact glenohumeral joint less commonly present with pain and dysfunction that requires reconstruction. In these cases prosthetic arthroplasty is not necessary and osteotomy is an appropriate option. There are no studies that specifically address the treatment of surgical neck malunion after proximal humerus fracture.

Methods: 14 patients with a mean age of 60 (44-78) who had a varus malunion of the surgical neck of the humerus underwent a closing wedge surgical neck osteotomy and internal fixation with a 90 degree blade plate. There were 5 male and 9 female patients. The indications for surgery were shoulder pain and limited motion. The dominant shoulder was treated in 8. 9 had previous non-operative treatment, 2 closed reduction and pinning, 3 ORIF. The interval between injury and osteotomy was 65.5 months (3-180 months).

Results: Mean follow-up was 33.4 months (12-76). The neck-shaft angle correction was 32° (17-50°). Shoulder pain was reduced in all cases. Active forward elevation improved 30° (-25-45°). Active external rotation improved from 9° (0-30°). The mean DASH score at final evaluation was 20 (11-42). 3 patients required additional surgery; one to treat an infection, one nonunion was converted to a total shoulder, and one nonunion was treated with bone grafting and revision internal fixation.

Discussion: Corrective valgus surgical neck osteotomy for varus surgical neck malunion predictably reduces shoulder pain and improves shoulder function, including active motion and upper extremity activities.