EIGHT COMMON PITFALLS IN SHOULDER ARTHROPLASTY (S)

Moderator– Edward V. Craig MD,MPH

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PREOPERATIVE AND INTRAOPERATIVE DECISIONS TO MINIMIZE COMPONENT MALPOSITION

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Introduction

Preoperative decision making in shoulder arthroplasty begins with preoperative planning. A properly planned and executed surgical procedure can minimize occurrence of prosthetic malposition and its associated complications.

Although the majority of cases of unconstrained shoulder arthroplasty are routine, certain cases have unique characteristics that merit special consideration. Preoperative planning identifies cases that may require deviations from routine unconstrained shoulder arthroplasty.

The reintroduction of the reverse design prosthesis has allowed surgeons to treat complicated shoulder pathology for which no good solution existed prior to the availability of this implant. The severity and diversity of shoulder pathology treatable with the reverse prosthesis makes preoperative planning even more important in these cases than with primary unconstrained shoulder arthroplasty. Candidates for the reverse prosthesis may include patients with substantial proximal humeral and/or glenoid bone loss.

In both unconstrained and reverse shoulder arthroplasty, preoperative planning should be done well in advance of the surgical procedure and should not be an afterthought the morning of surgery. Preoperative planning for shoulder arthroplasty requires that the surgeon review the patient's clinical history and examination, radiographs, and secondary imaging studies.

Humeral Component

Unconstrained shoulder arthroplasty. Radiographs are obtained in all patients presenting as candidates for shoulder arthroplasty. We prefer an anterior posterior view of the glenohumeral joint with the arm in neutral rotation, an axillary view, and a scapular outlet view. The anterior posterior radiograph is used to evaluate the glenohumeral joint space, the presence of humeral and glenoid osteophytes, the size of the humeral canal, the presence of any loose bodies, and the existence of any deformity of the humeral shaft (Figure 1) as these factors may all impact the planned procedure.

The axillary and scapular radiographs are also used to evaluate any deformity of the humeral shaft.

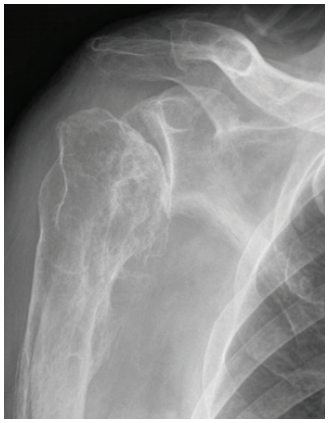

Figure 1. Diaphyseal malunion identified on preoperative radiographs.

Most shoulder arthroplasty prosthetic systems have radiographic templates available for preoperative planning. Use of an adaptable, anatomic prosthetic system minimizes the need for radiographic templates in most cases, as the humeral stem size, humeral head size and position will be determined intraoperatively. In patients with substantial deformity of the proximal humerus or an excessively small humeral canal, use of radiographic templates preoperatively is mandatory to determine whether existing prefabricated implants are sufficient or if a custom manufactured implant is needed.

Secondary imaging of the proximal humerus using computed tomography is useful in patients that have a rotational malunion. In these cases a computed tomogram can measure humeral retroversion allowing for correction at the time of surgery.

Intraoperatively, the most important step in avoiding malpositioning of the humeral stem in unconstrained shoulder arthroplasty is identification of the native anatomical neck. To identify the true anatomic neck of the humerus, any osteophytes are removed with an osteotome. Typically, capsular tissue exists between the osteophytes and the native humerus aiding in identification of the normal margin of the humeral head articular surface (Figure 2). The infraspinatus tendinous insertion should be visible on the posterior aspect of the humerus (Figure 3). The location of the posterior rotator cuff defines humeral version, which varies from 7° of anteversion to 48° of retroversion.1 Once the anatomical neck of the humerus is identified, the humeral head can be resected with an oscillating saw.

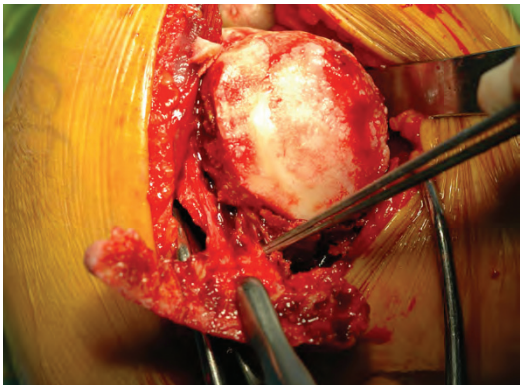

Figure 2. Identification of the anatomic neck of the humerus.

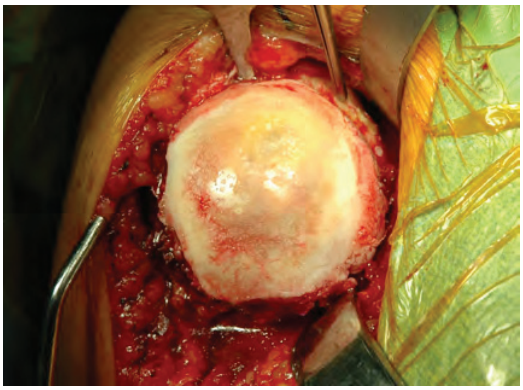

Figure 3. The infraspinatus tendon is identified.

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Avoidance of varus or valgus positioning of the humeral stem is best accomplished by selecting the appropriate entry point into the humeral canal. The desired entry point may be specific to the implant system chosen but is usually lateral and slightly anterior on the cut surface.

A trial prosthetic humeral head is selected to match the size of the resected humeral head. Most humeral heads are slightly elliptical; if this is the case, the smaller diameter is selected. Additionally, if the resected humeral head is in between sizes available in the prosthetic system, the smaller size is initially selected to avoid "overstuffing" the glenohumeral joint. Most prosthetic systems allow for variable head offset. Offset is chosen to best cover the cut humeral surface and avoid "overhanging" which can lead to impingement on the rotator cuff.

Reverse shoulder arthroplasty. The greatest challenge in preoperative planning for the humeral component in reverse shoulder arthroplasty is the patient with proximal humeral bone loss. Failure to position the humeral component of the reverse prosthesis at the appropriate height can result in instability. In patients demonstrating proximal humeral bone loss from etiologies such as fracture nonunion, bilateral full length magnification controlled anterior posterior humeral radiographs are obtained. These radiographs are utilized to help select at what height to implant the humeral stem.

Most reverse shoulder arthroplasty prosthetic systems have radiographic templates available for preoperative planning. For routine etiologies such as rotator cuff tear arthropathy, we do not routinely use preoperative radiographic templating, as we have not found this to be useful. In cases of proximal humeral bone loss, preoperative radiographic templating is useful. This is done using the full length humeral radiographs. The desired position of the reverse prosthesis is templated on the unaffected humeral radiograph and the level of the humeral component metaphyseal diaphyseal junction marked. The distance from the transepicondylar axis at the elbow to this point is measured. A mark is made at the same distance from the transepicondylar axis on the affected radiograph. A second mark is made at the most proximal extent of the humeral shaft. The distance between the desired prosthetic level at the metaphyseal diaphyseal junction and the proximal extent of the humeral shaft is measured (Figure 4). A ruler is used during surgery to measure the distance and mark the level on the humeral stem for desired prosthetic position. This technique of preoperative planning provides only a guideline and may be superseded by intraoperative observations. In general, intraoperative deltoid tension is more important in determining the correct prosthetic position than preoperative radiographic templating. Preoperative planning does provide a starting point for establishing proper prosthetic height.

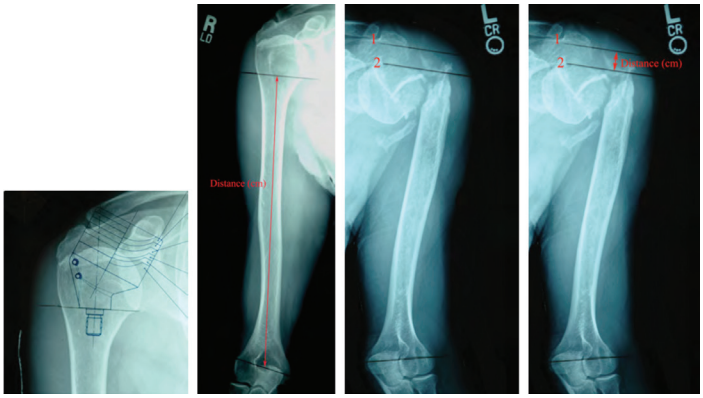

Figure 4. (a) The desired position of the reverse prosthesis is templated on the unaffected humeral radiograph and the level of the humeral component metaphyseal diaphyseal junction marked. (b) The distance from the transepicondylar axis at the elbow to this point is measured. (c) A mark is made at the same distance from the transepicondylar axis on the affected radiograph. A second mark is made at the most proximal extent of the humeral shaft. (d) The distance between the desired prosthetic level at the metaphyseal diaphyseal junction and the proximal extent of the humeral shaft is measured.

Rarely, proximal humeral bone loss is sufficiently severe to necessitate use of a custom implant or proximal humeral composite bone graft (prior trauma, tumor). Templates are useful to determine whether existing prefabricated implants are sufficient or if a custom manufactured implant is required. In cases of proximal humeral insufficiency limited to the proximal humeral metaphysis, no bone graft is indicated as the reverse prosthesis can be implanted into the intact humeral diaphysis. In cases that the proximal humeral bone loss extends distally to compromise the proximal humeral diaphysis, a bone graft reconstruction of the proximal humeral diaphysis is indicated.

Intraoperatively, when implanting the reverse prosthesis in cases of proximal humeral bone loss, we reinsert the trial humeral stem with the thinnest available polyethylene insert after completing glenoid component implantation and reduce the prosthetic glenohumeral joint. With longitudinal traction placed on the arm, the humeral component is manually telescoped maximally out of the humerus to the glenoid component and the level of the trial humeral implant with respect to the proximal humerus is marked. The distance between the metaphyseal diaphyseal prosthetic junction and the mark made with respect to the proximal humerus is compared to the distance preoperatively templated to evaluate restoration of appropriate humeral length. This enables an estimation of the appropriate level at which to cement the humeral component. If the humeral component is cemented too distal within the humerus, adequate tension may not be obtainable. Conversely, if the humeral component is cemented too proximal within the humerus, the prosthetic joint may be irreducible.

Glenoid Component

Unconstrained shoulder arthroplasty. Radiographs are of limited use in preoperative planning glenoid component positioning in unconstrained arthroplasty. The axillary radiograph is used to evaluate the presence of anterior or posterior humeral head subluxation and the presence of osseous glenoid wear and dysplasia, but is not reliable at quantifying such findings. Similarly, posterior glenoid wear can be difficult to appreciate even with direct intraoperative visualization. For these reasons, a secondary imaging study is obtained in all patients prior to unconstrained shoulder arthroplasty to evaluate glenoid morphology. Our preferred secondary imaging modality is the computed tomogram. Using the computed tomogram, any central glenoid wear, posterior glenoid wear, or glenoid dysplasia is identified and quantified. Glenoid morphology is critical when performing unconstrained shoulder arthroplasty in two scenarios. First, in patients with severe glenoid erosion (central or posterior) or severe dysplasia, insufficient glenoid bone stock may prohibit implantation of a standard glenoid component (Figure 5). In this scenario, the surgeon must opt for a hemiarthroplasty or choose to alter the glenoid component (i.e. shorten the keel or pegs). Second, in cases of posterior humeral head subluxation and a biconcave glenoid, a posterior capsulorrhaphy may be required at the time of shoulder arthroplasty (Figure 6). In select cases we identify preoperatively, we may opt for use of a reverse prosthesis with a concomitant glenoid bone graft to address severe posterior glenoid wear with subluxation.

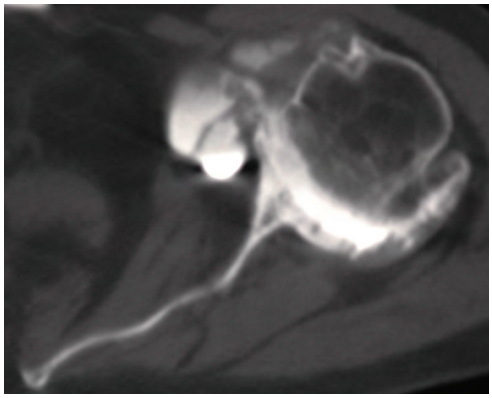

Figure 5. Severe central glenoid erosion.

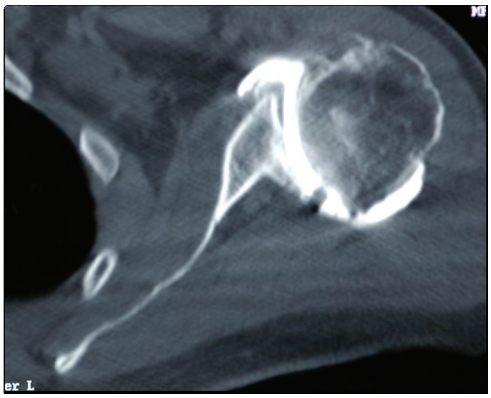

Figure 6. Posterior glenoid wear.

Intraoperatively, information obtained from the preoperative computed tomogram is used in glenoid preparation. Reaming the glenoid surface serves two purposes: first, it provides a congruent surface matching the apposing surface of the implant by removing any remaining cartilage and smoothing the osseous surface; and second, it corrects any deformity caused by bony wear, as identified on preoperative imaging. If no deformity is present, minimal reaming is performed to preserve as much subchondral bone as possible.2 In patients with posterior glenoid wear, however, the anterior portion of the glenoid should be preferentially reamed to correct the deformity. The goal of reaming in this scenario is to eliminate the biconcave glenoid morphology and restore a single concavity glenoid of appropriate version (2° to 8° of retroversion). When reaming a biconcave glenoid, the anterior glenoid is preferentially reamed until a single concavity is achieved and glenoid surface has been reoriented into correct version. As reaming progresses, the reamer should be periodically removed and the glenoid surface checked. A ridge on the glenoid surface demarcating the two concavities of the glenoid surface should move progressively posteriorly until it is no longer visible. If adequate correction is not possible because of too severe of osseous wear, a bone graft with a reverse prosthesis should be considered.

Reverse shoulder arthroplasty. In contrast to unconstrained shoulder arthroplasty, plain radiography is very useful in planning glenoid component positioning in reverse shoulder arthroplasty. Specifically, the presence of any superior glenoid wear is readily identified on the anterior posterior radiograph (Figure 7).). In cases of severe superior glenoid bony wear, a superior bone graft may be necessary to reorient the glenoid to a neutral or inferiorly directed position. A computed tomogram is obtained in all patients prior to reverse shoulder arthroplasty to evaluate axial glenoid morphology and bone stock just as in unconstrained shoulder arthroplasty. The axial sections of the secondary imaging scan are used to measure the depth of the glenoid vault to determine if sufficient bone exists to implant the 15 mm peg of the reverse prosthesis base plate (Figure 5).

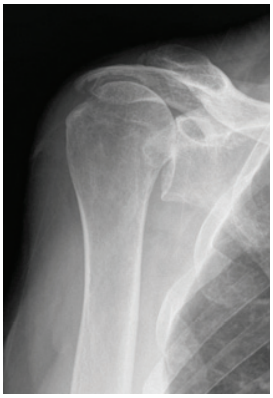

Figure 7. Superior glenoid wear from static superior humeral head migration.

Intraoperatively, the reverse glenoid component should be placed inferiorly on the glenoid surface to help avoid scapular notching caused by mechanical impingement. Most systems provide an inferior glenoid referencing guide to achieve this. Care is taken during reaming of the glenoid to avoid introducing superior tilt to the glenoid surface. Reaming also serves to correct any deformity caused by osseous wear much like in unconstrained shoulder arthroplasty. In reverse shoulder arthroplasty, however, this wear is more likely to occur in the coronal plane.

Glenoid bone loss can represent a challenging problem in reverse shoulder arthroplasty. Glenoid bone loss is most commonly observed in three scenarios when using a reverse prosthesis. In patients with massive rotator cuff tears and glenohumeral arthritis, static superior migration of the humeral head may lead to nonconcentric glenoid wear and superior erosion of the osseous glenoid (Figure 7). If this bone loss is not addressed, the glenoid component may be implanted inadvertently with superior tilt risking glenoid failure. In cases of mild to moderate superior bone loss, preferential inferior reaming alone can correct glenoid orientation. In cases of severe superior glenoid osseous deficiency, bone graft glenoid reconstruction using autologous humeral head or iliac crest may be necessary. Another scenario in which glenoid reconstruction may be necessary during implantation of the reverse prosthesis is in the treatment of fixed anterior glenohumeral dislocation. Chronic anterior shoulder dislocations in older patients often result in erosion of the anterior glenoid. When the severity of this erosion is such that no native glenoid is under the anterior base plate screw hole, an anterior glenoid reconstruction using iliac crest bone graft is required. Finally revision arthroplasty with glenoid bone loss may necessitate osseous glenoid reconstruction using bone graft.

If a glenoid reconstruction using bone graft is necessary prior to glenoid component insertion, every effort should be made to have a portion of the central peg of the base plate placed in native glenoid bone. Some companies manufacture revision base plates with a longer central peg or screw to address this problem. If it is not possible to place the central peg within the native glenoid bone and/or the glenoid component does not seem securely fixed, a staged arthroplasty should be employed.

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2. Walch G, Young AA, Boileau P, et al: Patterns of loosening of polyethylene keeled glenoid components after total shoulder arthroplasty for primary osteoarthritis: results of a multicenter study with more than five years of followup. J Bone Joint Surg Am 2012; 94:145-50.

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INFECTIONS IN SHOULDER ARTHROPLASTY

1. Introduction
- a. Periprosthetic joint infections (PJI) well recognized problem
  - i. 0.8 to 1.9% of knee arthroplasties
  - ii. 0.3 to 1.7% of hip arthroplasties
  - iii. proportion of primary total hip arthroplasty patients in medicare population free of PJI 98.37% after 1 year, 7.65% after 3 years, 97.04% after 5 years, and 96.65% after 7 years.
  - iv. frequency of infection is increasing as the number of primary arthroplasties increases
  - v. Represent an enmorous cost
  - vi. Have a substantial impact on patient functional outcome
- b. Shoulder PJI
  - i. Much is known about PJI of hip and knee and far less known about periprosthetic shoulder infections
  - ii. Annual rate of Shoulder Arthroplasty -100,000 leading to increasing incidence of infection

2. Definition-Lack of universal definition of PJI
- a. Variety of criteria for the diagnosis of PJI
  - i. single culture-positive periprosthetic specimen in the absence of histologic finding
  - ii. requirement for a minimum of three culture-positive specimens
  - iii. Several definitions based upon the results/findings of diagnostic testing
- b. Lutz, et al
  - i. 2 cultures positive for growth with a morphologically identical organism(s)
  - ii. 1 culture positive for bacterial growth with 5 neutrophils/high-power field on histologic analysis.
  - iii. particularly problematic in cases of PJI due to more indolent organisms, such as P. acnes, where overt clinical and laboratory signs of infection are often absent
- c. Del Pozo NEJM presence of at least one of
  - i. Acute inflammation detected on histopathological examination of periprosthetic tissue
  - ii. Sinus tract communicating with the prosthesis
  - iii. Isolation of the same microorganism from 2 or more cultures of joint aspiration or intraoperative periprosthetic tissue specimens
  - iv. Isolation of the organism in substantial amounts from sonicate fluid
- d. acute vs subacute vs late

3. Incidence of Periprosthetic Shoulder Infection
- a. Primary anatomic- 0.5-2%
- b. Primary reverse 0-3%
- c. Prevalence of infection subsequent to shoulder arthroplasty in many previous reports may have been underestimated.- culture incubation period too short

4. Microbiology of Periprosthetic Shoulder Infection
- a. Infecting Organisms Hip and Knee PJI
  - Staphylococcus aureus 95 (28%)
  - Coagulase-negative staphylococci 101 (30%)
  - Beta-hemolytic streptococci 13 (4%)
  - Polymicrobial infection 38 (11%)
  - Negative culture results 33 (10%)
  - Anaerobes 12 (4%)
  - Propionibacterium acnes <1%
- b. Shoulder PJI-Half of reported sub acute and chronic infections of shoulder arthroplasties are culture-positive for Propionibacterium acnes
  - i. Sperling, et al, CORR 2001-
    - Staphylococcus aureus (50%)
    - coagulase-negative Staphylococcus (35%)
    - Propionibacterium acne (19%).
  - ii. Butler, et al, J Clinical Microbiology 2011
    - Propionibacterium acnes (55%)
    - coag negative Staphylococcus (16%)
    - Staphylococcus aureus (14%)
- c. Propionibacterium Acnes
  - i. Anaerobic gram positive rod- non-spore forming
  - ii. Found in lipid rich areas and moist areas axilla, hair follicles, sebaceous glands-more prevalent around shoulder than hip and knee
  - iii. Forms a Biofilm on implants-infects prosthetic devices-VP shunts, heart valves, spinal implants
  - iv. Common contaminant of bacterial cultures
  - v. Avg 11.4 days to grow
  - vi. Sensitivities not routinely performed (No Standards) overall rates of susceptibility observed for all P. acnes isolates
    1. metronidazole, 0%
    2. clindamycin, 95.3%
    3. cefotetan, 98.4%, imipenem, 100%
    4. piperacillin-tazobactam, 100%
    5. ampicillin-sulbactam, 100%.
- d. Most peri-operative recommendations are based upon total hip and knee literature-does it make sense to follow the same?

5. Risk Factors for Periprosthetic Infection
- a. Primary arthroplasty- previous surgery of any type
- b. Revision arthroplasty
- c. Patient-related risk factors for PJI
  - i. tobacco abuse
  - ii. obesity
  - iii. rheumatoid arthritis
  - iv. neoplasm
  - v. immunosuppression
  - vi. diabetes mellitus
  - vii. higher ASA score
- d. Surgical risk factors for PJI
  - i. simultaneous bilateral arthroplasty
  - ii. long operative time (>2.5 hours)
  - iii. allogeneic blood transfusion
  - iv. room traffic
- e. Postoperative risk factors
  - i. wound healing complications (e.g., superficial infection, hematoma, delayed healing, wound necrosis, and dehiscence),
  - ii. atrial fibrillation
  - iii. myocardial infarction
  - iv. urinary tract infection
  - v. prolonged hospital stay
  - vi. S. aureus bacteremia

6. Preventing infections
- a. Pre-operative skin cleansing
  - i. chlorhexidine gluconate impregnated cloth better than soap and water shower at reducing cutaneous + culture rate
  - ii. preoperative skin disinfection with chlorhexidine evening before and morning of reduces surgical site infection (SSI) in elective hip and knee arthroplasty

b. Staph carriage screening
  i. intranasal mupirocin effective at decreasing nasal carriage of Staphylococcus aureus
  ii. most studies do not demonstrate a decrease in SSI rates
  iii. positive trend in favor of staphylococcus screening, decolonization with mupirocin, and perioperative Vancomycin for known MRSA carriers
c. Dental care
  i. Poor dental hygiene and periodontal or periapical infections associated with bacteremia
  ii. The incidence and magnitude of bacteremias of oral origin are directly proportional to the degree of oral inflammation and infection
  iii. dental hygiene visit decreases risk of periprosthetic hip or knee infection
d. Skin preparation
  i. alcohol based prep solutions better
e. Draping
  i. Occlusive adherent draping- ioban
f. Peri-operative antibiotics
  i. Medicare National Surgical Infection Prevention Project goal
    1. goal of antimicrobial prophylaxis is to achieve serum and tissue drug levels for the duration of the operation that exceed the minimum inhibitory concentration for organisms
    2. prevent infection of the wound with the most probable organisms to be encountered for that type of operation
  ii. For most operations, a single antimicrobial is sufficient to prevent SSIs. likely to be encountered during the operation
    1. Cefazolin 1gm (2gm for patients >80kg) within 60 minutes of start of surgery continue q 8 hours
    2. Beta Lactam allergy
      a. Vancomycin 15mg/kg (assuming normal renal function) within 120 minutes of surgery continue q12 hours
    3. Clindamycin
  iii. Complete antibiotics within 24 hours
  iv. MRSA prophylaxis
    1. hospital Infection Control Practices Advisory Committee guideline suggests that "high" levels of methicillin resistant Staphylococcus aureus (MRSA) infection in an institution should influence the use of vancomycin for prophylaxis
    2. no consensus about what constitutes high levels of methicillin resistance.
    3. no evidence that routine use of vancomycin forprophylaxis in institutions with perceived high rates of MRSA will decrease SSIs more than agents such as cefazolin.
g. Surgical technique- prolonged operating time, tissue handling
h. Antibiotic cement
  i. Norwegian Hip Registry-
    1. 0.5% revised for infection.
    2. lowest risk of infection with IV antibiotics and antibiotic cement
    3. IV antibiotics alone had 1.8x greater risk of infection
  ii. Vancomycin cement
    1. Delayed addition of vancomycin greater elution than standard mixing and double amount monomer
    2. Most elution occurs in first 7 days
  iii. antibiotic cement reduced infection rate in primary RSA 3% to 0%. Level III retrospective cohort study
  iv. Antibiotic cement is irrelevant in pressfit/uncemented implant
i. Drain
  i. Use of drains associated complications including infection, drain retention and soft tissue problems
  ii. The necessity of drains for total joint arthroplasty is controversial
  iii. With time, there is increased bacterial colonization of the drain tip and migration of skin organisms into the wound
j. Host co-morbidity Medical Management
  i. attention to intraoperative temperature control and supplemental oxygen administration,along with aggressive fluid resuscitation, may decrease infection rates
  ii. aggressive perioperative blood sugar control with insulin decreases SSI rates in patients undergoing cardiac operations. The risk of SSI appears to be related to the presence of hyperglycemia rather than to a diagnosis of diabetes mellitus
k. TED prophylaxis and bleeding- wound hematoma associated with wound healing problems including infection
l. Concommittant infection- eliminate prior to elective operation
  i. Hair Removal-clippers are associated with fewer SSIs than razors
m. Hand Scrubbing
  a. Limited evidence regarding the benefit
  b. Alcohol rubs are at least as, if not more, effective than aqueous scrubs in preventing SSI
  c. Chlorhexidine gluconate based aqueous scrubs more effective than povidone iodine based aqueous scrubs in terms of the numbers of CFUs on the hands.
n. Double Gloving
  i. There is no direct evidence that additional glove protection reduces SSI
  ii. Second pair of surgical gloves significantly reduces perforations to innermost gloves
  iii. Triple gloving, knitted outer gloves and glove liners significantly reduce perforations to the innermost glove
  iv. Recommend double gloving for orthopaedic surgery
o. Dental Prophylaxis
  i. Transient bacteremia commonly associated with physiologic activities such as chewing and brushing, as well as dental and oral procedures
  ii. Wide variation in the reported frequencies of bacteremia among patients resulting from dental procedures
  iii. Number of bacterial species recovered from blood cultures is large.
  iv. The majority transient bacteremias are due to viridans group streptococci, nonpathogenic gonococci, b-hemolytic streptococci, and gram-positive anaerobes
  v. Low-risk or high-risk dental procedures performed within 6 months to 2 years of arthroplasty were not significantly associated with an increased risk of prosthetic hip or knee infection, compared with no dental procedure
  vi. Large discrepancy between the low grade bacteremia caused by dental procedures and physiologic activities and the high-density bacteremia needed to get hematogenous seeding in animal models

7. Detecting infections
a. bacterial detection techniques
  i. tissue culture and polymerase chain reactions (PCR)
  ii. identify bacteria but are susceptible to contamination in the surgical field, during sample handling, and in the laboratory setting
  iii. confidence in treating a patient based solely on these tests is reduced by the concern for a false positive result

b. host response measures
   i. systemic measures-erythrocyte sedimentation rate (ESR), c-reactive protein (CRP), and Interleukin-6 (IL-6)
   ii. local measures- synovial fluid white blood cell (WBC) count, tissue WBC by histopathology
   iii. host response test can be highly sensitive and specific in the ideal setting
   iv. can be confounded by other causes of inflammation such as concomitant infections, systemic inflammatory diseases, and local diseases such as gout

c. Joint aspiration
   i. Hips – >4200 WBC with >80% neutrophils
   ii. Knee- 1700 with >65% neutrophils
   iii. Synovial-fluid culture
      1. sensitivity of 56 to 75%
      2. specificity of 95to 100%
      3. should be performed by means of inoculation into a blood-culture bottle.

d. Wound tissue culture
   i. Periprosthetic tissue
   ii. Sonicate specimens
      1. important that clinical microbiology laboratories utilize optimized culture conditions for the recovery of P. acnes from prosthetic joint specimens.
   iii. Periprosthetic-tissue cultures may be falsely negative because of previous antimicrobial therapy, leaching of antimicrobial agents from antimicrobial- impregnated cement, biofilm growth on the surface of the prosthesis (but not in the surrounding tissue), a low number of organisms in tissue, an inappropriate culture medium, an inadequate culture incubation time, or a prolonged time to transport the specimen to the laboratory
   iv. intraoperative swab cultures and Gram's staining not recommended
   v. Fungal cultures, mycobacterial cultures, or both may be considered (e.g., if bacterial cultures are negative in a patient with apparent infection), but they are not routinely recommended.

e. PCR
   i. direct 16S rRNA gene PCR, limited utility in the diagnosis of PJI due to P.acnes

f. Evidence Review-most relates to hip and knee replacement surgery and PJIExtrapolate to shoulder
   i. AAOS Guidelines for Diagnosis of Periprosthetic Joint Infections of Hip and Knee
      1. Screening inflammatory markers-ESR, CRP- strong recommendation
         a. negative ESR is better at ruling out infection than a positive result is for ruling in infection
         b. CRP level is a better test for ruling out infection but is somewhat better than the ESR at ruling in infection
         c. These tests are not specific for diagnosis of periprosthetic infection and may be elevated with any type of infection or inflammation.
      2. Joint aspiration strong recommendation
         a. knee infections who have abnormal ESR and/or CRP level results
            i. aspirated fluid for microbiologic culture, synovial fluid WBC count, and differential WBC
            ii. count synovial fluid white blood cell count >1,700 cells/µL (range, 1,100 to 3,000 cells/µL) or a neutrophil percentage >65% (range, 64% to 80%) is highly suggestive of chronic PJI
         b. Hip-Aspiration is indicated for lower probability hip patients without planned reoperation only when both the ESR and CRP level are abnormal. Lower probability hip arthroplasty
         c.

8. Treatment of Periprosthetic Shoulder Infection

a. Clinical presentation relates to virulence of infecting organisms
   i. Early high virulence-swelling, erythema, fever, leukocytosis
   ii. Delayed and late low virulence-non specific presentation-difficult to make diagnosis

b. Acute post-operative infection
   i. Arthroscopic vs open debridement/humeral head exchange; IV antibiotics

c. Late acute infection
   i. Determine history- recent infection or procedure
   ii. Early presentation- debridement and IV antibiotics

d. Late chronic infection
   i. 2 stage treatment

e. Unexpected positive cultures in revision setting
   i. Pre-operative evaluation of systemic and local host response parameters
      1. ESR, CRP
      2. Joint aspiration
      3. Intra-operative joint aspiration
      4. Intra-operative tissue cultures
         a. aerobic and anaerobic
         b. hold cultures for minimum 14 days
   ii. Treat as if infected based upon the bacteriology without additional debridement and implant removal
   iii. Systemic antibiotics
      1. Short Course (6 week) Oral
      2. Short Course (6 week) IV
      3. Long Term Suppression
      4. NO Antibiotics (Surveillance)-risk of Infection may be overstated
      5. Consider risk of antibiotics and prolonged intravenous catheter access

9. Summary

a. Shoulder PJI are uncommon but represent a substantial problem
b. Identify and modify or control relevant host factors
c. Employ procedures for preventation
d. Appropriate evaluation to identify shoulder PJI
e. Successful outcome of treatment requires aggressive management

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AVOIDABLE CAUSES OF PROSTHETIC INSTABILITY AND DISLOCATION

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I. Posterior instability
- a. Etiology[1]
  - i. Preoperative instability
    - 1. Glenoid retroversion
      - a. Preoperative imaging (XR/CT/MRI)
    - 2. Capsular laxity
      - a. Best appreciated on MRI
  - ii. Soft-tissue imbalance
    - 1. Inadequate anterior release
    - 2. Tight subscapularis repair
  - iii. Components
    - 1. Version
      - a. Retroversion of glenoid component
      - b. Retroversion of humeral component
- b. Treatment
  - i. Correction of component version
    - 1. Eccentric reaming
    - 2. Posterior glenoid augmentation
      - a. Bone graft
      - b. Cement
      - c. Prosthetic augments
    - 3. Restoration of humeral version
  - ii. Posterior capsulorrpahy
    - 1. Tucks
    - 2. Glenoid anchors

II. Anterior instability
- a. Etiology
  - i. Failure of subscapularis[1]
    - 1. Tissue quality
    - 2. Repair
    - 3. Rehab
  - ii. Components
    - a. Oversizing
    - b. Humeral malrotation
  - iii. Anterior deltoid dysfunction
- b. Treatment
  - i. Subscapularis repair[2]
    - 1. Primary
    - 2. Allograft reconstruction
    - 3. Pectoralis transfer
  - ii. Component revision

III. Superior instability
- a. Etiology
  - i. Rotator cuff dysfunction[1,4]
    - 1. Not all studies support (Boyd et al: major rotator cuff tears in 21% of patients with stable joint; 24% of patients with superior subluxation)[5]
  - ii. Component height[4]
- b. Treatment
  - i. Adjustment of component height
  - ii. Revision to reverse

IV. Inferior instability
- a. Failure to restore humeral length
  - i. More common in setting of fracture or tumor[6]
- b. Treat by revision with restoration of length

V. Risk Factors and Prognosis[7]
- a. Risk factors
  - i. Age
  - ii. Preoperative rotator cuff disease
  - iii. Preoperative instability
- b. Prognosis after revision surgery
  - i. Revision surgery successful in 9 of 32 shoulders
  - ii. Anterior instability had a higher failure rate than posterior instability (p=0.04)
  - iii. 4 excellent, 6 satisfactory, 23 unsatisfactory results

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PREOPERATIVE AND INTRAOPERATIVE DECISION-MAKING TO MINIMIZE POSTOPERATIVE CUFF FAILURE

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Introduction

In reviewing complications of total shoulder arthroplasty in published articles rotator cuff tearing was recognized as the third most common complication (Wirth MA, 1996). Reviewing 431 total shoulder arthroplasties from a single institution with a mean length of follow-up of 4.2 years, rotator cuff tearing was identified as the most common postoperative complication, occurring in 17 or 4% of cases. In 8 rotator cuff tearing was present preoperatively, in 4 the subscapularis disrupted after surgery creating anterior instability. Six cases (1.4%) required reoperation to deal with this subset of complications (Chin PYK, 2006).

Rotator cuff tearing can lead to instability as identified in the laboratory (Hsu H-C, 1997) or clinically in an anterior direction if there is a postoperative subscapularis tear (Moeckel BH, 1993). In specifically studying postoperative instability after total shoulder arthroplasty a group of 33 shoulders was studied, and in 22 the primary cause of the instability was rotator cuff tearing (Sanchez-Sotelo, 2003).

There are a number of clinical variations including early subscapularis tearing, acute traumatic rotator cuff tear or chronic attritional tear, all can be with or without glenohumeral instability. Treating these problems with rotator cuff repair after shoulder replacement is not consistently effective. We identified 18 shoulders requiring rotator cuff surgery after shoulder replacement. A variety of tendons were involved and instability was present in 10. The repair healed in 4, instability continued in 7. Pain relief was commonly achieved, but range of motion was unchanged (Hattrup SJ, 2006).

Preoperative Decision-Making

Preoperatively it is important to know about pre-existing disease. At surgery one wishes to leave supporting structures intact and reduce stresses on the rotator cuff repair. After surgery the repair needs to be protected and rehabilitation carefully planned.

A number of studies have reported the frequency of pre-existing rotator cuff disease in those undergoing shoulder arthroplasty (Torchia ME, 1997, Foruria AM, 2010, Sperling JW, 2007, Hattrup SJ, 2000). In osteoarthritis there is commonly tendinopathy, some degree of muscle atrophy and frank rotator cuff tearing in approximately 5% of shoulders, typically the tearing is small in size. In rheumatoid arthritis tearing can exist in one-quarter to one-third of shoulders, and in other shoulders the rotator cuff may be markedly thinned. In post-traumatic conditions the rotator cuff can be stretched with thinning or scarred and stiff. In osteonecrosis with its inflammatory response, the rotator cuff can be stiffened and contracted.

One should always have a suspicion of rotator cuff issues when undertaking shoulder arthroplasty, and this is heightened by active motion notably less than passive motion, by shifting of the humeral head on active or passive range of motion, by weakness on manual muscle testing in elevation, internal rotation or external rotation, or by subluxation on plain x-ray, especially when the subluxation is superior or anterior in direction. These heightened suspicions will typically lead to the performance of MRI. On preoperative MRI one wishes to ascertain the presence or absence of tearing, the location of the tearing, the tear size, and identify additional tendinopathy. The muscles are assessed for atrophy or fatty infiltration and the bones are evaluated for an asymmetrical erosion or joint subluxation.

Several studies have identified the effects of preoperative rotator cuff tearing in osteoarthritis. In one study, 42 of 514 shoulders had preoperative rotator cuff tearing, all affected the supraspinatus, and there was no effect on outcome after surgery (Edwards TB, 2002). In a second study 16 of 176 shoulders had tearing of the supraspinatus in osteoarthritis. Again the tearing was small to medium in size, and there was no effect on outcome (Norris TR, 2002). The third study including secondary osteoarthritis, tear sizes varied considerably from small to large, and clearly movement scores were better when there was an intact rotator cuff (Haines JF, 2006).

We studied 33 shoulders undergoing concomitant total shoulder arthroplasty and rotator cuff repair in osteoarthritis. The tear sizes were small in 10, medium in 14, and large in 9. The outcomes were all satisfactory in small tears, there were 3 unsatisfactory results in medium tears, and 2 unsatisfactory results in large tears. Four of the 5 unsatisfactory results were due to instability associated with rotator cuff failure.

Intraoperative Decisions

Intraoperatively, to protect the rotator cuff one should leave supporting structures intact and minimize stresses on the rotator cuff and capsule repair. The supporting structures include the coracoacromial arch. This should be left intact. If there is roughness on the undersurface of the acromion or distal clavicle this can be smoothed. The arthrotomy in the interval should be through the inferior third of the interval. If the interval is contracted, release contractures around the base of the coracoid. Maintain the strength of an intact anterior shoulder capsule - subscapularis junction when performing the arthrotomy. Retain the long head of the biceps for whatever stability it may provide (Itoi E, 2010). One step in minimizing stresses or translational forces on the glenohumeral joint is to release tight structures including scarring in the subacromial/subdeltoid bursa and tight aspects of the shoulder capsule. Removing humeral head osteophytes will effectively lengthen a shoulder capsule (Cofield RH, 1990).

A second component to minimize stresses on the rotator cuff postoperatively is to "balance" the joint. This includes placing the glenoid component in neutral position. Humeral component positioning is complex. There are different opinions about this. Some prefer an "anatomic" osteotomy. Others including myself prefer a more standard osteotomy using a guide that has intramedullary and extramedullary referencing to create more exactness in the osteotomy that is performed. Humeral head selection has become difficult. There used to be only a few sizes available. Now in many systems there are over 20 sizes available not only in different sizes but in different shapes. The size can be estimated by the size of the person, the size of the person's shoulder region, by preoperative templating, by measuring the amount of bone removed adding 2 mm of thickness for cartilage loss, and assessing the rotator cuff/capsule laxity. If using a stemmed component, after preparing the humeral canal one can measure the eccentricity of the humeral head after removing osteophytes and plan for an eccentric head be it posterior, medial, anterior, or lateral. It is important to recall that the humeral head should rest against the glenoid or "register" throughout much of the range of motion. Various humeral head sizes and shapes have

proven useful. When assessing hundreds of cases there was a bell-shaped distribution of humeral head sizes used and almost an equal number of humeral heads were standard in shape, eccentric, or off-set, that is thicker but not wider.

After preliminary selection of the humeral head, one should trial the joint construction. The humeral head should rest opposite the glenoid with slight tension on the superior aspect of the rotator cuff and capsule when the arm is at the side. Downward rotation should be available to approximately 70 degrees and external rotation to at least 35 degrees with traction placed on the subscapularis and anterior shoulder capsule to assess the ability to reattach it to the proximal humerus. The shoulder should be stable throughout a range of motion without joint subluxation, and with the arm in slight abduction there should be less than 50% humeral head translation posteriorly with gentle passive force.

If there is a pre-existing rotator cuff tear sutures can be placed more carefully with the trial humeral head removed and then after the permanent head is in place the sutures can be tied. If there is a medium or large or pre-existing supraspinatus tear that is somewhat anterior, try to avoid joining this tear with the arthrotomy, for doing so in effect creates a large to massive size rotator cuff tear (Cofield RH, 1982).

Subscapularis and anterior shoulder capsule closure should be precisely performed (Caplan JL, 2009). It is helpful to rest the arm on a stand in neutral flexion-extension, approximately 25 degrees of abduction, and 30 degrees of external rotation. Carefully close the lateral two-thirds of the rotator interval (it may be helpful to place these sutures before the permanent prosthetic humeral head is placed). Perform a strong repair of the subscapularis and anterior shoulder capsule to tendon/capsule or to bone. After closure, reexamine the range of motion and record the safe range for postoperative passive exercises.

Postoperative Care

It is important to educate the patient about being careful concerning arm support and avoiding undue arcs of movement and force, especially during the first 4 to 8 weeks after surgery. Consider using an immobilizer during the first week, both day and night, and during the first 4 to 6 weeks during the night. After the first week but during the first 4 to 6 weeks use a sling for arm support.

Develop a passive range of motion program within a safe arc to be performed by the patient and assistant (typically a relative) for the first 4 to 6 weeks, when an active range of motion program can be commenced. We performed a study assessing preoperative arcs of movement, passive movement intraoperatively and active movement more than 1 year following surgery. We learned that motion obtained at surgery is usually maintained with this type of postoperative planning. Complications concerning the rotator cuff developed in 4 of these 81 shoulders evaluated but in none of these 4 was there instability or the need for additional surgery (Boardman ND III, 2001).

Summary

To minimize postoperative rotator cuff issues develop insite relative to the preoperative condition of the rotator cuff, at surgery preserve supporting structures and minimize stresses on the joint reconstruction. Finally, carefully plan postoperative protection and the rehabilitation program.

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WILL INTRA-OPERATIVE NERVE MONITORING AVOID NERVE INJURY IN TOTAL SHOULDER ARTHROPLASTY?

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I. Introduction

A. The incidence of neurologic injury following shoulder arthroplasty has been reported to be 0.6-4.3%.[1-6]

B. Most authors report spontaneous resolution in 80-85% of cases.

C. Nerve injury is probably under-reported, is likely more common than previously reported, and may not recover as often as is thought.[7]

D. Intraoperative nerve monitoring has been used in spine surgery to prevent or decrease the incidence of nerve injuries.[8]

II. Intra-operative Nerve Monitoring—shoulder arthroplasty

A. Intra-operative neurologic compromise is much more common than the reported incidence of clinical nerve injuries.[7]

1. Monitoring in 30 patients undergoing arthroplasty using SSEP, MEP, spontaneous EMG activity.
2. 17 of 30 (56.7%) patients had at least one nerve alert (MEP <50% of baseline) throughout the procedure.
3. 7 patients left the OR with MEP < 50% of baseline. 4 of those seven (57.1%) had positive EMGs in the same distribution as had been seen intraoperatively. None had clinical nerve injuries.
4. Lessons
   a. Intraoperative nerve alerts common
   b. Alerts more common in patients with prior open surgery and ER < 10 degrees (p< .05)
   c. Threshold for alert may be too low—false positives?
   d. Post-operative EMG findings also more common than reported rate of clinical nerve injuries.
   e. No clinical nerve injuries—was it related to the nerve monitoring? Unclear.

B. Larger study

1. 134 cases in 121 patients-- One surgeon monitored all comers (JAA) and one monitored only patients with history of prior open surgery and < 10 degrees of external rotation.
2. Nerve alert threshold redefined to 80% decrease in baseline MEP
3. One or more nerve alerts occurred in 59 cases (44%)
4. 12 of 59 cases had MEP < 20% of baseline at the completion of the procedure. 6 of these cases had absent MEP in one or more nerves at closure.
5. 2 of these 12 cases had clinical motor nerve injuries. 10 of 12 with ending MEP < 20% of baseline had no clinical motor nerve injury. 4 of 6 with absent MEP in one or more muscles at closure had no clinical motor nerve injury.
6. Lessons
   a. Even with higher threshold, intraoperative nerve alerts common.
   b. Nerve alerts involving more than one nerve are likely more important than single nerves.
   c. False positives still a problem with 10 of 12 patients with sustained deficits of 80% or more of baseline MEP having no injury and 4 of 6 with completely absent MEP at closure in more than one nerve having no motor nerve injury.
   d. Clinical relevance of intraoperative nerve monitoring still unclear.

C. Intra-operative nerve stimulation

1. May be useful alone or as an adjunct to intraoperative nerve monitoring.
2. Helps to identify nerves
3. With appropriate stimulator can measure the electrical threshold for generation of an action potential. This is a known quantity and can be used to confirm nerve injury.

D. Future

1. Nerve injury in shoulder arthroplasty is a difficult problem.
   a. Likely more common than reported
   b. Does not always recover and, in my experience, often does not recover completely.
2. Attempting to decrease incidence is justified
3. Intraoperative nerve monitoring may play a role
   a. We have never had a false negative
   b. False positives must be reduced
4. Intraoperative nerve stimulation may be a useful adjunct

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PERIPROSTHETIC FRACTURES

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Etiology

Risk Factors
-Osteopenia
-Cortical thinning from osteolysis
-Excess reaming of the cortex
-Eccentric placement of the humeral component

Avoidance
-Keys to avoiding fractures

Type of periprosthetic fracture
-Intra-operative
-Post-operative

Clinical Evaluation

Radiographic Evaluation
-Plain radiographs
-Advanced imaging options

Classification
-Wright and Cofield Classification
-Type A: Fracture at the tip of the prosthesis which extends proximally
-Type B: Fracture at the tip of the prosthesis without extension
-Type C: Fracture at the tip of the prosthesis with distal extension

Treatment Planning
-Status of component fixation
-Indications for non-operative treatment
-Indications for operative intervention

Surgical Planning
-Type of exposure
-Fixation
-Post-operative management

Literature Review of Outcomes

Case Examples

PITFALLS OF THE DIFFICULT OSTEOARTHRITIC: MARKED POSTERIOR HUMERAL HEAD SUBLUXATION AND GLENOID EROSION MANAGEMENT OF THE WALCH B2 GLENOID WITH POSTERIOR SUBLUXATION OF THE HUMERAL HEAD

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1. Disclosure Statement

2. The Pitfall Is: Inability to Get it Right:
- Posterior subluxation of the humeral component
- Anterior subscapularis failure with anterior subluxation of the humeral component

3. Common Problem is Subscapularis Failure Due to Anterior Deficiency
- Decreased Function
- Pain
- Instability
- Requires Revision

4. Options to the Subscapularis
- Tenotomy
- Peel
- Osteotomy

5. Revision Options for Subscap Failure
- Primary Repair
  - Augmentation Pectoralis Major
  - With additional allograft (ST)
- Reverse Arthroplasty
  - Need to assess glenoid bone stock

6. Our Approach to Getting the Closure Right:
- "We Are looking for closure"
- Subscap tenotomy with Mason Allen Closure
- Appropriate Subscap releases

7. Closure Depends on Assessment of Contractures
- May perform a capsulectomy, especially with external rotation contracture
- Assess preoperatively with EUA??
- If no external rotation contracture, tendon and capsule together
- For IR contracture, Coronal Z-Plasty rarely used, weakens the construct
  - 1cm =20°

8. Glenoid Can be Just as Challenging (Walch B2)
- Excess Retroversion
- Biconcave Glenoid
- Significant Posterior Subluxation of the Humeral Head

9. Walch Classification (Glenoid)
- A1, A2
- B1, B2
- C
- Will show xrays and diagram of classification
- Recommend CT
  - Request 3D recon, with and without humeral head subtraction
  - No Extra $, reformatted from acquired data

10. Steps for Walch B2 Glenoid
- Less humeral retroversion
- Ream glenoid high side 30°→20° ? (10°)
- Test for Posterior Subluxation, If present consider:
  - Larger or Offset Heads with Modularity
- If Posterior Subluxation still present:
  - Suture posterior capsule- purse strings with #2 sutures
- If still present:
  - Sutures (absorbable) through the joint, posterior capsule,
  - ER brace for 3 weeks

Determination of Fit (Compromise)
- 50% posterior translation with bounce back
- IR to abdomen with no posterior subluxation
- 50% Inferior Translation
- Ability to appropriately close the subscapularis (have the appropriate humeral head height)

11. Posterior or Offest Augments
- Limited reports to date

12. Bone Grafting (Post)
- Humeral Head or Allograft?
- Paper description

13. Reverse Arthroplasty for Primary Glenohumeral OA with Walch B2 (JSES Meeting 2012)
- Retrospective Review of 27 pts
- 10 required bone graft for posterior erosion
- F/U of 54 months
- Constant Score increased from 30→76
- No evidence of radiolucent lines
- Conlusion: RSA option to solve problem of:
  - Static Posterior Instability
  - Glenoid Erosion

14. Post-Op Rehab Considerations
- If subscap is a problem-immobilize
- If subscap repair is good- mobilize
- Possible benefit with RSA- accelerated rehab (careful with ER)

15: Summary
- Multiple Pathologies to Consider (Challenging)

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HOW TO PREVENT LOOSENING IN SHOULDER ARTHROPLASTY

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How do components loosen?
Modes
1. Mechanical
2. Infection

Mechanical Causes
a. Poor fixation
b. Component malposition
c. Asymmetric Loads
d. Patient demands/Excessive Loads

Prevention starts with preoperative planning
Preop CT for all shoulder arthroplasties
Evaluate for:
1. Poor bone quality
2. Glenoid deficiency
3. Version (both humeral and glenoid)

a. Technical Pearls of good fixation
Anatomic Total Shoulder Arthroplasty
Humerus
Prefer cementless
Must ensure secure fixation
- Perceive metaphyseal impaction as impacting component
- Once component impacted place distraction and rotational force on component to ensure stability

If poor bone quality consider:
1. Adding metaphyseal autograft from humeral head osteotomy
2. Upsize component to obtain diaphyseal fit

If unable to obtain secure cementless fixation, then cement component.

Glenoid
Ensure concentric Reaming
- Apply concentric and eccentric load on trial implant after reaming to ensure stability with no rocking

Adequate glenoid coverage of implant (min 80%)
Do not violate subchondral plate

Reverse Shoulder Arthroplasty
Glenoid
Ream to cancellous bleeding bone
Obtain good bone for central screw/peg
- Use alternate center line

Prevent notching
- Increase varus neck shaft angle
- Slight inferior baseplate tilt
- Inferior placement of baseplate

b. Proper Component Positioning
Glenoid
Match native version
Center component in glenoid bone

Humerus
30 degrees retroversion
Do not overstuff head

c. Patient Demands/Excessive Loads
Patient selection

d. Prevent Asymmetric Loading
Soft tissue balancing
Complete capsulectomy

Examples:
Anatomic Total Shoulder Arthroplasty
Reverse Shoulder Arthroplasty

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