Surface Replacement Arthroplasty of the Shoulder
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Introduction

Resurfacing arthroplasty of the shoulder is a concept that has been utilized since the 1970’s. The original implants were silicone and silastic and used in cases of Rheumatoid arthritis (RA). Initial results in these limited series of cases were not encouraging.

In 1984, Steffee reported on the use of a hip resurfacing cup for shoulder applications. Results were encouraging at 22 months follow-up in 56 shoulders with a mean age of 65 years. This implant was later modified for use in the shoulder, with a more appropriate radius of curvature. About the same in time, a cemented cobalt chromium version was reported with good outcomes in cases of osteoarthritis (OA) and avascular necrosis (AVN), but poor outcomes in RA. Subsequently, in several investigations using the cemented Scan design, resurfacing was noted to be comparable to stemmed implants in RA patients at 28 months follow-up. In one series, there was 25% cup migration and central glenoid erosion but this did not appear to have a clinical effect on outcome.

In 1979, development of the Copeland implant was initiated by Stephen A Copeland, FRCS (Br) at the Reading Shoulder Unit in Reading, UK. It was first implanted in 1986. Early designs of this device (i.e. Copeland implant) included a cobalt chromium alloy implant with a central peg and screw. It was initially used in conjunction with a glenoid component. Several modifications were made resulting in the current version of a cobalt chromium shell with a central peg and hydroxyapatite coating, suitable for non-cemented applications (Figure 1).
Rationale of Resurfacing Replacement

The ideal humeral replacement implant should mimic normal anatomy. Pearl and Volk reported that anatomy varies among individuals and even between shoulders in the same individuals. This includes variable humeral version of 5 degrees ante-version to 55 degrees retroversion and variable radius of curvature. An ideal implant should preserve bone stock, restore lateral offset, be flexible and adaptable intra-operatively, be revisable, and durable (including bearing surface and method of fixation). Altering offset, inclination or version can alter shoulder kinematics. Given the variations, implants must allow for adaptability during surgery.

Resurfacing has an advantage over stemmed designs as they allow: 1) true anatomic head coverage (not replacement), 2) bone preservation, 3) easy revisability to total shoulder arthroplasty (TSA), and 4) easy conversion to arthrodesis, in rare cases. Retention of the native head and neck of the humerus will preserve the biomechanics of the joint. This technique also eliminates the risk of humeral fracture or perforation during implantation and allows the head position to be independent of the shaft. The latter is important in cases where proximal humerus malunions or other deformity may preclude access to the humeral shaft. As the shaft is not violated, it minimizes the risk of peri-prosthetic fractures post-operatively. The design inherently allows placement in infinite variations of version, offset and angulation. Since no humeral canal reaming or cementing is required, it
eliminates the risk of fat embolus or hypotension during humeral preparation and implantation.

In cases of prior elbow arthroplasty, intra-medullary nailing of the humerus, and prior plating of the humerus resurfacing allows for anatomic arthroplasty without having to remove all of the hardware. If there has been a proximal humeral malunion, this can be left undisturbed without worry about the head offset relative to the shaft.

Indications

Indications for resurfacing arthroplasty vary among authors. Copeland and colleagues prefer this implant for all cases of primary shoulder arthroplasty where a stemmed implant would be considered, except fresh fractures. For primary arthroplasty, we have focused on the use of resurfacing in the younger or more active patient where a stemmed implant may force an alteration in lifestyle as a result of implant failure concerns. Although we have not directly compared the resurfacing implants and standard stemmed hemi-arthroplasty or TSA in active patients, we have observed a much greater return to sports and active lifestyle in the resurfacing population and have not observed implant failure as a result. This includes several of our cases athletes who participate in collision sports.

In 2001, Copeland reported on 103 cases of OA or RA with a mean age of 64 years and follow-up of 6.8 years. This was an older, low demand group of patients with 94% indicating improvement with the surgery. In his series, 68 cases were implanted as a TSA with a cemented glenoid and the remainders were hemi-
arthroplasty. Best results were seen in cases of OA (Constant score 93.7%) while poorest results were seen in cuff tear arthropathy (CTA, Constant 61.3%), instability arthropathy (Constant 62.7%) and other causes (Constant 58.7%). Range of motion improved regardless of disease. Revisions were required in 5.9% of cases with only 2 cases of aseptic loosening.

In 2004, the same authors reported on 71 patients in OA only and noted a 90% overall improvement. This series consisted of 42 resurfacing TSA and 37 hemi-resurfacing implants. In 2005, Thomas reported that resurfacing was comparable to stemmed prostheses at 34 months and also noted that the geometry of the resurfacing implant better matched the normal anatomy with restoration of offset.

Bailie et al published a series in 2008 reviewing the experience of Cementless resurfacing humeral arthroplasty (CRHA) in active patients younger than 55 years of age. There were 36 cases with a mean age of 42.3 years (range 24-54) and mean follow-up of 38.1 months. Visual analog pain scores (VAS) improved from 7.5 to 1.3, ASES (American Shoulder Elbow Surgeons) scores improved from 29.8 to 87.7 and SANE (Subjective Assessment Numeric Evaluation) scores improved from 24.7 to 88.6 from preop to latest follow-up. Range of motion improved most dramatically in the first 12 weeks after surgery following a graduated, progressive rehab program. There were no cases of radiographic loosening or significant glenoid erosion at latest follow-up and all cases were hemiarthroplasty (Figure 2). Of the 36 cases, 35 were satisfied and returned to their desired activity at a satisfactory level. Only one case was revised to stemmed TSA for continued pain, which continued even after conversion.
Authors differ on acceptability of resurfacing in cases of AVN or other head deformities. Copeland has used resurfacing in cases of humeral head defects of 40% or less. This has also been the experience of Burgess et al. These defects are typically bone grafted at the time of surgery using reamings from humeral head preparation or local bone from acromioplasty or distal clavicle excision. Although these authors do not seemed concerned with durability in cases with sizable head defects, we prefer stemmed implants except in cases of contained humeral head defects where structural support of the resurfacing implant will not be compromised. This philosophical difference may also be related to the higher demands in younger active patients seen in our clinic. However, no comparative studies defining the maximum defect size allowable have been performed.

Since the Copeland implant was first introduced in the United States in 2001 (Biomet, Inc, Warsaw, IN), we have used this device in 30.5% of primary arthroplasty cases. Our mean age remains low at 55.1 years (range 17 to 81). Currently, we are collecting data on our 5 to 10 year results on approximately 100 cases. Our unpublished observations are that clinical outcomes are generally better (VAS, ASES, SANE, patient satisfaction) at mid-term follow-up than at 2-year follow-up. We have not seen significant glenoid erosion as we have with standard stemmed hemiarthroplasty. In addition, when there has been slight medialization, it appears to be limited and without an effect on functional outcome or pain. We hypothesize that resurfacing, when done correctly and respecting normal anatomy, restores lateral offset and provides better head coverage, thus improving kinematics of the glenohumeral joint and normalizes muscular forces. This may improve articulating
contact area throughout motion and decrease glenoid contact pressures, thus
decreasing the likelihood of painful glenoid erosion.

It has been reported by many authors that stemmed hemiarthroplasty
revision rates are higher and survivorship lower than for stemmed TSA at 10 years.
Several studies have demonstrated a higher revision rate for stemmed
hemiarthroplasty than for stemmed TSA. This has been our experience as well, but the reverse seems to be true for resurfacing.

Copeland demonstrated in his series of 210 cases, that the Kaplan-Meier Survival curve for resurfacing hemiarthroplasty was 90% at 10 years while it was only 68% for resurfacing TSA. Thus at the Reading Shoulder Unit in the UK, resurfacing hemiarthroplasty remains the preference in all cases, regardless of age or diagnosis, except in cases where a contraindication exists.

In our experience, we have revised 7.7% of our resurfacing cases to stemmed TSA. All of the revisions have been for pain and appeared to have some degree of head collapse or soft bone under the humeral implant at the time of revision. None of these cases appeared to have significant glenoid erosion at revision surgery and all were revised within the first 5 years after resurfacing. We have not had any infections.

Currently, our choice in primary arthroplasty is to reserve resurfacing arthroplasty for active individuals (generally younger than 60 years of age, although age alone is not an indicator) who do not have contraindications, we continue to utilize stemmed TSA, when possible, for all others. Contraindications, in our practice include: 1) significant subchondral cystic changes on either side of the joint as can
be seen with advanced RA or post-arthroscopic glenohumeral chondrolysis (PAGCL) from prolonged intra-articular infusion of local anesthetics, 2) acute fracture, 3) uncontained humeral head defects that may compromise component fixation, 4) soft humeral head bone which may collapse under the implant (may be determined at time of surgery), 5) contained AVN involving more than 40% of the humeral head, 6) tumors, and 7) significant glenoid erosion requiring a glenoid replacement. The latter situation could be addressed as a resurfacing TSA, but we find it simpler and more predictable to do a standard stemmed TSA in those cases. However, there have been rare cases where we have used a biologic resurfacing technique for the glenoid. This has included: 1) cases of lateral meniscus allograft when there is posterior subluxation from an early biconcave glenoid in a highly active individual, and 2) use of dermal allograft covering of contained defects of the glenoid that we have filled with bone graft, as frequently seen in failed Bristow procedures. Because biological glenoid resurfacing tends to be less predictable, we have started to be less aggressive on the glenoid side if we have chosen a hemiarthroplasty instead of a TSA. More often, the glenoid is either left alone or only the remaining articular cartilage (in the case of 50% loss or more) is removed without altering the subchondral plate and version of the glenoid face. As stated previously, resurfacing is done in primary arthroplasty in approximately 1/3 of our cases.

Cuff Tear Arthropathy (CTA)

Patients with massive non-repairable rotator cuff tears with arthropathy are often in need of surgical management to alleviate pain. In our clinic, we have
identified 2 distinct groups of patients with this disorder. Functional CTA (FCTA) include those with greater than 90 degrees of elevation with an insidious onset of pain. Older patients, who may have had multiple prior rotator cuff surgeries or injections often have nonfunctional CTA (NFCTA) with anterior-superior escape and elevation less than 90 degrees. If surgery is contemplated in the latter, reverse arthroplasty is the procedure of choice.

FCTA patients have pain and weakness but preserved function (often elevation greater than 150 degrees). Their shoulder has adapted to the loss of the rotator cuff and the deltoid has the power to initiate and maintain abduction and elevation. If conservative treatment in this group fails (i.e. no more than 2 annual corticosteroid injections and deltoid retraining rehabilitation) then arthroplasty can be considered to alleviate pain and preserve function. Our preference is a resurfacing head with an extended articular surface (Copeland EAS, Biomet Inc, Warsaw, IN). The benefit of this implant is that the structures that are allowing for compensated shoulder function are not disturbed. By preserving the humeral head, and replacing only the diseased cartilage surface, pain is relieved (Figure 3). At the same time, the thickness of the implant allows for some restoration of the center of rotation to a more lateral and inferior position, thus improving deltoid power. (Figure 4). Results have been encouraging with adequate pain relief and preservation of function, although we have not seen predictable strength gains. In the event of decompensation to a NFCTA, the EAS can easily be removed and revised to a reverse arthroplasty, when indicated.
Humeral Resurfacing Technique

The patient is given an inter-scalene block while awake using nerve stimulator control. The surgeon marks the operative site and antibiotic prophylaxis is given within 1 hour of incision. The patient is positioned on a table adapter to allow for free arm motion, including full rotation and extension, while maintaining head stability. The table is inclined to elevate the head approximately 30 degrees. A timeout is called prior to starting the surgery and all implants are verified.

Our surgical approach is the same as we use for standard TSA. Although the resurfacing technique is straightforward, it requires good soft tissue releases since the humeral head is not being removed, a step that makes exposure easier in stemmed arthroplasty. The humeral head must be seen en face in resurfacing and we cannot emphasize enough the importance of soft tissue contracture releases.

We use a deltopectoral approach as we have found this useful for primary, revision and all shoulder surgery. Copeland and colleagues prefer the antero-superior approach in order to perform acromioplasty and distal clavicle excision at the same time. Once the cephalic vein has been located, it can be moved medially or laterally, but we do try and preserve this structure to avoid compromise of venous outflow. Others have chosen to sacrifice this vein. The subacromial space and subdeltoid space are gently freed of adhesions. The conjoined tendon is gently retracted medially using hand held retractors. Self-retainin retractor can be used but tend to increase soft tissue tension and limit surgical access in some cases. In addition, the musculocutaneous nerve is at risk of compression injury with a medial based retractor. In resurfacing, the anterior circumflex vessels are preserved to
minimize any risk of latent AVN. In stemmed arthroplasty, they can be sacrificed
which allows for more distal releases along the humeral neck and improves
exposure tremendously. The long head of biceps (LHB) is routinely tenodesed at the
level of the pectoralis major tendon. This is done for several reasons: 1) to enhance
exposure, 2) to avoid painful LHB adhesions after removal of loose bodies from the
bicipital groove, and 3) to decrease likelihood of postop pain as a result of LHB
tenosynovitis as activity levels increase.

The subscapularis (SSC) is released 1 cm lateral to the myotendinous
junction from the rotator interval to the anterior circumflex vessels. A horizontal
incision is made high in the interval and directed toward the base of the coracoid,
thus releasing the superior glenohumeral ligament and coracohumeral ligament.
The inferior muscular portion of the SSC is separated from the underlying capsule,
the latter of which is then incised to the glenoid rim while protecting the axillary
nerve with a blunt retractor or gloved finger. The anterior capsule is then left on the
posterior aspect of the SSC (this helps to reinforce repair strength at closure) but
incised from inferior to superior at the capsulolabral junction.

Osteophytes are removed beginning anteriorly and extending inferiorly then
posteriorly to the infraspinatus insertions. The capsule is released on the humerus
as exposure progresses posteriorly. The entire humeral head can then be rotated
into the field of view en face (Figure 5). The glenoid is inspected and if glenoid
replacement is needed, we convert to a stemmed implant system. A glenoid can be
placed with the Copeland implant but we do not have any experience with that
procedure. If a resurfacing TSA is planned, an anterior-superior approach may be easier, given the more direct glenoid access.

Any glenoid work deemed to be necessary, can be performed at this time. There are times when manual debridement of the glenoid is required, rare microfracture or bone grafting of cysts is performed. Loose bodies, including those in the subcoracoid space, are removed, as they can impede postoperative SSC excursion.

The humeral head sizer is then used to determine the proper size implant observing head diameter and depth. A sizing chart allows for quick comparison of available sizes (Figure 6). The sizer is placed parallel to the anatomic neck of the humerus, which automatically sets inclination and version anatomically. A pin is drilled through the sizer to the lateral cortex of the humerus. The pin will be located in the anatomic center of the humeral head but may visually appear not to be centered if head deformity is present. The sizer is removed, leaving the pin in place. The corresponding color-coded head reamer is used to shape the head to match the underside of the implant chosen. Care must be taken to avoid toggle on the guide pin and avoid reaming into the cuff insertions. If during remaining, it is observed that the reamer is either too large of a diameter or too deep, a new size can be chosen from the chart and used without removing the central pin. It is better to err on the side of too small of an implant than too large. In the former, the end result will not be as affected, as the portion of head that remains uncovered will be replaced with fibrocartilage along the periphery. We have observed this in cases where arthroscopy has been done for rotator cuff issues years after successful
arthroplasty. Too large an implant can impinge on the cuff or overstuff the joint and inhibit post-operative motion.

Once the proper size is chosen and head reamed, the central peg reamer is used over the guide pin to create the peg hole. Cancellous bone reamings from this step are preserved for later use under the implant, if needed. The trial is placed and confirmation of size is made. If, at this stage, the implant size appears to be too large, a central peg adapter with guide pin can be placed in the central peg hole and the head can be reamed again.

Once proper size and fit of the trial is confirmed, any remaining cartilage or fibrous tissue is removed down to subchondral bone (but without penetrating this layer) with a high-speed burr. Small 2 mm drill holes are then placed into the subchondral bone to allow for marrow elements to egress and facilitate bone on-growth to the implant (Figure 7). The trial is placed again and any low spots identified and filled with bone graft. The trial is spun to skim off any excess graft, leaving the defects or low areas filled to the proper level. We use copious amounts of irrigation during the procedure starting with the soft tissue releases. However, no irrigation should be done after the drill holes are made until the final implant is placed, to avoid washing away the marrow elements and bone graft. The final implant is then gently impacted into place. Position and size are confirmed again. The shoulder is reduced and the humeral head should point directly to the glenoid center with the arm in neutral, which confirms anatomic version (Figure 8). Translation should allow for posterior translation with spontaneous reduction
when pressure is released. A minimum of 50% translation should be seen or the implant may not be seated completely or may be too large (depth).

If a glenoid work is desired, it is best to perform this after reaming the head but prior to reaming the center peg hole. This will maximize exposure and minimize bleeding from the peg hole. More extensive capsular releases around the glenoid may be required at this stage. In addition, a torn labrum and glenoid osteophytes need to be removed, as in stemmed TSA. If the labrum is intact, it is our preference to leave it *in situ* to prevent instability.

EAS Technique

The Copeland EAS implant is ideal for FCTA cases. The technique is essentially the same as for the primary Copeland resurfacing implant, except for a few extra steps to accommodate the lateral flange. The goal is to replace the articulating diseased cartilage surface, including the pathologic subacromial articulating fibrocartilage at the greater tuberosity.

After the peg hole is created, the EAS cutting block is placed with the laser mark oriented to the bicipital groove (Figure 9). It is fixed with pins and a small oscillating saw is used to remove a wafer of bone at the greater tuberosity. The anterior and posterior cutting slots are used to score the bone only. Avoid using the oscillating saw to complete these cuts, as the cuff insertions (SSC and infraspinatus, if present) may be compromised. These can be completed with an osteotome or rongeur and really are very small wedges at the corners of the implant. The trial is placed and if it does not seat, check for small ridges of bone at the flange levels.
These can be removed by hand with a small burr or a rongeur until the implant seats completely. Observe for any low spots that may need bone graft from the reamings. Place the trial and ensure that there is smooth transition from the lateral aspect of the flange to the lateral edge of the tuberosity and if needed, perform a tuberoplasty. Impact the final implant. Radiographs will demonstrate some normalization of the humeral head position as it is displaced lateral and inferior as compared to preoperatively, thus preserving favorable center of rotation (Figure 10).

With FCTA, it is imperative to avoid injuring the cuff insertions. If any infraspinatus can be repaired, this can be done with suture anchors after the final implant is placed. Supraspinatus tears should not be repaired if the EAS implant is used, as the indication for this device is a non-repairable tear. The subscapularis and the coraco-acromial ligament must be preserved or function may be compromised.

In both the primary Copeland and the EAS, the SSC is closed primarily using 4 #5 non-absorbable sutures in a modified Mason-Allen suture configuration. Suture anchors can be used if needed but the SSC should not be medialized or lengthened. This can lead to weakness and loss of force couples. The lateral portion of the rotator interval is closed with the arm adducted and full externally rotated.

We presented data on internal rotation strength (IRS) in our arthroplasty patients (resurfacing and stemmed) using this closure technique and found that IRS returned to near preop levels by 12 weeks after surgery. This was measured using accepted isometric technique with an isokinetic dynamometer.
Postoperatively, patients stay in the outpatient center until the next morning or can go home the evening of surgery if no drain is used. Gentle Codman exercises are started on day 1 and sling usage is used for 6 weeks just to protect the SSC repair, but not to immobilize the arm. The sling can be removed as tolerated. Patients avoid extremes of external rotation for 6 weeks based on intra-operative motion limits. Although not required, we use a formal accelerated rehab program coordinated by the same physical therapist (Appendix A). For those that live out of town, they visit with our physical therapist preoperatively and whenever they return to our office for clinical visits. The physical therapist communicates with and coordinates rehabilitation with a colleague in the patient’s hometown. If quality rehab is not available, it is best to have patients perform a self-directed therapy program and avoid the risk of overzealous stretching which can rupture the SSC repair in the first 6-8 weeks. Follow-up is routine, based on surgeon’s preference. We prefer clinical and radiographic evaluation at 1-2 weeks after surgery, 6 to 12 weeks, 6 months, 1 year, then annually.

In summary, we believe resurfacing arthroplasty is not a substitute for stemmed arthroplasty or TSA but is useful for patients who meet certain criteria. This includes younger or highly active individuals where implant survival with a stemmed TSA is a concern. It is also useful when there would be extreme difficulty accessing the humeral canal with a stem. Several authors have demonstrated comparable or superior results with resurfacing compared with stemmed arthroplasty at short and mid-term follow-up. Indications for EAS resurfacing are limited, in our hands, to patient with painful, non-repairable rotator cuff tears and
early FCTA. The technique preserves existing anatomy that has allowed the patient to maintain function, and only replaces cartilage at the painful articulations. The Copeland resurfacing design appears to be a durable implant and easily revisable, when needed, to stemmed TSA or reverse arthroplasty.

Suggested Reading


Appendix A: REHABILITATION FOLLOWING HUMERAL RESURFACING

General Guidelines

- Sling use directed by surgeon in post-operative instructions
- Immediate post-operative Passive and Active Assistive Range of Motion consisting of Stomach Rubs, Sawing Movements, and Elbow Range of Motion instructed following hospital discharge
- Initial post-operative range of motion limitations may be set by surgeon based on underlying shoulder mobility status and range of motion obtained in the OR post-implantation

Post Op Weeks 1-4

1.) Modalities to decrease pain and inflammation
2.) Passive range of motion initiated with no limitation in flexion, abduction, or internal rotation. **NO EXTERNAL ROTATION** stretching or anterior capsular mobilization in this rehabilitation phase to protect the subscapularis repair. Gentle PROM into external rotation allowed without overpressure up to 30 to 45° with 45° abduction. **NO EXTERNAL ROTATION ROM** in 90° Abduction during this phase.
3.) Elbow, wrist and forearm range of motion / stretching
4.) Manually applied scapular resistive exercise for protraction / retraction strengthening and scapular mobilization.
5.) No biceps manual resistance for initial 6-8 weeks due to bicep tenodesis performed with procedure.
6.) Ball approximation (Closed Chain Codman’s) using Swiss Ball or Table Top
7.) Initiation of active assistive range of motion using pulley for sagittal plane flexion and scapular plane elevation as well as supine active assistive exercise using a cane or stick

Post Op Weeks 4-6
1.) Continuation of above program
2.) Initiation of submaximal multiple angle isometrics and manual resistive exercise for shoulder external rotation, ab/adduction, flexion/extension. **No internal rotation resistive exercise** for initial 6 weeks to protect the subscapularis repair
3.) Upper body ergometer (UBE)
4.) External rotation isotonic exercise using pulley or weight/tubing with elbow supported and glenohumeral joint in scapular plane and 10-20 degrees of abduction (towel roll or pillow under axilla)
5.) Manual resisted external rotation exercise in scapular plane position by therapist in varying degrees of elevation (30-60 degrees) from full internal rotation position to neutral external rotation position.

**Post Op Weeks 6-8**

1.) Initiation of passive external rotation range of motion and stretching beyond 30-45° in 45 to 60° of abduction.
2.) Initiation of internal rotation submaximal resistive exercise progression
3.) Traditional rotator cuff isotonic exercise program
   a. Sidelying external rotation
   b. Prone extension
   c. Prone horizontal abduction (limited from neutral to scapular plane position initially with progression to coronal plane as ROM and scapular control improves)
4.) Biceps / Triceps curls in standing with glenohumeral joint in neutral resting position
5.) Oscillation exercise with flex bar or body blade
6.) Rhythmic stabilization in open kinetic chain environments
7.) Scapular stabilization exercise progression including seated rows, external rotation with retraction, low rows and serratus presses/punches
8.) Initiation of elevation progression consisting of rhythmic stabilization with shoulder on small Swiss ball in 80-90° in the scapular plane

**Post Weeks 12 - 24**

1.) Continuation of Rehabilitation
2.) Isometric Internal / External rotation strength testing assessment in neutral scapular plane position, functional rating scales SST, SANE and ASES.
3.) Addition of ball dribbling and upper body plyometrics with small Swiss ball
4.) Advanced rotator cuff and scapular exercise progressions
Figure Legends

1. Copeland Resurfacing Humeral Head Implant and Copeland EAS (Biomet, Warsaw, IN)

2. AP and axillary radiographs at 6 year follow-up after resurfacing arthroplasty

3. A: Note fibrocartilage remodeling at the greater tuberosity from chronic rotator cuff tear and articulation with the underside of the acromion; B Note reproduction of this same area and replacement with metal with the Copeland EAS implant (Biomet, Warsaw, IN)

4. Active elevation in a patient 6 years after EAS resurfacing arthroplasty

5. Operative technique: humeral head exposure must be complete in order to see the entire circumference

6. Operative technique: Copeland sizing chart demonstrating graduated increase in size with comparison of inside/outside diameter, radius of curvature and implant depth

7. Operative technique: Drill holes placed in subchondral bone prior to implant placement, after drilling for central peg
8. Operative technique: Final resurfacing implant in place and humeral head reduced on glenoid

9. Operative technique: Copeland EAS cutting block in place

10. AP radiograph of Copeland EAS implant in a patient who had failed multiple attempts at rotator cuff repair, yet had preserved function and pain
Figure 3

A                                                                           B

Figure 4
Figure 9

Figure 10