An Overview on Anatomical Total Shoulder Arthroplasty

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Abstract:

Glenohumeral arthritis in young, active patients poses many treatment challenges, and significant concerns about component loosening and failure limit the available surgical options. Total Shoulder Arthroplasty (TSA) in young, active patients provides reliable improvements in range of motion and pain.

Keywords: Anatomical Total Shoulder Arthroplasty, Glenohumeral arthritis, TSA.

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Introduction

The rate of shoulder arthroplasty has increased over the last decade and is predicted to continue to rise. Anatomic shoulder arthroplasty results improved pain and functional outcomes. Anatomic shoulder arthroplasty is indicated for patients with an arthritic shoulder experiencing shoulder pain and decreased range of motion that compromises activities of daily living. The most common indication for anatomic shoulder arthroplasty is primary glenohumeral osteoarthritis. **(1,2)**

Other indications include post-traumatic arthritis, rheumatoid arthritis, osteonecrosis, and arthritis due to shoulder instability or prior shoulder instability surgery. Contraindications for anatomic shoulder arthroplasty include an irreparable rotator cuff repair or rotator cuff tear arthropathy and insufficient glenoid bone stock to support a glenoid component. In these patients, other options such as hemiarthroplasty or reverse shoulder arthroplasty can be considered. **(3)**

In a total shoulder, the arthritic surface of the ball is replaced with a metal ball with a stem that is press fit in the inside of the arm bone (humerus) and the socket is resurfaced with a high-density polyethylene component. **(4-6)**

After a general or regional anesthesia, this procedure is performed through an incision between the deltoid and the pectoralis major muscles on the front of the shoulder. It includes release of adhesions and contractures and removal of bone spurs that may block range of motion. **(7-9)**

Goldberg et al (2001) The magnitude and durability of functional improvement after total shoulder arthroplasty for degenerative joint disease), cement the humeral component and others use implants that foster bone ingrowth, they find that these approaches stiffen the bone making it more likely to fracture in a fall on one hand and greatly complicating any revision surgery that may become necessary in the future on the other. **(10)**

Boorman et al. A Conservative Broaching and Impaction Grafting Technique for Humeral Component Placement and Fixation in Shoulder Arthroplasty), prefer to fix the component by impaction grafting the inside of the humerus (using bone harvested from the humeral head that has been removed) until a tight press fit of the implant is achieved. The bone of the glenoid is precisely shaped with a glenoid reamer and then the glenoid component is secured with a combination of press fitting and cementing. **(11,12)**

Early motion after a total shoulder replacement is critical for achieving optimal shoulder function. This procedure is less likely to be successful in individuals with depression, obesity, diabetes, Parkinson's disease, multiple previous shoulder surgeries, shoulder joint infections, rotator cuff deficiency and severely altered shoulder anatomy. Success requires technical excellence of the surgery and participation by the patient in a simple exercise program until the desired range of motion can be achieved comfortably. **(13,14)**

Indications of anatomical total shoulder Arthroplasty

1. **Glenohumeral osteoarthrosis**

primary osteoarthrosis of the shoulder is less common compared with arthrosis of other joints but is no less amenable to treatment by prosthetic replacement than other joints. The presence of symptomatic osteoarthrosis in a well-motivated patient is a clear indication for total shoulder replacement, which in this situation can be expected to give excellent results. Secondary osteoarthrosis of the shoulder as a result of previous trauma or after previous surgery is a good indication for functional replacement. The end result does depend on the condition of the soft tissues around the shoulder and the ability to reconstruct them at the time of surgery. **(15)**

2. **Glenohumeral rheumatoid arthritis**

In rheumatoid arthritis the primary indication for shoulder replacement is pain. In the presence of reasonable soft tissue cover, and less than total destruction of the humeral head, and in the presence of reasonable bone stock, one can expect moderate functional return after total shoulder replacement. **(16)**

3. **Avascular necrosis of the humeral head**

Avascular necrosis affecting the humeral head usually results from the long-term use of steroids or from radiotherapy for treatment of malignancies e.g., breast cancer. It may also result from trauma, particularly a fracture of the anatomical neck, with or without associated fractures of the surgical neck and tuberosities. In these circumstances, if the glenoid is well preserved, as indeed it often is, a hemiarthroplasty can be expected to give good results in the well-motivated patient, and return the shoulder to a near normal condition. **(17)**

4. **Trauma**

Primary replacement in traumatic circumstances can be expected to give excellent functional results if the patient is reasonably mentally competent, accepts the procedure and is prepared to consider the postoperative rehabilitation

program. **(18)**

The preferred indications for replacement following acute proximal humeral fractures.

Four-part fractures and fracture dislocations.

a. Three-part fractures and fracture dislocations in elderly patients with osteoporotic bone.

b. Chronic anterior or posterior dislocations with impression fractures that involve more than 40% of the articular surface.

c. Head splitting fractures.

Anatomic neck fractures. **(18)**

Nonunions of fractures of the proximal humerus.

Fracture of the proximal shaft of the humerus in the presence of a stiff shoulder or of rheumatoid arthritis. It is difficult to get such fractures to unite, particularly in the elderly patient. The use of a hemiarthroplasty to achieve a mobile shoulder and early union of the fracture, using the excised humeral head as a bone graft. can achieve excellent results in these patients, and may return a patient to independence, whereas continuing disability from an ununited and stiff shoulder may well prevent such a return. **(15)**

5. Tumors of the proximal humerus

Arthroplasty reconstructions after tumor resections involve the use of an allograft in addition to a prosthesis, referred to as the composite reconstruction. The reconstructive alternative to allograft transplantation lies with the use of a custom-made prosthetic implant. **(19)**

Contraindications of total shoulder arthroplasty

1- Active infection; is absolute contraindication to a shoulder replacement with evidence of continuing infection. As in other joints, the insertion of a prosthesis into an infected site is a disaster.

2- Insufficient glenoid bone stock; if glenoid is eroded down to coracoid process, then glenoid resurfacing is contraindicated

3- Irreparable rotator cuff and rotator cuff arthropathy; if rotator cuff is deficient and proximal migration of humerus is seen on x-rays (rotator cuff arthropathy) then glenoid resurfacing is contraindicated, an isolated supraspinatus tear without retraction can proceed with TSA.

4- Deltoid dysfunction and brachial plexus injury. **(20)**

Operative Technique of anatomical total shoulder replacement

1) preoperative assessment and patient preparation

The preoperative assessment includes a thorough clinical and radiological examination. The clinical examination involves a detailed history taking, an assessment of the patient's general health, and an assessment of the shoulder. It is important to assess function in the other joints. It is or considerable importance to establish the function in the lower limbs in patients who need to use

walking aids. The use of a walking aid after shoulder replacement frequently gives rise to further pain, despite early reasonable results with respect of pain relief. Similarly, it is important to consider the other joints in the upper limb, especially the elbow. The overall function of the upper limb is a combination of shoulder, elbow, wrist and hand function, and if elbow and distal arm function is significantly impaired, then a reasonable shoulder can help in a limited way to improve things, but obviously cannot be expected to overcome some of the disabilities related to the more distal joints. As part of the preoperative work-up, the physiotherapist discusses the postoperative rehabilitation regimen with patients so that they know what is expected of them. **(21)**

All patients have an axillary shave on the day of operation, and the arm and upper chest are prepared with a topical alcoholic solution of povidone iodine. Vertical laminar flow, if available, reduces the chance of airborne infection. After induction of anesthesia, a single dose of 3 $^{rd.}$ generation cephalosporine is given by intravenous injection. This combination of clean air plus antibiotics should reduce the rate of infection dramatically. **(21)**

In case of fractures and fractures-dislocations, surgery should be as soon as the patient's general condition permits. Delay of surgery longer than 10 to 14 days results in increasing scar and contracture. And increasing osteoporosis of the bone fragments. Because of the severe pain occurring with motion, the skin cannot ideally prepare before anesthesia. To prevent skin maceration and to reduce the bacterial count, Neer recommends the placement of a pad saturated with an antiseptic solution in the axilla while awaiting surgery. A thorough 10-minute scrub and preparation of the skin is done after the patient is anesthetized. **(22)**

2) Positioning

The operation is performed with the patient in the "beach-chair" position, the head and knees being raised 30 degrees. This reduces bleeding from the shoulder and provides better access during surgery. It is essential that the patient be placed at the edge of the operating table to allow the arm to hang down freely. This will facilitate the reaming of the humerus. A small sandbag placed along the vertebral border of the ipsilateral scapula controls movement of the scapula during manipulation of the arm. **(23)**

3) Surgical exposure

The surgical exposure of the shoulder most commonly used is the extended anterior deltopectoral approach. The incision extends proximally from the acromioclavicular joint to the upper part of the arm. After the cephalic vein is identified, it is mobilized and retracted medially. Care should be taken to keep the vein intact, although if it is damaged no problems seem to arise from ligating it as Neer used to ligate it on finding it. **(24) (Fig.1)**

Deep surgical dissection and preparation of bony parts

A) In the case of non-traumatic indications:

1)**The shoulder joint is entered by:**

A) Division of the subscapularis tendon **(Fig. 2)**. This may be necessary if there is an internal rotation contracture of the subscapularis as it will allow a Z.plasty to be performed to improve the external rotation.

B) However, in those cases without a contracture, it is preferable to perform an osteotomy of the lesser tuberosity and retract it medially with its attached subscapularis tendon. This gives an excellent exposure and the reattachment seems to be very strong, allowing early mobilization, **(23)**

2) Humeral head cut

The joint is now open, and further exposure is obtained by osteotomizing the humeral head. The humeral head is exposed anteriorly by gentle external rotation and slight extension. The level of cut is a matter of judgement and it is always better to take too little rather than too much. It can be adjusted later. **(23)**

3) Mobilization of the rotator cuff

After the humeral osteotomy, the joint volume remaining for the glenoid and humeral head components is evaluated by pushing the humeral neck laterally with a finger. This step is helpful in determining the need for further soft tissue releases. If the capsule is so tight that even the smallest head will not fit, more release is required. Cutting away more humerus is not an option, because the humeral head has already been resected at the cuff insertion and further resection will jeopardize this essential attachment. **(25)**

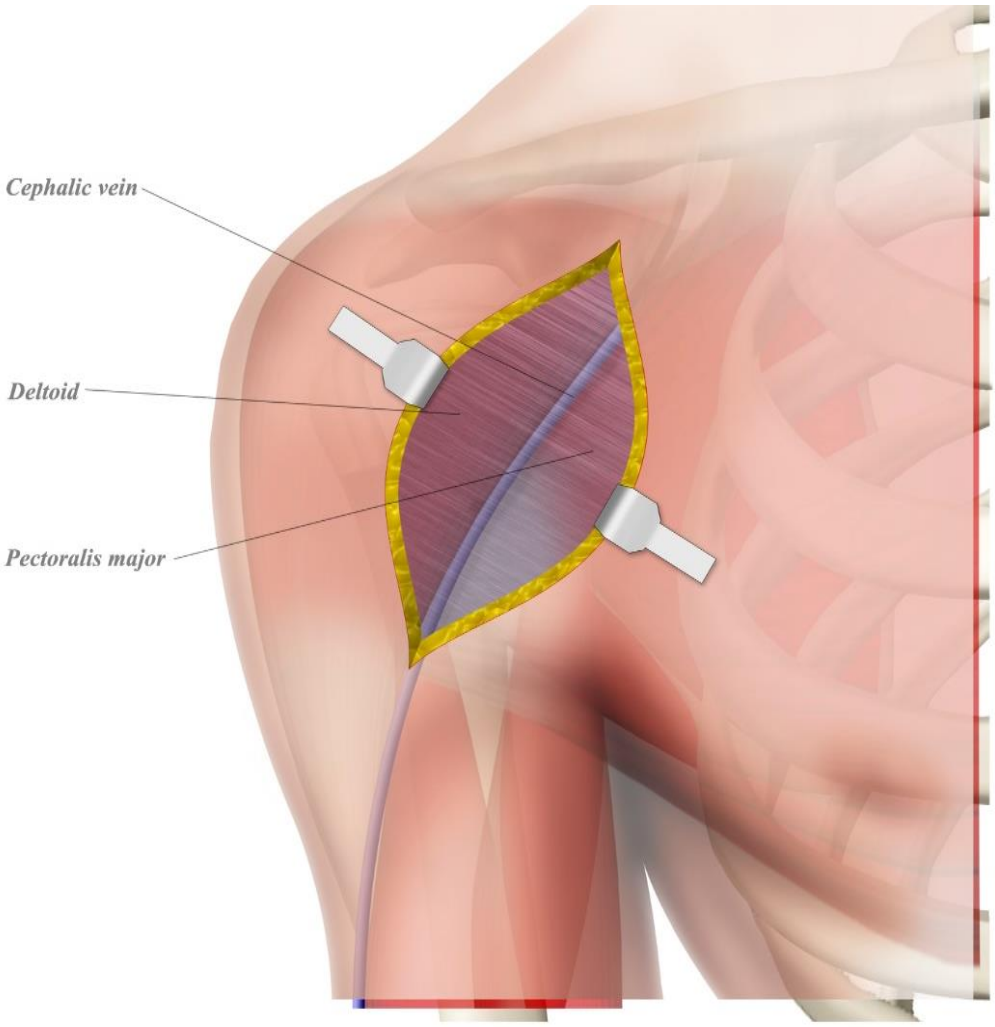

Fig (1) a) Skin Incision b) The Cephalic vein (26)

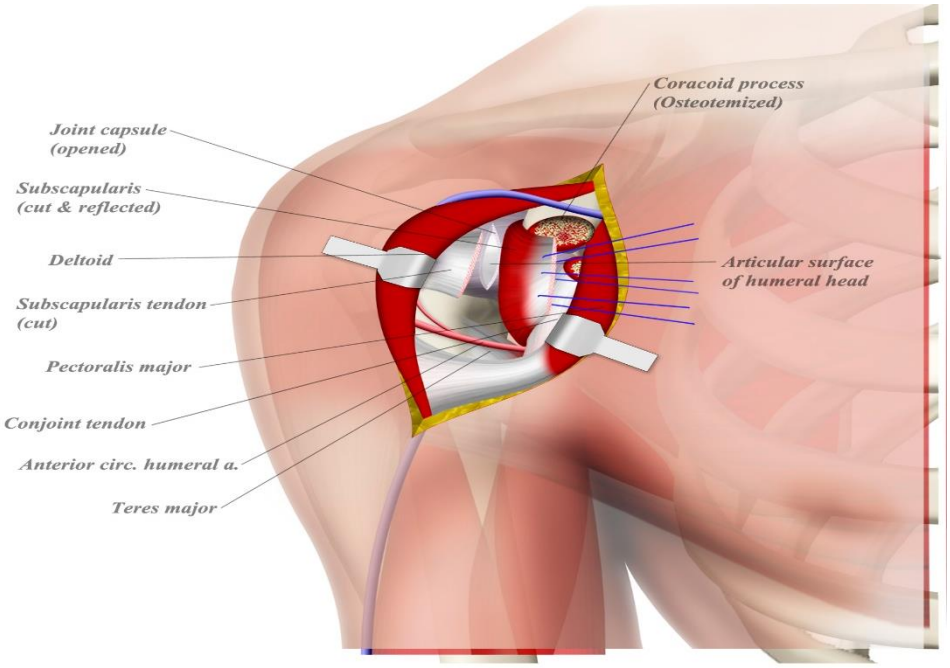

Fig (2) Division of Subscapularis (26)

4)preparation of the humerus

The shaft is reamed using the sized reamers to allow insertion of the largest breaching the humeral cortex. **(Fig .3)** The humeral head size stem is the one which best fits the anatomy of the patient and allows the best tensioning of the rotator cuff. The larger humeral head biomechanically improves the lever arm, thereby improving the efficiency of deltoid. **(26)**

5) preparation of the glenoid

preparation of the glenoid is of great importance as the glenoid loosening accounts for a large portion of the failures in prosthetic shoulder arthroplasty. It is important to have an axial radiograph of the shoulder available in the operating room at this stage as osteophytes may shift the apparent center of the glenoid anteriorly or posteriorly, leading to an incorrect placement of the glenoid component. Preoperative radiographs will also indicate whether superior glenoid erosion has taken place and if this needs to be corrected. **(27)**

In order for the glenoid component to stabilize the humeral head against transverse loads, it must be well supported by the bone beneath it. It has been demonstrated that precise contouring of the bone to fit the back of the glenoid component provides excellent support of the prosthesis. This is best done using spherical reaming **(Fig .4)** of the glenoid as it has two important advantages.

1. It normalizes glenoid version.

2. It provides bone back support of the glenoid component with the opportunity for optimal stability and load transfer without the use of metal backing. **(23)**

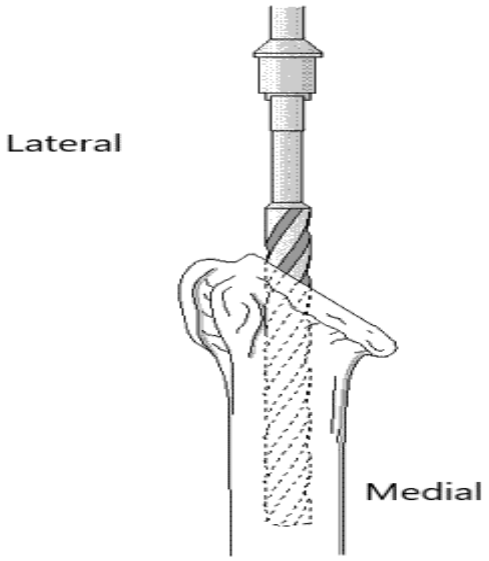

Fig (3) Reaming of the humerus. (23)

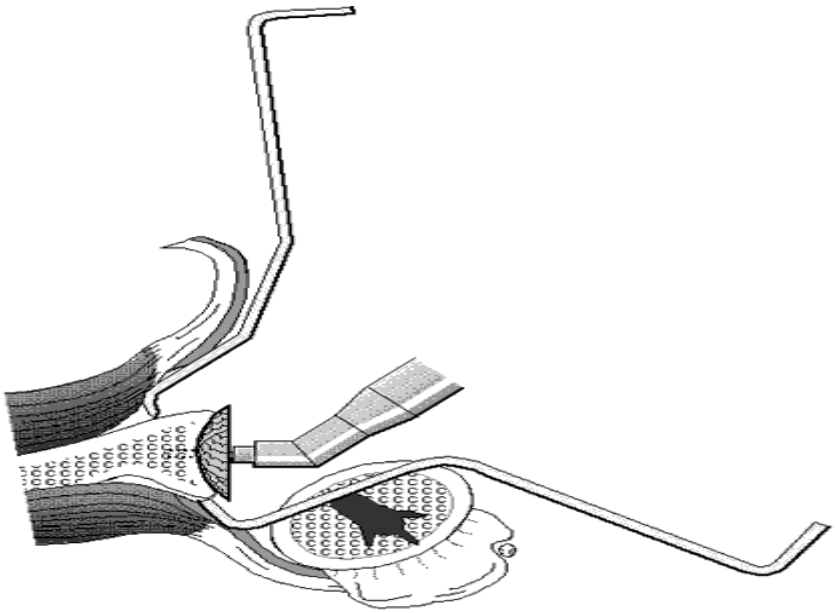

Fig (4) Spherical reaming of the glenoid. (23)

A simple cadaver study demonstrated a practical method for normalizing the glenoid orientation. The center of the race of the glenoid was located in each of 10 normal cadaveric scapulae. A drill was then inserted perpendicular to the surface, starting at the glenoid center. In each case, the drill emerged from the anterior glenoid neck at the lateral aspect of the subscapularis fossa at a point midway between the upper and lateral borders or the scapula. This spot is known as the "centering point." This point is easily palpated at arthroplasty surgery after an anterior capsular release has been performed. The line connecting it to the center of the glenoid face is the normalized glenoid center line. Orienting the prosthetic glenoid to this normalized glenoid center line. enables the

surgeon to correct pathologic glenoid version, which is frequently encountered in degenerative joint disease and other conditions that require shoulder arthroplasty. **(28)**

If the glenoid is to be cemented and whether a pegged or keeled prosthesis is selected, the peg/keel holes are thoroughly washed and dried, and a small amount of cement is placed in each hole. Excessive cement might extrude out of the holes and lie between the prosthesis and the glenoid bone. This has two undesirable effects:

l. Creation of an uneven seat for the prosthesis.

2. The thin segments of cement between the glenoid and the prosthesis may fragment and become loose in the joint, damaging the polyethylene. **(23)**

B) In the case of fractures and fracture dislocations

In the case of fracture or fracture-dislocation the division of the subscapularis is unnecessary. The key to the approach is the long biceps tendon, which when intact should be followed to the inside of the joint. Usually, the greater tuberosity is found lateral to it while the lesser tuberosity is found medial to it. with varying degrees of retraction according to the time interval between trauma and surgical intervention. head might be displaced in various positions according to the initial trauma. There might be variable loss of substance from the proximal humerus as a result of the trauma, which necessitates extreme care during adjustment of prosthetic height. **(29)**

Closure

The rotator interval is closed with interrupted absorbable sutures. If previously detached. as might be in fracture cases, the long head of the biceps tendon is sutured over this repaired rotator cuff interval or transplanted into the bicipital groove. If the anterior deltoid has been detached, it is carefully reattached to the distal end of the clavicle, the anterior aspect of the acromioclavicular joint. and the anterior aspect of the acromion. The deltoid and pectoralis major muscles are approximated over a suction drain. The skin is closed using a continuous subcuticular suture, either absorbable or 2/0 Proline suture removed at 10 days. **(30)**

After-treatment

The arm is placed in a broad arm-sling until removal of the drain at 48 hours. Under supervision gentle passive exercises consisting mainly of forward flexion and external rotation are begun. Pendulum-type exercises are permitted at about 10 days, and gentle passive and active assisted exercises progress according to the patient's pain tolerance. The functional recovery reported by Neer following prosthetic replacement is superior. To a great degree this is attributed to his systematized postoperative physical therapy regimen. **(31)**

Important technical considerations

Prosthetic shoulder arthroplasty provides the surgeon with the opportunity to restore the biomechanics or the shoulder joint, namely; **motion, strength, stability, and smoothness.**

Motion is re-established by:

1. Releasing all adhesions and contractures at the glenohumeral motion interface.

2. Inserting a smooth humeral prosthesis whose articular surface area represents a large portion of the sphere.
3. Inserting a smooth glenoid prosthesis whose articular surface area represents a small portion of the sphere.
4. Removal of blocking osteophytes.
5. Avoiding overstuffing of the joint.

Strength and stability are achieved by:

1- Normalizing glenoid and humeral joint surface location and orientation so that full surface contact occurs throughout the useful range of motion, thereby minimizing joint pressure and maximal stability.

2- Selecting and positioning the new glenoid joint surface so as to balance the range of net humeral joint reaction forces usually encountered.

3- Re-establishing normal compressive muscle force, by releasing, repairing, balancing, and rehabilitating cuff muscles. The **Deltoid** is the most important muscle in prosthetic shoulder arthroplasty, and the integrity of its origin, insertion and nerve supply must be guarded at all times. Rehabilitation of the deltoid is of crucial importance to prosthetic shoulder arthroplasty. **(31)**

The rotator cuff mechanism is at risk during prosthetic shoulder arthroplasty for various reasons. The suprascapular nerve is at risk during surgical releases as it courses medial to the coracoid and down the back of the glenoid 1cm medial to the glenoid lip. Also, the cuff tendons are at risk during surgery because the humeral cut must come close to their insertion to the tuberosities superiorly and inferiorly. A humeral cut made in excessive retroversion is likely to detach the cuff posteriorly, and a cut made too low on the humerus is likely to detach the cuff superiorly. Also overstuffing the joint places, the cuff under tension when the arm is adducted or rotated. In addition, most of prosthetic shoulder arthroplasties are performed to older people in whom the quality of the cuff may be compromised. If a cuff defect exists at the time of prosthetic shoulder arthroplasty, a cuff repair to bone should be carried out. provided the quantity and quality of cuff tissue are sufficient to allow a secure repair under physiologic tension with the arm at the side. If these conditions are not met, a cuff repair may not be worthwhile, especially that when a cuff repair is performed, the rehabilitation for prosthetic shoulder arthroplasty must be changed dramatically to allow for secure reattachment of the cuff mechanism before active use is allowed. In these conditions a humeral head replacement is considered in place of total shoulder arthroplasty. **(32)**

Ensuring that capsular ligaments are neither too tight (in which case obligate translation may occur at the limits of motion), nor too loose (in which case the joint may over-rotate beyond the positions in which the muscles can stabilize the head in the socket). **(32)**

Smoothness is provided by:

1. Inserting smooth prosthetic joint surfaces.
2. Managing all glenohumeral motion interface roughness.

Implementing immediate postoperative motion as it not only prevents unwanted scar formation, but may also increase the strength of soft tissue repairs.**(32)**

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