Recent advances in shoulder surgery

Introduction

Being the most complex and mobile joint in the body, the shoulder joint is vulnerable to injuries and disorders. Shoulder surgery, especially Arthroscopic, has evolved enormously over the last ten years and newer techniques and instrumentation have facilitated the remarkable expansion of ambulatory or "day case" surgery.

History of Shoulder Surgery

Almost a hundred years ago EA Codman published his first two known cases of rotator cuff repair, but they were not well received by the surgeon's community at that time. He in fact had to resign from the chair of the District Surgical Society. But this did not deter him and in 1934 he authored the first book on shoulder surgery: The Shoulder: Rupture of the Supraspinatus Tendon and Other Lesions in or about the Subacromial Bursa; a book that is still pertinent today and should be studied by any practicing shoulder surgeon.[1] The book was decades ahead of its time, it described the pathology of rotator cuff disease, shoulder anatomy and biomechanics, shoulder rehabilitation, a classification of proximal humeral fractures, neurologic disorders about the shoulder, and tumors about the shoulder. Codman believed that critical avascular zones in the distal portion of the tendon predisposed it to calcification and degeneration, a theory which was never validated, but lately *in vivo* studies by Rudzki *et al*., 2008 found significant decrease in the vascularity of the rotator cuff after the age of 40 which correlates with the higher incidence of cuff tears in this age group.[2]

The next major contribution in the field of shoulder surgery was made by Dr Charles Neer who described the classification of proximal shoulder fractures which is used till date.[3] He explained the pathogenesis and the treatment of impingement syndrome and most importantly he designed an implant for hemiarthroplasty of the shoulder for comminuted fractures of the proximal humerus which still derives its name after him.

This was followed by the need for treatment of arthritis with massive cuff tears. The aim of shoulder surgery is to restore or replicate the anatomy of glenohumoral joint and function of rotator cuff. The conventional total shoulder replacement has been successful in reducing pain and improving function in patients with and intact rotator cuff. But the results of TSA in large or massive cuff tears are unsatisfactory due to suboptimal function, eccentric glenoid loading, and early loosening. These limitations were overcome in 1987 when Professor Paul Grammont described a new reverse prosthesis with improved biomechanics.[4] The principles of this design were inherent implant stability, convex glenoid component with center at or within the glenoid neck, and medialized and distalized center of rotation (COR).

In 1950s, Masaki Watanabe, often called the "founder of modern arthroscopy" developed the first practical arthroscope.[5] Initially use of arthroscope was limited to the knee, but many surgeons saw its use in the shoulder and began to apply it in the 1980s. The use of the arthroscope in shoulder surgery was a major milestone which led to the development of many new instruments and techniques. During the 1990s the improvements in implants, fluid pressure pumps, shavers, radiofrequency devices, and instruments improved; leading to almost every shoulder surgery being performed arthroscopically.

Recent Advances in Shoulder Arthroscopes

Shoulder arthroscopy has seen many advances in the recent years which include both better technology and instruments and use of newer techniques. Starting first with the most important instrument: The arthroscope, the use of magnifying lenses with fibreoptic technology, and digital monitoring has tremendously improved the visualization of the shoulder joint. These new scopes have smaller diameters with better fields of vision, better optics, and better flow of fluid through the sheath. In addition to the commonly used 30° scope, the new 70° scope is useful in those difficult corners.

Suture anchors

Suture anchors have undergone remarkable changes over time, and the newer designs have focused on greater load to failure strength, ease of insertion, and ability to accommodate multiple sutures. The most recent innovations address the issue of potential revision surgery.

Bioabsorbable suture anchors

Suture anchors basically function to attach soft tissues to bone; they were initially made of metal, but lately have been replaced by bioabsorbable suture anchors. Bioabsorbable fully threaded suture anchors provide higher pull out strength in poor quality bone. The fully threaded design also prevents anchor pull back as seen in countersunk design.

Bioabsorbable materials

Composed of Poly L-lactic acid (PLLA) and β-tricalcium phosphate (β-TCP) have better osteoconductive and bioreabsorbable qualities leading to early bone formation.

Polyether ether Ketone (PEEK) is another thermoplastic material used in suture anchors with excellent stability and biocompatibility [Figure 1].

Knotless double row repairs

The use of fully threaded anchors and forming a knotless construct using two anchors medially and two lateral locks can provide a low profile secure fixation with increased tendon to bone contact[6] [Figure 2].

All suture anchors have recently exploded on the market with a view to eliminate concerns of bone loss and hardware prominence Made of high-strength polyethylene MaxBraid suture material with a polyester-sleeve anchoring element, the anchor is placed in a prepared hole. Then, when tension is applied to the sutures, the anchor sets by bunching up to a size larger than the prepared hole[7] [Figure 3].

Figure 1: PEEK suture anchors Image source: http://www.smith-nephew.com/professional/products/all-products/peek-suture-anchors/

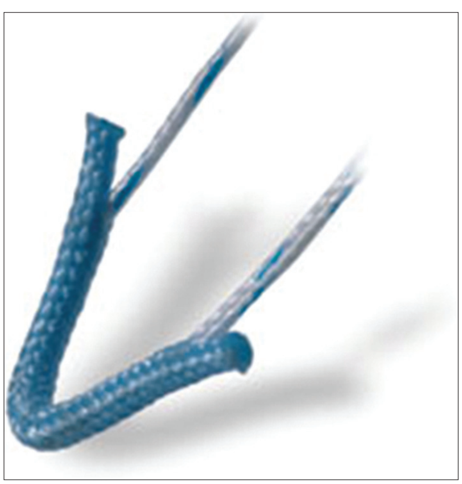

Figure 3: All suture anchor Image Source:http://www.qmed.com/mpmn/article/suture-anchor-system-flings-soft-tissue-injuries-under-juggerknot

Bioabsorable sutures with titanium tip allows direct push in technique of suture insertion minimizing the need to prepare a bone channel for the lateral row, where soft tissue can sometimes obscure the view [Figure 4].

Shoulder Arthroscopy Under Regional Block

Use of regional blocks after shoulder surgery was described as early as 40 years ago by Winnie who advocated giving a single injection after shoulder surgery.[8] Two decades later Tuominen recommended continuous infusion of anestheticby an indwelling catheter. Initially, regional blocks (the gold standard now is ultrasound-guided interscalene nerve block) were used to supplement a general anesthetic, but recently many units (including my unit) have started performing arthroscopic surgery under the nerve block alone, without a general anesthetic, in appropriate cases. The advantages of regional anesthesia are decreased postoperative pain as well as nausea and vomiting and a lower complication rate. There are further advantages of

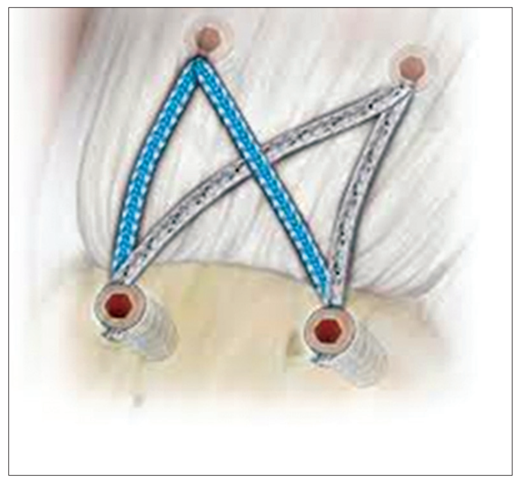

Figure 2: Knotless double row repair Image Source: https://www.arthrex.com/shoulder/knotless-suture-anchors

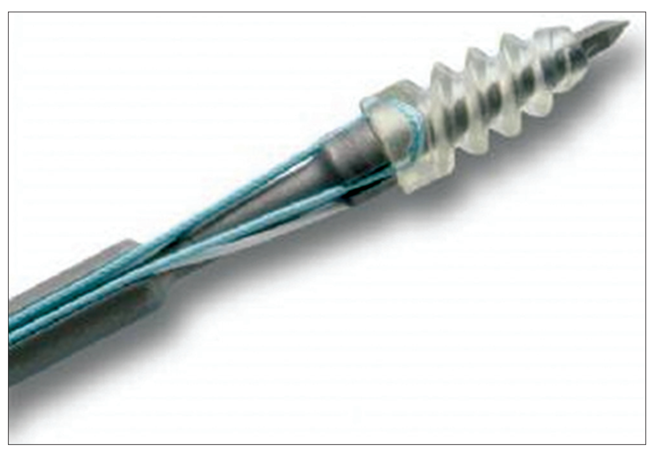

Figure 4: Bioabsorable sutures with titanium tip Image Source: http://www.orthopaediclist.com/category/306.html

decreased time spent in anesthetic rooms, decreased time spent in post-anesthetic unit, and reduced total costs.

Shoulder Replacement

History of shoulder arthroplasty dates back to 1893 when a French surgeon Jules Emile Pean replaced the shoulder for tuberculosis of the joint, when a humeral stem made of platinum and leather was used to articulate with a head made of rubber coated with paraffin. This was followed by Charles Neer in 1955 reporting the first simple, humeral prosthesis in a case of fracture of the humeral head. Neer emphasized that the soft tissue components of the procedure were the most important for stability and function, with the hemiarthroplasty providing a scaffold upon which to rebuild the shoulder. By the early to mid-1970s, several total shoulder arthroplasty systems using a PE glenoid component had been introduced. The first complete system was the Neer II, created by Neer and Robert Averill and introduced in 1973.[9] Similar designs at that time included the DANA, St George, Monospherical, Cofield and Mazas; which had both unconstrained and semiconstrained options [Figure 5].

Copelands shoulder replacement

The aim of this design was to mimic anatomy as closely as possible and to replace the damaged surface with minimal interference. The use of cementless technique and minimal bone loss were the main pros for this design [Figure 6].

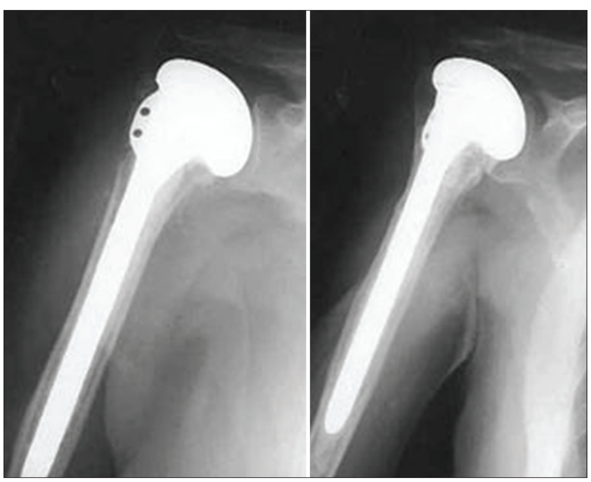

Figure 5: Neer's prosthesis

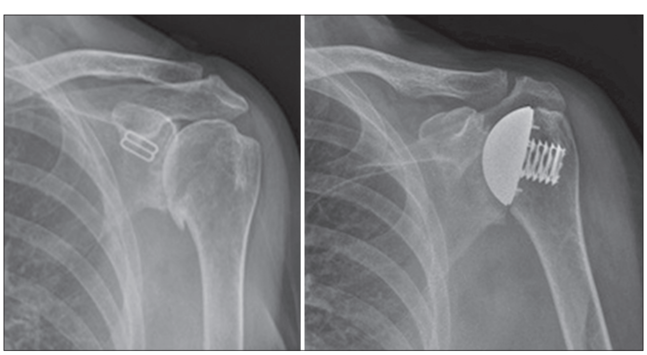

Figure 7: Arthrex eclipse shoulder replacement

Newer stemless designs based on the same principles include the Simplicity and Eclipse from Arthrex, which by resecting a part of the head lead to lesser stretching of rotator cuff and associated pain. These designs still preserve a lot of bone stock required for any revision [Figure 7].

Total shoulder arthroplasty or anatomical total shoulder arthroplasty has come a long way since its advent in the 1970s. The latest designs allow for accurate reconstruction of the proximal humeral head taking into account variations in inclination angle, version, and head offset. All these adjustments can be made with the humeral stem *in situ* using modular components. With anatomical reconstruction of head and glenoid, there is accurate balancing of the rotator cuff leading to better functional outcomes [Figure 8].

Reverse Shoulder Arthroplasty

The latest design Delta Xtend is a modification of the Delta I from Grammont in 1985. It consists of a cementless titanium

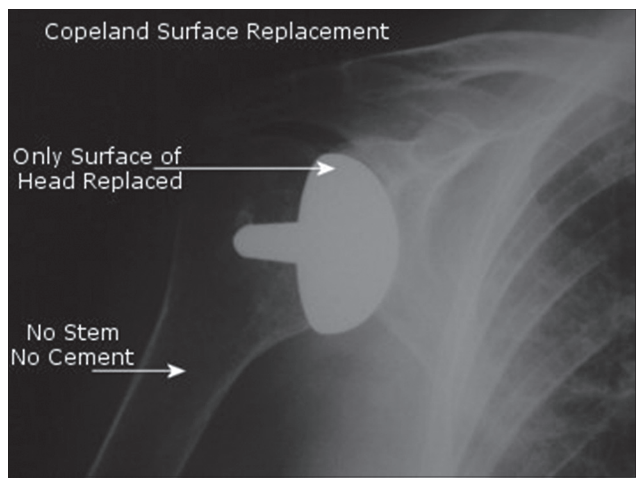

Figure 6: Copeland surface replacement

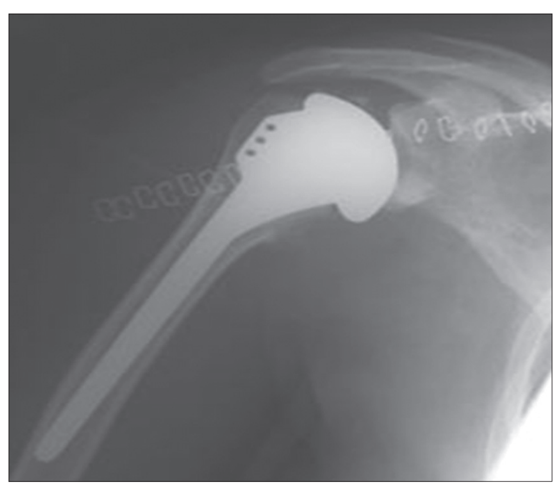

Figure 8: Total shoulder replacement

modular hydroxyapatite (HA)-coated or monobloc cobalt–chromium alloy (Co–Cr) cemented stem, variable thickness polyethylene (PE) cup and a glenoid component with a central peg and cannulated screws. Zimmer produced the Trabecular Metal Reverse Shoulder System (TMRS). Instead of Hydroxy Apatite coating, the implant integrates porous tantalum on the base plate, its central peg and on the proximal side of the humeral stem. In order to prevent scapular notching, the humeral stem has a low profile with no metal above the humeral osteotomy. Lima LTO (Italy) has produced the SMR (Systema Multiplana Randelli) prosthesis and recently the SMR HP design. The main difference between the two designs is that the HP has a PE glenosphere, instead of the standard metal design and the PE insert; this has been advocated by the company in order to reduce scapular notching. Equinoxe of ExactechInc (Gainesville, Florida) combines a medialized Center of Rotation (COR) along with a curved glenoid metal plate, which has a unique cylindrical hollow peg with holes in order to augment bone in growth and graft insertion. The humeral stem can be used for primary standard and for reverse arthroplasties and has less angle than the Grammont design in order for the humerus to be lateralized, without lateralizing the COR[10] [Figure 9].

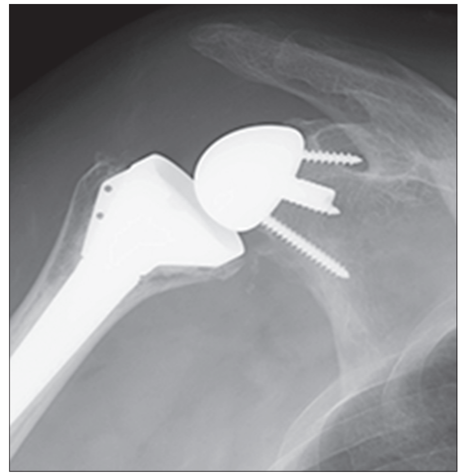

Figure 9: Reverse total shoulder replacement

Arthroscopic Arthroplasty

Treatment of bipolar osteochondral lesions in the shoulder in a young patient is a challenge for a shoulder surgeon. Treatment by conventional shoulder arthroplasty carries the risks of glenoid loosening, osteolysis, and polyethylene wear. One of the novel techniques used in this situation is the use of all arthroscopic biological shoulder resurfacing. This technique uses cadaveric osteochondral grafts from the humeral head, medial tibial condyle, and tibial plafond performed through the rotator interval. Short-term follow-up of patients with this technique shows promising results in terms of pain relief, regained motion, and accelerated rehabilitation. Potential advantages proposed are preservation of bone stock and lesser damage to surrounding structures allowing early rehabilitation.[11]

Arthroscopic Latarjet Procedure

The Latarjet procedure was developed over 50 years ago by French surgeons to treat shoulder instability. It involves using a bone graft from the coracoid and attaching it to the anteroinferior glenoid with the help of screws. A modified method for the arthroscopic procedure was developed to facilitate the procedure and minimize the risk of injury to the brachial plexus. The arthroscopic placement of the sleeves is a safe and reliable technique, which avoids extensive exposure. Secondly, the use of arthroscopically positioned sleeves permits an even more precise placement of the coracoid graft by drilling the inferior hole once the graft is already partially fixed by the superior screw. The arthroscopic preparation of the glenoid rim and the capsulolabral reconstruction can be achieved more precisely by arthroscopy.[12]

Arthroscopic assisted Latissimus dorsi Transfer

Latissimus dorsi muscle–tendon transfer is performed to replace the irreversibly lost contractile elements in patients with irreparable tears of the posterosuperior aspect of the rotator cuff. Grimberg *et al*., described a new arthroscopic assisted LD transfer with tendon tubularization and fixation in a bone tunnel in the humeral head. A mean follow-up of 29 months showed results similar to open procedure with significant improvements in constant score, active anteflexion, external rotation, and strength. Some surgeons have extended the indication of LD transfer in reverse total shoulder arthroplasty to improve external rotation.[13]

Future

Shoulder surgery has enormously evolved in the last few decades, especially with the introduction of arthroscopic surgery. Advances in surgical technique were supported with advances in instruments, implants, and technology. Also, the training curve forarthroscopic surgery shortened by the increase in experienced arthroscopists, training simulators and models, and a new generation of keen trainees brought up on computer games.[14] These advances lead us to question, what is in store in the future?

With ever-evolving technology and inventive brains of surgeons, nothing seems impossible. Computed tomography (CT) navigation systems in shoulder arthroplasty has already been introduced. The use of navigation in both anatomic and reverse shoulder arthroplasty holds promise in the future[15] [Figure 10].

The use of robotic arthroscopic surgery may enable the surgeon to perform more complex and precise tasks in restricted spaces. Arthroscopic polymer resurfacing joint replacement and office needle arthroscopy are currently being trialed. The possibility of a genetically-engineered rotator cuff inserted via the arthroscope is also being explored.[16]

Figure 10: Senior author, Vishal Sahni, who performed and reported the World's first Robot Assisted Arthroscopic Shoulder Surgery, using the Prosurgics Freehand© robotic camera, controlled by a head band mounted Infra-Red device

Another exciting field is the use of 'signature shoulders'. These are custom-made for each patient for most accurate anatomical reconstruction. First a Computed Tomography (CT) scan with three dimensional (3D) reconstruction is done to accurately note anatomical parameters. The images are then sent to the company to design a computer-generated preoperative plan for custom shoulder replacement. This guide helps ensure accurate anatomy and placement of the prosthesis. After the preoperative plan is approved by the surgeon, it is sent to the company where a 3D printer is used to make custom shoulder blocks.[17]

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