First shoulder arthroplasty designed by Pean in 1983 for tuberculosis involvement of the glenohumeral joint using platinum and rubber components.
Reverse Total Shoulder Arthroplasty
Educational Objectives

- **Rotator Cuff Arthropathy**
  - Historical review
  - Clinical presentation
  - Imaging features
  - Proposed Etiologies
    - Rotator Cuff Theory
    - Crystalline-Induced Arthritis (Milwaukee Shoulder Syndrome)
- **Treatment**
- **Reverse total shoulder arthroplasty**
  - Past Designs
  - Grammont Delta III Reverse Total Shoulder Arthroplasty
  - Indications / Contraindications
  - Biomechanics
  - Imaging Features
Cuff Tear Arthropathy/Milwaukee Shoulder Syndrome

- Progressive and destructive arthropathy of the glenohumeral joint in a small percentage of patients with chronic rotator cuff tears
Rotator Cuff Arthropathy – Historical Review

- **Adams and Smith** (19th century) - Earliest description of the pathoanatomical features of rotator cuff tear arthropathy (CTA). Described as localized form of rheumatoid arthritis.

- **Codman** (1934) – “subacromial space hygroma” in woman with recurrent shoulder swelling, absence of the rotator cuff, cartilaginous bodies attached to the synovium, and severe destructive glenohumeral osteoarthritis.

- **DeSeze** (1968) - L’épaule sénile hémorragique (the hemorrhagic shoulder of the elderly). Three elderly women w/o trauma history who had recurrent, blood-streaked effusions about the shoulder, severe glenohumeral degeneration, and chronic rotator cuff tears.
Rotator Cuff Arthropathy – Historical Review

- McCarty and Halverson (1981) - Milwaukee shoulder syndrome. Condition seen in four elderly women who had recurrent bilateral shoulder effusions, severe radiographic destructive changes of the glenohumeral joints, and massive tears of the rotator cuff.


- Neer et al (1983) - Cuff Tear Arthropathy. Term used to describe GHJ arthritis and massive chronic RCT in 26 patients who had total shoulder replacements

- Dieppe (1984) - Apatite-associated destructive arthritis and idiopathic destructive arthritis were introduced to describe rotator cuff tear arthropathy.
Cuff Tear Arthropathy – Clinical Presentation

- More common in **women** than men, especially elderly women with long standing shoulder symptoms
- Dominant side more commonly affected, **bilateral in 60%** in one series
- Symptoms:
  - Moderate joint **pain**
  - **Limited range** of motion
  - Recurrent **swelling** of the shoulder
- Physical Exam:
  - Swelling about the glenohumeral joint
  - **Atrophy of the supraspinatus and infraspinatus** muscles
Cuff Tear Arthropathy – Imaging Features

- Superior migration of the humeral head with articulation with the acromion sometimes resulting in rounding-off the greater tuberosity.
- Severe destructive GJH osteoarthritis
- Anterior or posterior humeral head subluxation
- Neer et al reported an area of subchondral collapse in humeral head in all twenty-six patients in one series; they considered this finding a requirement for the diagnosis of rotator cuff tear arthropathy
Cuff Tear Arthropathy – Imaging Features

- Massive tears of the supraspinatus and infraspinatus tendons with muscle atrophy
- Glenohumeral joint destruction
- Occasionally, geyser phenomenon with fluid communicating between the glenohumeral joint, SA/SD bursae and AC joint as a result of massive rotator cuff tear and ACJ capsular ligament injury
Rotator Cuff Tear Theory

Neer et al (1983) – A small percentage (4%) of untreated chronic, massive rotator cuff tears would lead to severe glenohumeral degeneration from mechanical and nutritional alterations.

- **Mechanical factors**: Instability of the humeral head resulting from massive RCT and rupture or dislocation of the long head of the biceps, leading to proximal migration of the humeral head and acromial impingement.

- **Glenohumeral cartilage loss** was a result of repetitive trauma from the altered biomechanics because loss primary and secondary stabilizers of the glenohumeral joint.
Rotator Cuff Tear Theory – Nutritional Factors

- **Nutritional**: Inadequate diffusion of nutrients to the cartilage as the loss of a watertight joint space diminished the quantity of synovial fluid.

- **Disuse osteoporosis** of the proximal part of the humerus would decrease the density of the subchondral bone in the humeral head and contribute to atrophy of the articular cartilage.

- **Degenerative arthritis** and subchondral collapse eventually would develop as a result of changes in the articular cartilage.

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**Nutritional Factors**

- Massive cuff defect
  - Reduced motion and function
  - Loss of “water-tight” joint space
  - Disuse osteoporosis and biochemical changes in water and glycosaminoglycan content of cartilage
- Loss of pressure and diminished quantity of joint fluid
  - Cartilage atrophy and subchondral collapse
  - Cuff-tear arthropathy
Milwaukee Shoulder Syndrome – Crystalline-Induced Arthritis of the GHJ

- McCarty and Halverson (1981) postulated that phagocytized basic calcium-phosphate (BCP) crystals in synovial fluid induce release of proteolytic enzymes which cause destruction articular and periarticular tissues.

- Hydroxyapatite-mineral phase develops in the altered capsule, synovial tissue, or degenerative articular cartilage and releases basic calcium-phosphate crystals (crystal very similar to Hydroxyapatite) into the synovial fluid.

- These crystals then are phagocytized by synovial cells, forming calcium-phosphate crystal microspheroids which induce the release of activated enzymes.
Cuff Tear Arthropathy - Treatment

- **Medical** management of the pain / physical therapy
- Arthroscopic *lavage* / arthroscopic débridement - Limited short-term results; rationale is remove activated enzymes and crystals
- **Hemiarthroplasty** – Provides some return of function but pain relief is variable
- **Arthrodesis** - Not well tolerated because of cosmetic appearance/poor function
- **Constrained** arthroplasty – High rate of glenoid component loosening
- **Total** shoulder arthroplasty - Associated with high rate of glenoid loosening because superior migration of humeral head results in “rocking-horse” phenomenon
Conventional Total Shoulder Arthroplasty: Abandoned because of glenoid component loosening

Because of superior humeral head migration, eccentric loading on the glenoid component resulted in “rocking-horse” glenoid loosening.
Hemiarthroplasty: Some pain relief but no significant improvement in range of motion

- Relatively fewer problems with glenoid component loosening as in the conventional TSA
- Limited pain relief, less than with conventional TSA
- Modest improvement in active elevation or abduction can deteriorate as a result of subsequent glenoid and/or acromial erosion
Past constrained reverse ball-and-socket designs: Provided fixed center of rotation but high rate of glenoid loosening

- Fixed center of rotation provided some active elevation
- Lateral offset of the center or rotation placed increased torque at the glenoid-bone interface resulting in loosening
Grammont Reverse Shoulder Arthroplasty

- Designed in 1985 by Paul Grammont
- Used in Europe for past 20 years, approved by FDA in March, 2004 in U.S.
- Components: Humeral component, polyethylene insert, glenosphere, metaglene (baseplate)
Small lateral offset (absence of component neck) places the center of rotation more medially surface and reduces the torque at glenoid-bone interface.
Grammont Reverse Shoulder Arthroplasty - Biomechanics

- The lever arm distance (L) is increased and deltoid force (F) is increased by lowering and medializing the center of rotation which is now also fixed.

- Torque (F x L) in abducting the arm is increased.
Grammont Reverse Shoulder Arthroplasty - Biomechanics

- Large glenoid ball component offers a greater arc of motion
Medializing the center of rotation recruits more of the deltoid fibers for elevation or abduction but...
But external rotation is decreased

Ant. Pos.

... Fewer posterior deltoid fibers are available for external rotation

Important to comment on status of teres minor on any MR imaging showing findings of rotator cuff arthropathy

Grammont Reverse Shoulder Arthroplasty
Indications for Reverse TSA

- Rotator cuff tear arthrosis – most common
- Failed hemiarthroplasty with irreparable rotator cuff tears
- Pseudoparalysis (i.e., inability to lift the arm above the horizontal) because of massive, irreparable rotator cuff tears
- Some reconstructions after tumor resection
- Some fractures of the shoulder (Neer three-part or four-part fx)
- Severe proximal humerus fractures with tuberosity malposition or non-union
60 y/o Female With Rheumatoid Arthritis and Pain

Courtesy Tudor Hughes, M.D.
Glenosphere and humeral component should be aligned on trans-scapular Y view

Slight posterior position of the humeral component acceptable on the axillary view

Metaglene flush against the glenoid
Contraindications for Reverse TSA

- Primary osteoarthritis or osteonecrosis where the articular surface–tuberosity relationships are normal and the rotator cuff is intact
- Marked deltoid deficiency, as the shoulder will not function well and will be prone to dislocate
- History of previous infection – recurrent infection high
- Use sparingly in patients less than 65 years old, as long-term survivorship and complication rates are unknown
Complication Rates for Reverse TSA

- Higher for intraoperative and postoperative complication rates for reverse TSA (mean 24%) vs. conventional TSA (mean 15%)

- Besides cuff arthropathy, reverse TSA still regarded a salvage procedure for failed hemiarthroplasties. If exclude these salvage procedure, complication rate is less
Complications of Reverse TSA

• Recent postoperative
  • Hematoma
  • Dislocation
  • Prosthesis loosening
  • Infection
  • Periprosthetic fracture
  • Metaglene migration

• Late postoperative period:
  • Scapular erosion
  • Osteophyte formation
  • Heterotopic ossification
  • Acromion or scapular stress fractures
Unconstrained TSA abandoned b/c of glenoid loosening

• Most commonly anterior-superior b/c unopposed pulled of deltid muscle
• 20% of reverse TSA had dislocations in one series
• More likely to occur if deltid tension not adequate

Complication - Dislocation
Complication – Malposition of the Metaglene (baseplate)

- Back of metaglene must be flush to the glenoid
- Perioperative complication
Complication – Component Loosening

- The baseplate and glenosphere have migrated superiorly
- Irregularity of the glenoid from contact by the humeral component
- Humeral component loosening

*Courtesy Heinz Hoenecke, M.D.*
Complication – Scapular Notching

- Most common complication – result of contact of humeral component with inferior margin of the scapula.
- Seen soon after implantation and stabilizes after 1 year.
- Controversial as to clinical significance but higher grade notching has been associated with lower Constant (postop. patient satisfaction) scores.

**Nerot Classification of Scapular notching**

- Grade 1: Confined to the scapular pillar.
- Grade 2: Notch outline contacts lower.
- Grade 3: Notch over the lower screw.
- Grade 4: Notch extends to baseplate.
Complication – Scapular Notching
Complication – Inferior metaglene screw in soft tissue
Complication – Acromial Stress Fracture

- Unique to reverse TSA
- Believed to be secondary to loading to the posterior aspect of the acromion, from increased deltoid tension
- Increased load on the acromion may also explain rare complication of scapular spine fracture
Complication – Scapular Spine Fracture in 80 y/o Female

Courtesy Heinz Hoenecke, M.D.
Interpretation Checklist for Radiologic Evaluation of Reverse Shoulder Arthroplasty

☐ Are the humeral and glenosphere components aligned? If there is a dislocation, is it anterior or posterior?
☐ Is the metaglene placed flush with the native glenoid?
☐ Are the metaglene anchoring screws within the scapula?
☐ Are there regions of radiolucency at the component-bone or cement-bone interface?
☐ Are the components of the prosthesis intact?
☐ Is the inferior border of the scapula being eroded by the humeral component?
☐ Are there regions of new (heterotopic) bone formation?
☐ Are the supporting bones intact?
References


