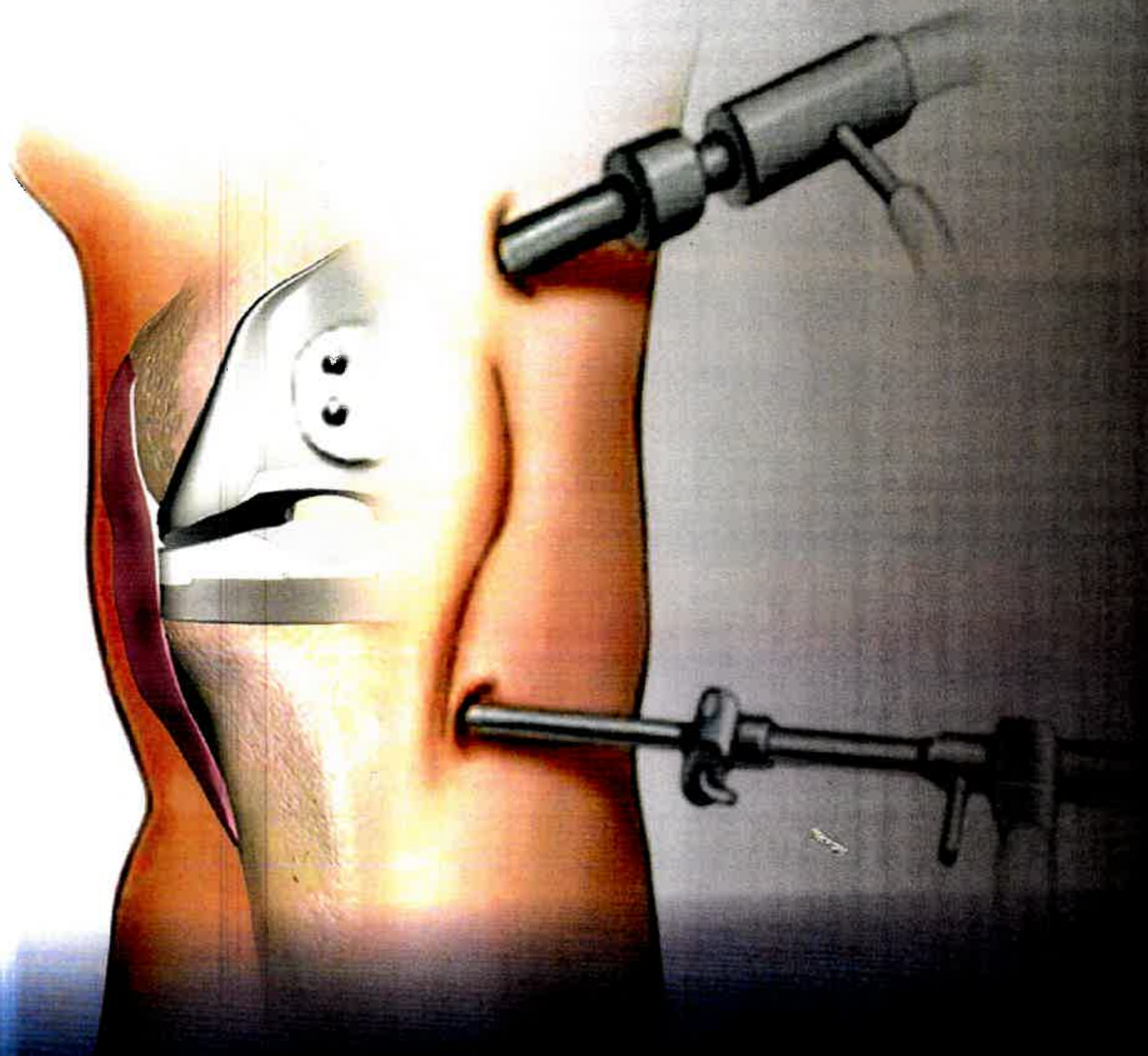
Conceptual Orthopedics
The Learning Never Ends



Arthroscopy & Arthroplasty for Postgraduates

Adolescent to Geriatric Joint Care
Diagnosis to Treatment

Authored By The Faculty of Conceptual Orthopedics

Arthroscopy & Arthroplasty for Postgraduates

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Diagnosis to Treatment

First Edition

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The Learning Never Ends

AUTHORS AND THEIR DEDICATIONS

Prof. Dr. SM Tuli

Dedicated to my parents Shanti Tuli and Ram Lal Tuli, my Parents; my teachersProf. K.S Grewal, Prof P. K Duraiswamiand Prof. Balu Sankaran my teachers; and large number of my stimulating students, and my ungrudging patients, who provided me the opportunities to study and enjoy the science and art of Medicine.

Prof. Dr. Sudhir Kumar

Dedicated to my students and patients.

Prof. Dr. Anil Dhal

Dedicated to 'The art of clinical examination from the masters of yesterday to the torchbearers of tomorrow.' The lines on coverpage "Adolescent to Geriatric Joint Care Diagnosis to Treatment" are thoughtfully written by Prof. Dr. Anil Dhal.

Prof. Dr. Shantharam Shetty

I dedicated this work to thousands of my patients, my teachers and my students who have made it possible for me to be what I am today.

Prof. Dr. VB Bhasin

This book is dedicated to all who want to master Orthopedics.

Prof. Dr. Gopa Kumar

I dedicate my work in conceptul orthopedics to my wife and children

Dr. Ravinder Dimri

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Dr. Shekhar agarwal

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Dr. Ajith Kumar

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Dr. Mrinal Sharma

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Dr. Anuj Jain

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Dr. Zeeshan Muzahid T

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Dr. Rohit Prasad

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Dr. Amite Pankaj Agarwal

I dedicate my work to my patients.

Dr. Apurv Mehra

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Section 1

Arthroplasty
Part – 1 - Shoulder

1.1.1 Chapter

Hemiarthroplasty Shoulder

- Proximal Humeral Fracture: 5-6%
- Bimodal: Young males: High Energy Trauma
- Old Females: Low Energy Trauma
- Young People: Generally head is preserved
- Old People: Generally old people with 3-4 part fracture are treated with hemiarthroplasty
- 3–4 part fracture in old people:
  - With potential of tuberosities to heal→ hemiarthroplasty
  - Without potential of tuberosities to not heal → Reverse shoulder arthroplasty
- 1955: Near → Described hemiarthroplasty for shoulder.

Several factors led to diminished use of hemiarthroplasty

1. Usage of locking (philos) plate (proper fixation).
2. Proper understanding of humeral head.

Indications

- Displaced fractures in which adequate fixation of fractures is not possible:
  - Head split fractures
  - 3, 4 part fractures
  - Fracture dislocation

Surgical Technique

Under GA
↓
Beach chair position
↓
Deltopectoral approach
↓
Removal of hematoma and adhesion
↓
Identify the bicipital grovel
↓
Identify tuberosities
↓
Tag them with sutures (different colour is preferable)
↓
Humeral head removed
↓
Canal identified and reaming done
↓
Head size: Humeral head represents portion of sphere
↓
Head should be match with prosthesis in height, radius, width
↓
If head size falls between two sizes smaller one should be used
↓
If large head is used increased tension will be there between tuberosities
↓
Which may lead to nonuion

Head Height

- Biglani and Flatow
- Jigsaw method: The native head is reduced on the shaft to create an intraoperative template
- Warner et al Distance between top of head and upper border of pectoralis major is 5-6 cm

Version: Version can vary between 0-50 degree

But normally acceptable version is retroversion of 20–30 degree
↓
Two drill holes are made 1.5cms below neck to lie tuberosities to shaft and 2 non absorbable sutures kept passed through these nodes
↓
Now prosthesis is fixed with cement

↓

The Tuberosities are Fixed Back

(a) With SS wire
(b) With suture
(c) Or both

↓

Encirclage wire can be used to keep fragments together.

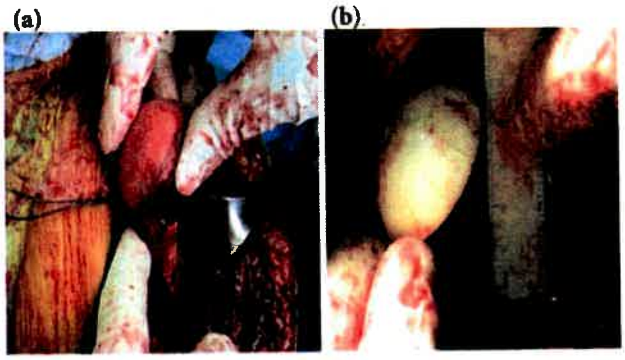


Fig. 1.1.1.1: (a) The native head is reduced to the neck in an anatomic position . (b) A trial prosthesis is placed in position to recreate the native head-neck alignment.

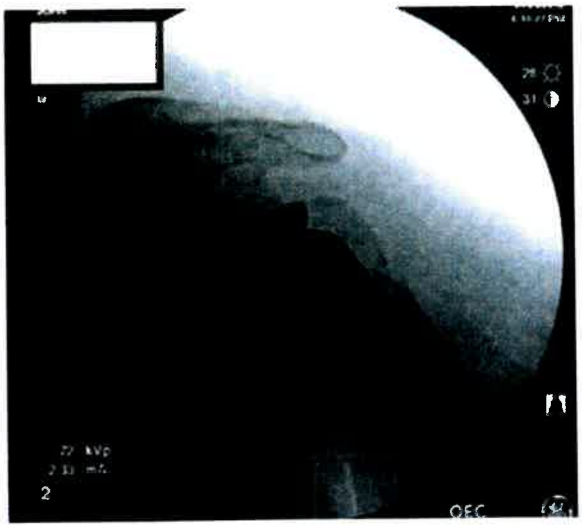


Fig. 1.1.1.2: Intraoperative image confirming that the reconstruction has adequately recreated the native alignment.

- Another indication of shoulder hemiarthroplasty is humeral head AVN with no activity or glenohumeral arthrities with preserved glenoid.
- Even in fractures, reverse shoulder arthroplasty has shown better results than hemiarthroplasty and is being prefered to hemiarthroplasty except in young patients.

1.1.2
Chapter

Total Shoulder Repalcement

TOTAL SHOULDER ARTHROPLASTY

Fig. 1.1.2.1:

Anatomy of Glenohumeral Joint

- Ball socket type of synovial joint.
- Glenoid- very shallow,pear shaped, AP dimension superior<AP inferior.
- Head of humerus very large.
- Increase movements in all axis makes joint highly unstable.

To Provide Stability

Static stabilizers	*Dynamic stabilizer*
Labrum- increase depth upto 50%	Rotator cuff muscles-works on contraction compression model of stability
Glenohumeral ligaments(S-GHL, MGHL &IGHL)	Long head of biceps
Negative intraarticular pressure	

Biomechanics

- Head shaft angle(130 to150 degree)
- Humeral retroversion (30 to 40 degree)
- Glenoid version-2 degree anteversion to 7 degree retroversion.
- Humeral head offset : 7mm medial offset and 3mm posterior offset
- Head is 1cm superior to GT tip
- Lateral humeral offset(5 to 7 cm)- increase offset leads to overstuffing of deltoid muscles and decrease offset leads to decrease tension of deltoid and cuff. If these are altered after TSA than increase risk of glenoid wear
- Scapular plane- 30 degree anteverted to coronal plane of body.

Classification of Shoulder Arthritis

Classification

	Walch Classification of Glenoid Wear
Type A	• Concentric wear, no subluxation of HH, well centered • A1: no or minor central erosion • A2: deeper central erosion, line connects anterior/posterior glenoid rims and transects humeral head (HH)
Type B	• Biconcave glenoid, asymmetric glenoid wear and head subluxated posteriorly • B0: pre-osteoarthritic posterior subluxation of HH • B1: posterior joint narrowing (no posterior bone loss), osteophytes, subchondral sclerosis • B2: posterior rim erosion, retroverted glenoid • B3: mono-concave, posterior wear, at least HH subluxation >70% OR retroversion >15%
Type C	• C1: Glenoid retroversion >25 degrees, regardless of erosion • C2: Biconcave, posterior bone loss, posterior translation of HH
Type D	Glenoid anteversion or anterior HH subluxation (HH subluxation <40%)

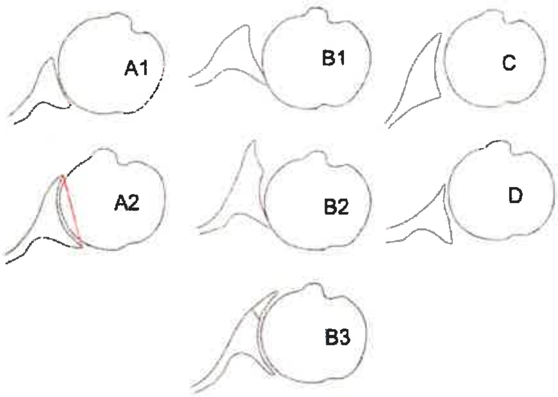


Fig. 1.1.2.2:

Indication of TSA

Shoulder pain and inability to perform activities of daily living because of:

- Primary Osteoarthritis
- Osteonecrosis
- Rheumatoid arthritis
- Post-traumatic arthritis
- Proximal humerus fracture
- Post capsulorapphy arthropathy(loose bodies).

Contraindications of TSA

- Non- functional/ irreparable rotator cuff
- Infection (active or Recent)
- Nerve injury- Brachial plexus, Axillary nerve
- Insufficient Glenoid bone stock (Type B2, B3 or C glenoid –Reverse shoulder arthroplasty is preferred in these situations along with bone grafting)

Investigations and Work Up

X-rays

- True AP and axillary view:
  - To look for extent of arthritis and to look for posterior glenoid wear.
  - Also to rule out superior humeral migration (which will indicate a chronic cuff tear – where Reverse Shoulder Arthroplasty may be preferred),

Role of CT

- To look the glenoid bone stock and version
- Loose bodies
- Non-union or malunion.

Role of MRI

To look status of cuff (especially in Rheumatoid Arthritis)

Surgical Steps

- Deltopectoral approach-incision
- Subscapularis tagged and release (2cm from insertion or using LT osteotomy)
- Dislocation of joint – in adduction and extension
- Osteotomy of head- inclination (45°) &Version (30° retro)
- Entry point for zig- just posterior to bicipital groove, 1cm medial to GT tip.
- Glenoid preparations.
- Glenoid Varieties (most of the glenoid options are cemented)
- All poly: Peg version better than keeled
- Metal backed- risk of loosening
- Hybrid

For Posterior Glenoid Wear Options Are:

1. Ream excess anterior glenoid
2. Bone graft posterior aspect

For Excessive Medial Glenoid Wear Options Are:

1. Use hemiarthroplasty
2. Soft tissue interposition arthroplasty-Fascia lata
3. Ream and run arthroplasty

Humeral Prosthesis Insertion

Humeral component may be inserted as cemented or press fit

If posterior subluxation still present after reduction trial *Option are-:*

1. Use large humeral head.
2. Reduce the retroversion of humerus- difficult.
3. Tighten the posterior capsule.
4. Immobilize in external rotation or delay ROM exercise.

Outcomes and Results

- Good and predictable pain relief (better than hemiarthroplasty)
- Reliable range of motion
- Almost 93 %survival at 10 years
- Results have been worse for post-capsulorrhaphy arthropathy

Complications of TSA

- Loosening of glenoid component - Most common "Rocking Horse effect"
- Posterior subluxation/ gleno-humeral Instability
- Anterior dislocation- due to subscapularis rupture- (treatment – Repair/ Revise to Reverse shoulder arthroplasty)
- Periprosthetic # Most common intraop# humerus shaft
- Infection
- Rotator cuff tear
- Deltoid muscle dysfunction
- Stiffness
- Heterotopic ossification
- Implant failure including dissociation of modular prosthesis.

1.1.3 Chapter

Reverse Shoulder Arthroplasty

- Historically, Cuff tear arthropathy (CTA) has been a difficult clinical condition to treat.
- Conventional total shoulder arthroplasty and hemiarthroplasty had very limited success in the treatment of this conidition.
- Grammont introduced his reverse shoulder arthroplasty (RSA) in 1987 and FDA gave its approval for use of RSA for cuff tear arthropathy in 2003.
- Since then RSA has had great success in the treatment of CTA and indications for use of RSA have expanded to include several conditions and situations that were difficult to treat with anatomical shoulder arthroplasty, such as acute proximal humerus fracture, chronic locked dislocation, chronic pseudoparalysis caused by irreparable rotator cuff without arthritis, glenohumeral arthritis with severe glenoid bone loss, immunological arthritis with or without associated rotator cuff tears, malunited/nonunited proximal humerus fracture, failed shoulder arthroplasty and tumours.
- However, with major complication rates as high as 26%, limited implant longevity, and a lack of long-term functional outcome data, concerns have continued about its widespread use.

BIOMECHANICS AND RATIONALE BEHIND THE USE OF RSA

- The revolutionary Grammont reverse prosthesis was based on four key principles that altered the biomechanics of the prosthesis to mitigate shortcomings of its predecessors in the cuff-deficient shoulder. These principles included

1. medialization of the center of rotation,
2. re-tensioning of the deltoid by distalizing the humerus,
3. a constant center of rotation leading to an inherently stable implant, and
4. a semi-constrained prosthesis with a larger arc of motion

Medialization of the Centre of Rotation

- With the center of rotation (COR) medialized compared with an anatomic shoulder, but lateralized to or flush with the glenoid, the RTSA confers stability at the bone-implant interface. Movements around the fixed COR convert the compressive and shear forces into a largely compressive vector.
- In a native shoulder, at 90° of abduction there is a 90% body weight joint reactive force, and up to 42% body weight(BW) shearing force is seen at 60° abduction. *Peak forces are reduced in both compression and shear across the shoulder joint throughout ROM in reverse total shoulders. In one cadaveric study, it was suggested that that glenohumeral joint force in abduction decreases by 41.5% BW. In a shoulder lacking the compressive force of the cuff, minimization of the ratio of shear to compressive forces at the joint leads to an inherently stable prosthesis.*

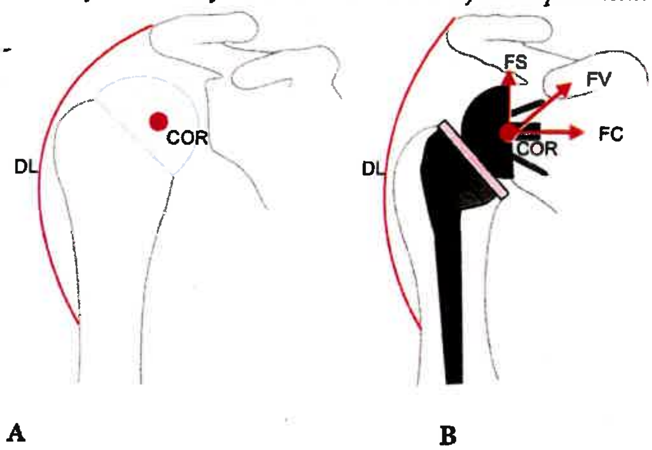
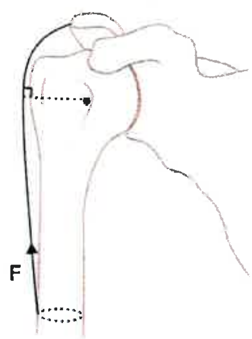


Fig 1.1.3.1: (A) The natural center of rotation (COR) and deltoid lever arm (DL) in a native shoulder. (B) Reverse total shoulder arthroplasty implants medialize and distalize the center of rotation, which minimizes shear forces (FS), and increases compressive forces (FC), to create an overall favorable force vector (FV) at the bone-glenoid interface, as well as re-tensions the deltoid to provide a mechanical advantage.

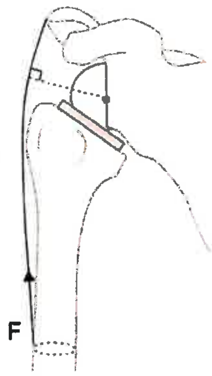
Re-Tensioning of the Deltoid

- Medialization of CoR leads to increased lever arm of deltoid leading to increased efficiency/power of deltoid in abducting/overhead elevation of arm. The lever arm of the deltoid muscle is almost doubled with an inverse prosthesis; thus, the efficacy of the deltoid for abduction is also approximately doubled.

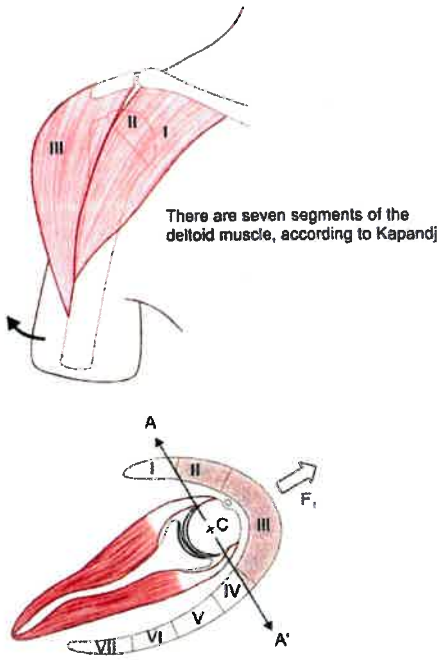
- RSA also distalises the deltoid insertion thus increasing its length and thus its tension and efficiency. Distalization of the center of rotation is necessary to provide space for unrestricted ROM of the proximal humerus.
- In their original experiments, Grammont et al noted that an abduction angle of 60° and medialization of the center of rotation by 10 mm increased the deltoid moment by 20% and that distalization of the center of rotation by 10 mm increased the efficacy of the deltoid by another 30%.
- The fibres that are medial to the center of rotation in a normal shoulder come to lie lateral to the center of rotation and thereby become abductors and/or elevators. Thus, it is presumed that the longer lever arm resulting from the reverse prosthesis allows the recruitment of more deltoid fibers for elevation and abduction. The orientation of the muscle fibers becomes more vertical, and muscle recruitment changes such that all three sub-regions of the deltoid become primary shoulder abductors.



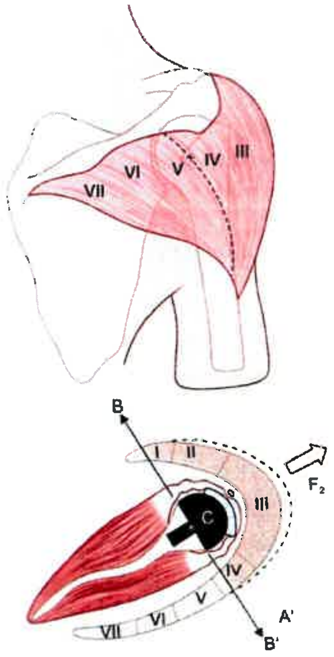
Centre of rotation (.) and deltoid lever arm (DL) in normal shoulder



Medialised COR and increased DL and increased in RSA



In a normal shoulder, only the middle deltoid segment (III) and part of the anterior deltoid segment (II) can participate in active elevation



After implantation of a reverse prosthesis, the medialization of the center of rotation recruits more of the deltoid fibers (segments I and IV) for active elevation

- These changes in muscle recruitment for abduction are not without cost. As centre of rotation is medialised and the posterior deltoid is recruited to become an abductor, its external rotation moment arm is lost, contributing to the common external rotation deficit seen following a reverse shoulder arthroplasty, i.e., the anterior and posterior deltoid fibers loose their external and internal rotator moment.

An Inherently Stable Shoulder

- The minimization of shear forces conferred by a constant, medial COR leads to an inherently stable prosthesis.
- RTSA components have no mismatch. The radii of curvature of the humerus and the glenoid are identical, imposing concentric motion. The convex component is smaller than that used in TSA (usually of a diameter of between 36 and 42 mm) and has a substantially shorter radius of curvature. The concave component is larger and deeper than in TSA. The angle that the total joint force vector can subtend without risk of dislocation with the center line is thereby increased to ≥45°. With a head-neck-shaft angle of 155° for the concave component, *an isolated contraction of the deltoid does not superiorly dislocate the joint but induces rotation about the medialized, fixed center of rotation, thereby converting superior subluxation of the humerus into glenohumeral elevation or abduction.* Furthermore, the radius of curvature in the glenoid and humeral components are congruent in an RTSA, allowing it to tolerate a greater joint reaction force vector up to 45°. *RTSA stability has been found to be two to three times higher than an anatomic TSA, and up to five times more stable than a native shoulder joint at 90° abduction.* Furthermore, likely due to the larger muscle forces acting throughout abduction, increasing angles of abduction confer greater forces required to dislocate the RTSA.
- The intrinsic stability of the two prosthetic components depends on the ratio between their depth and diameter. Larger components are not automatically more stable. Rather, they provide more stability only if the ratio between the central depth and the diameter of the concave component is higher than in smaller components.

Semi-Constrained Prosthesis

- A semi-constrained prosthesis is achieved by utilizing a relatively larger glenosphere relative to the humeral cup component.
- The Grammont RTSA offered a semi-constrained design, with a smaller humeral cup to provide larger ROM prior to impingement. Modern RTSA implants have strove to balance the amount of constraint—with a humeral component deep enough to allow inherent stability in a cuff-deficient shoulder, but shallow enough to minimize impingement and shear forces generated in extremes of motion.

INDICATIONS AND CONTRAINDICATIONS

Indications

1. Cuff tear arthropathy
2. Irreparable cuff tear causing pseudoparalysis without arthritis in elderly
3. Communited proximal humerus fractures in elderly
4. Malunited /non-united proximal humerus fractures
5. Gleno-humeral arthritis with glenoid bone erosion
6. Chronic locked glenohumeral dislocation
7. Rheumatoid arthritis with or without cuff tear
8. Revision arthroplasty
9. Tumours

Contraindications

1. Non functioning deltoid muscle
2. Axillary nerve damage
3. Glenoid vault deficiency precluding baseplate fixation,
4. Infection and
5. neuropathic joints,
6. Severe osteopenia, such as in the patient with long-standing, steroid-dependent rheumatoid arthritis, is a relative contraindication.

Patients undergoing RTSA should be aware of its high rate of intra-operative and post-operative complications. The patient must be informed that the complication rate of RTSA is approximately three times that of conventional SA. There is also concern about clinical deterioration at approximately ten years after implantation of the Grammont-type prostheses.

SURGICAL TECHNIQUE

- RTSA is performed via a deltopectoral or a superolateral approach. Both the approaches have significant advantages and disadvantages.
- A superolateral approach is better than a deltopectoral approach in terms of postoperative instability and in terms of preventing fractures of the scapular spine and the acromion. A deltopectoral approach affords better preservation of active external rotation as well as better orientation of the glenoid component, glenoid loosening, and inferior scapular notching. The approach must be selected according to surgeon experience and patient-specific factors. Revision surgery appears to be more frequently and easily performed through a deltopectoral approach, but when instability is a major concern, a superolateral approach may be preferable. A superolateral approach is used when the subscapularis is intact and preservation of active internal rotation is a high priority, such as in patients with only one

functioning arm. The deltopectoral approach facilitates glenoid exposure, identification and protection of the axillary nerve, and access to the humeral shaft in prosthetic revisions.

- The subscapularis is tenotomized close to the musculotendinous junction or a lesser tuberosity osteotomy is performed. And at the end of the procedure the subscapularis is repaired back. In addition, it is hoped that subscapularis repair decreases the rate of instability by creating an anterior envelope.
- The humeral head is resected, respecting the greater and lesser tuberosity, and the tendon of the long head of the biceps is tenotomized.
- The glenoid is exposed, the labrum is excised, and the capsule is released circumferentially.
- Inferiorly, the tendon of the long head of the triceps is released under protection of the axillary nerve.
- The exact positioning and orientation of the guidewire for the reamer are crucial. Preoperative planning must ascertain that reaming can be performed without creating glenoid anteversion or retroversion, or superior glenoid tilt.
- Upward tilting must be avoided to prevent glenoid component loosening. Inferior notching can be avoided by inferior positioning of the glenoid component. For this purpose, the guidewire for the glenoid reamer must be positioned so that the glenoid baseplate is as low as possible. The inferior border of the baseplate should not be proximal to the inferior glenoid rim, so that the glenoid component eventually overlaps the inferior border of the glenoid.
- Locking screws are used to provide primary stability. They are usually anchored in the lateral pillar of the scapula and in the base of the coracoid.
- An appropriate-size glenoid hemisphere (ie, glenosphere) is then mounted on the baseplate. Current results suggest that larger glenospheres are associated with less pain and better strength, but it may not be possible to use a large implant in a small individual. In larger patients with good glenoid bone stock, a larger glenosphere appears to be preferable.
- The humerus is then broached, and the humeral cup is inserted. The humerus should be inserted in neutral torsion.
- The height of the polyethylene component should be such as to lengthen the arm (ie, tip of the acromion to the elbow) by approximately 2 to 3 cm with a very snug fit after relocation.
- The implanted prosthesis is relocated by pushing the concave humeral cup downward rather than by pulling on the arm. Seating of the prosthesis is easiest in approximately neutral rotation and slight anterior elevation.
- Stability is tested with the arm in abduction and internal rotation. This is the position that patients use to get out of bed or out of a chair, and it represents the most frequent position of anterior dislocation.
- When anterior dislocation occurs with the arm in abduction and internal rotation, the antetorsion of the humerus must be increased, and the surgeon has to ascertain that the glenoid component was not implanted with anteversion.
- Following readaptation of the subscapularis, one or two suction drains are inserted. The design of the RTSA provides a large, empty subacromial space; in early series, hematoma formation has been the most frequently reported complication. Draining for 24 to 48 hours has solved this problem.
- A sling is used postoperatively, and the arm may be used for activities such as brushing teeth or eating. Sling use is discontinued after 4-6 weeks

RESULTS AFTER RSA

Rotator cuff tear arthropathy

- Rotator cuff tear arthropathy is one of the most reliable indications for RTSA.
- Cuff tear arthropathy remains the only FDA-approved indication for RTSA
- Studies have reported an implant survivorship rate of 89-95% at ten years with significant improvements in pain relief and improved elevation and high rate of patient satisfaction.
- However, a systematic review of RTSA in CTA and massive cuff tears showed a high complication rate across the studies of 17.4%, while ROM was significantly improved in all directions.

Pseudoparalysis caused by massive, irreparable rotator cuff tear without OA

- Several studies have reported results of RTSA in patients with massive, irreparable rotator cuff tears without OA in whom the major symptom was severe loss of ROM (i.e. pseudoparalysis)
- Recently, a systematic review with meta-analysis and meta-regression reported that patients with massive, irreparable rotator cuff tears without OA have a high likelihood of achieving a painless shoulder and functional improvements after RTSA.
- Studies have found no difference in outcomes among patients with massive rotator cuff tears and no associated arthritis *versus* those who underwent primary RTSA for rotator cuff tear arthropathy.
- Studies have reported 94% survivorship at 5 years and 90% at 10 years. Improved motion and functional scores were maintained at 10 years
- A longitudinal study with 15-year follow-up suggested a failure rate of 27% and almost a 60% complication rate, although constant scores and anterior elevation were improved overall at final follow-up. A systematic review

showed no significant decrease in functional scores or ROM up to 20 years post-surgery

- Overall, a younger age at the time of surgery, prior rotator cuff repair, and higher pre-operative shoulder scores were associated with poorer outcomes in this population

Acute Proximal Humerus Fracture

- One condition for which RTSA is becoming increasingly utilized is proximal humerus fractures(PHF), especially in elderly
- One of the challenges with either primary fixation or hemiarthroplasty for PHF is achieving tuberosity healing, which is associated with improved outcomes. Again, given the altered biomechanics of the RTSA, this implant offers the possibility of improved function regardless of tuberosity healing.
- Many prospective studies of RTSA in comminuted PHF have resulted in 97% of patients with stable fixation, average forward flexion of 130° and average external rotation of 32° and 92% of patients rating their outcome as excellent or good. Resected or displaced greater tuberosities on imaging did correlate with inferior clinical outcomes in this cohort
- Comparisons of RTSA with hemiarthroplasty for treatment of PHF has generally favored RTSA in terms of improved functional motion, pain scores, and revision rate. The healing status of the tuberosities did not affect the functional outcomes of the RTSA group, and more hemiarthroplasties required revision
- A meta-analysis has also confirmed superior outcomes regarding ROM, pain, and functional scores in RTSA compared with hemiarthroplasty.
- Despite promising data on outcomes of this population when managed with RTSA, comparison between RTSA and non-operative management of PHF does not consistently demonstrate that superiority of RTSA. In Retrospective reviews of patients aged 70 or older with three- or four-part PHF, there was no difference in functional score, although the anterior elevation was improved in the RTSA group compared with the non-operative group. However, there were more complications in the RTSA group. Furthermore, delayed primary RTSA compared with acute primary RTSA yielded similar clinical results and reoperation rates, suggesting that perhaps in this frail population a trial of non-operative management may be prudent when appropriate.

Malunited/Nonunited Proximal Humerus Fracture

- Surgical options to address malunited proximal humerus fractures are determined largely by the existing deformity and can be categorized broadly as humeral head-preserving techniques (*e.g.*, osteotomies, soft-tissue releases and removal of bony protuberances) or humeral head-sacrificing techniques (e.g. HA, TSA and RTSA).
- Studies with short-term follow-up have reported high rates of patient satisfaction with RTSA for improving ROM, treating malunited proximal humerus fracture and reducing pain.
- Before surgery, patients should be informed that active external rotation might not be restored after RTSA, particularly if an osteotomy of the greater tuberosity is performed.

Glenohumeral OA with Severe Glenoid Bone Loss

- Due to the potential fixation strength of the glenoid component in RTSA, RTSA may be considered for patients with severe glenoid bone loss, such as from primary osteoarthritis, tumor, inflammatory arthritis, or failed prior arthroplasty [87].
- There are several classifications of glenoid bone loss that define various defects caused by OA. The most commonly used classification is that of Walch et al: type A2, central bone loss; type B2, posterior bone loss; and type C, severe retroversion of the glenoid. Glenoid bone loss resulting in a biconcave (B2) or severely retroverted and dysplastic (C) glenoid may be considerations for RTSA based on other patient characteristics. Bone grafting of the glenoid to achieve sufficient bony fixation, to restore the glenoid version with posterior augmentation, and to lateralize the COR to avoid impingement on the coracoid and scapula is also a possible option

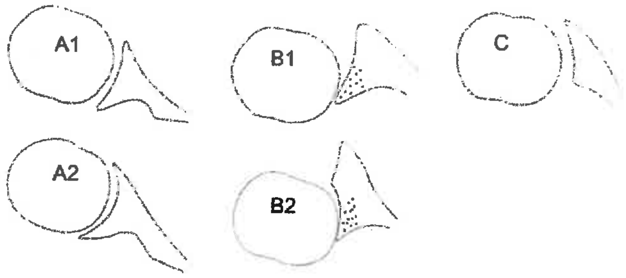


Fig 1.1.3.2: Walch classification of glenoid erosion in osteoarthritis.

- Retrospective studies have reported significant improvements in PROs and ROM with complications in 15% of patients and no recurrent posterior instability at minimum 2-year follow-up. A single-stage procedure was feasible in 92.5% of patients, and the authors recommended considering a two-stage procedure when intraoperative glenoid baseplate stability was unsatisfactory. Bone grafting was recommended if medialization occurred past the point of the coracoid.
- Some companies have marketed implants or techniques specifically to address glenoid bone loss. *The bony increased offset-reversed shoulder arthroplasty (BIO-RSA) is an option in which cancellous humeral head autograft is used to lateralize the COR, and in medium-term follow-*

up, has demonstrated excellent graft incorporation, a low rate of scapular notching, and satisfactory post-operative ROM.

- Long-term follow-up studies are needed before RTSA can be recommended in patients with severe glenoid bone loss.

Chronic Locked Glenohumeral Joint Dislocation

- Chronic locked glenohumeral dislocation presents many challenges caused by humeral and glenoid bone loss, concomitant soft-tissue contractures and rotator cuff lesions.
- In these patients the failure rate for TSA has increased, with increasing follow-up because of recurrent instability, glenoid loosening and graft subsidence.
- In Studies with patients treated with glenoid bone grafting with RTSA for neglected anterior dislocation with substantial glenoid bone loss, Outcomes were rated as excellent, good or fair by the majority of patients.

Rheumatoid Arthritis with or without Associated Rotator Cuff Tears

- The use of RTSA for patients with rheumatoid arthritis has been studied by several authors.
- Some studies have raised concerns about the high incidence of glenoid baseplate radiographic lucency at follow-up in this patient population.
- However, excellent to satisfactory results have been reported in up to 95% of patients with rheumatoid arthritis who were treated with RTSA.

Tumours

- Several shoulder reconstruction techniques have been reported for patients after wide resection of the proximal humerus and rotator cuff tendons for malignant bone tumours, including allograft, arthrodesis and shoulder arthroplasties.
- These patients may be younger and require substantial resection depending on the tumor size. If a wide oncologic resection necessitates removal of the tuberosities, then RTSA may be the only implant that allows for restoration of joint stability and preservation of shoulder function.
- However, a prerequisite for the ability to implant a RTSA in these cases requires preservation of the axillary nerve and deltoid muscle to be successful.
- Studies have reported improvement in all outcome scores and concluded that RTSA is an acceptable option to preserve function after resection of a malignant tumour of the proximal humerus.
- The authors recommend long-stemmed, modular components, optimization of stability through component positioning and soft tissue tensioning, and consideration for patients with a life expectancy of greater than 6 months.

Revision Shoulder Arthroplasty

- Reverse total shoulder arthroplasty may also be indicated for use in the setting of failed anatomic or hemiarthroplasty.
- If the rotator cuff fails in the setting of a hemiarthroplasty or anatomic TSA, instability and anterosuperior escape may manifest. The reverse prosthesis is a reasonable solution as it does not rely on the rotator cuff for stability.
- In the study of patients with failed total shoulder arthroplasty, conversion to RTSA resulted in improved subjective and functional outcomes though with higher complication rate than primary RTSA.
- Relatedly, if there is nonunion, malunion, or resorption of the tuberosities following HA for PHF, RTSA can be used as a salvage operation.
- Another indication for revision may be glenoid wear in hemiarthroplasty, or glenoid component failure in anatomic or reverse TSA. In these settings, glenoid bone stock may not be adequately addressed by a revision anatomic TSA, even if the rotator cuff is intact. Due to the ability of the RTSA prosthesis to make up for deficient rotator cuff (which is necessary for both hemiarthroplasty and anatomic TSA) and provide glenoid resurfacing with less glenoid bone stock due to enhanced fixation options, it is becoming a more common solution to challenging revision arthroplasty cases.

COMPLICATIONS

- Reported complication rates after RTSA are in the range of 19% to 68% and include acromial fracture, haematoma, infection, instability, mechanical baseplate failure, neurological injury, periprosthetic fracture and scapular notching.
- These rates are influenced by the indications for RTSA and the proportion of revision procedures included in each study. Other factors influencing complication rates include component design and surgeon experience.
- Studies have reported a 13-25% complication rate for primary RTSA and a 24-37% complication rate for revision RTSA.
- The most frequent complications were neuropathy, intra-operative fracture and dislocation, with the primary cause for revision surgery being dislocation.

Instability

- Dislocation after RTSA is a major concern.
- The incidence of post-operative instability has been reported to be in the range of 2% to 31%.
- Patient risk factors for dislocation include body mass index > 30, male sex, previous surgery and subscapularis deficiency.
- Surgical factors contributing to instability include inadequate soft-tissue and deltoid tensioning,

malpositioned implants, mechanical impingement, insufficiency of the subscapularis and use of the deltopectoral approach compared with the anterosuperior approach.

- The instability rate has also been associated with prosthesis design; prostheses with a head-neck angle of -155° have been shown to have a higher instability rate than those with a more horizontal head-neck angle of 135°
- Instability of RTSA often occurs within six months after surgery, with half of cases occurring within three months.
- When dislocation occurred within three months, a surgical error was considered the most likely cause and closed reduction was typically unsuccessful. Conversely, late dislocation (> 1 year after surgery) can usually be treated successfully with closed reduction.

Infection

- Reported rates of infection after RTSA are in the range of 1% to 15%, which is higher than the infection rate after anatomical TSA.
- In a systematic review including primary and revision RTSA, Zumstein et al reported a mean infection rate of 3.8%, with a higher rate of infection after revision surgery than after primary surgery.
- Studies have reported a six fold greater risk of infection after RTSA compared with an anatomical TSA.
- A history of shoulder trauma or failed HA has also been shown in some studies to be a risk factor for infection.

Scapular Notching

- Scapular notching is a complication unique to RTSA, with a reported incidence of 50% to 96%
- Scapular notching typically occurs within six months after surgery and appears to stabilize in most cases. However, some studies report an apparent increase in incidence and severity of notching with increasing follow- up.
- In a prospective study predictors of notching in RTSA patients, concentric or superior glenoid placement were shown to have the largest effect on the occurrence of notching
- The rate of notching in RTSAs with a medialized centre of rotation has been reported to be 47%; however, systematic review has reported rates of up to 97%. The reported rate of notching when using lateralized RTSAs (4.6%) is significantly lower compared with medialized designs.
- The major concern with notching is that it may lead to baseplate failure, but that concern remains controversial. Although some authors have suggested an increased risk of baseplate loosening with scapular notching, others have not found such a relationship.
- The clinical implications of notching are controversial; some authors have reported no associations with clinical outcomes, whereas others have reported that high grades of notching may be associated with worse clinical outcomes.
- The use of an anterosuperior approach, a high position of the baseplate on the glenoid and superior tilting have all been associated with higher rates of notching caused by mechanical impingement with the arm in adduction.
- Eccentric glenospheres with an inferior offset and glenoid components with a more lateral offset (bony or metal) can reduce the risk of notching.

Fig 1.1.3.3: Radiograph of shoulder showing notching after RSA.

Heterotopic Ossification

- Heterotopic ossification after RTSA is a relatively common finding of unknown clinical importance.
- Studies have found an overall rate of heterotopic ossification of the long head of the triceps tendon of 62%.
- They found that men had a higher rate of heterotopic ossification than women, and that heterotopic ossification was associated with worse post-operative ROM.
- The exact cause of heterotopic ossification in the long head of the triceps tendon after RTSA is unknown. It has been postulated to be caused by releases, traction on the triceps and more extensive exposure of the glenoid than is typically done in anatomical TSA

Neurological Injury

- Neurological injury is a known complication of shoulder arthroplasty of all types, with reported incidence in the range of 1% to 4%.
- Nerves from the brachial plexus can undergo stretch injuries at the extremes of motion that occur during intra-operative positioning of the arm.
- Brachial plexus palsies have been shown to be more

common in RTSA than in TSA, possibly because of the lengthening effect on the arm during RTSA and the need for greater glenoid exposure.

Scapular Fractures

- Scapular fractures are a well-recognized complication of RTSA, and they have been reported in 0.8% to 7.2% of cases.
- Postulated causes include excessive tensioning of the deltoid, placement of a superior screw in the baseplate and stress of the implants on osteoporotic bone.
- Insufficiency fractures of the acromion or displacement of the os acromiale after RTSA can be painful and can limit ROM.
- Conversely, scapular spine fractures lead to painful dysfunction and may require ORIF.
- Post-operative scapular fractures have been associated with inferior clinical results and increased risk of revision.
- Bilateral scapular fractures and clavicle stress fractures after RTSA have also been reported.

DESIGN CHANGES

Since the introduction of Grammont's principles, there have been multiple proposed changes to the design and component placement of RTSAs with goals of improve ROM and outcomes while reducing impingement. These adjustments include glenoid baseplate placement modifications as well as humeral-sided design changes.

Glenoid Position

- Medialization of the COR decreases shear forces across the glenoid component and creates compressive forces at the bone-implant interface. Medialization results in less glenoid baseplate motion and lower force generation by the deltoid to initiate motion compared with lateralized components.
- However, medialization may lead to increased scapular notching and reduced shoulder ROM due to impingement.
- Clinically, in a study of RTSAs, patients with increased medialization had decreased external rotation, but improved pain scores. Those with increased glenoid lateralization had less radiographic notching. Other biomechanical and clinical studies have also demonstrated improved ROM with glenoid lateralization.
- Solutions to address these contrasting benefits have included improving glenoid baseplate fixation, moving from a highly constrained to a semi-constrained joint, and more inferior placement and inferior tilt of the glenosphere to avoid notching.
- The superior-to-inferior position and tilt of the glenosphere has also been studied with regard to reducing impingement. Initially, a computer-based model predicted less impingement in inferiorly placed and inferiorly tilted implants. In a CT modeling study, inferior tilt of the glenosphere and inferior eccentric placement of the glenosphere both improved predicted ROM compared with a standard concentric glenosphere. However, other studies have raised concerns about glenoid fixation with a tilted configuration. Currently, inferiorly tilted and eccentric designs are available to allow for inferior positioning of the glenosphere. While short-term results have been promising, long-term results with these modern implants are not yet available.

Humeral Component Design

- Humeral component design and position have also been modified to diminish impingement and improve ROM since Grammont's initial designs.
- The Delta prosthesis humeral component neck-shaft angle was in 155° of valgus, providing superior stability in a cuff-deficient shoulder. However, this non-anatomic, nearly-horizontal humeral component is more likely to impinge on the lateral pillar of the scapula. More contemporary designs offer a neck-shaft angle closer to normal anatomy, with options between 135 and 145°. Biomechanical studies have demonstrated reduced impingement and improved ROM, findings further supported in clinical studies demonstrating reduced notching in patients receiving implants with a lower neck-shaft angle.

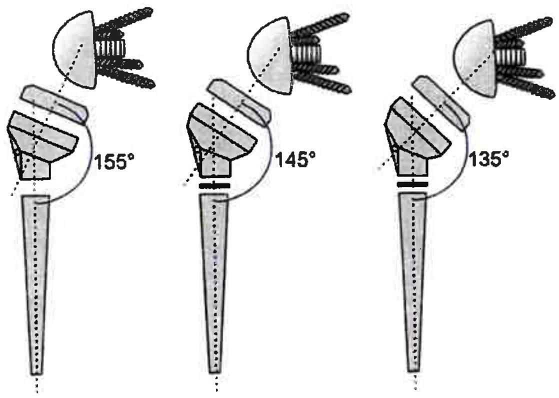


Fig 1.1.3.4: Different head-neck angles of Grammont-type prostheses *vs* a more horizontal head-neck angle seen in more recent designs

- Humerus preparation has also been modified since Grammont's inlay prosthesis. Grammont's initial stem was straight with a horizontal inlay-type humeral tray. A theoretical advantage of the inlay stem is increased bony contact between the proximal component and bone. However, the inlay design involves reaming more metaphyseal bone and preparation may risk greater tuberosity fracture. Curved-stem designs with an onlay proximal interface have been utilized as well. The onlay design preserves proximal bone, and is generally has a more varus cut, preserving greater tuberosity bone