Joint Resurfacing

Policy

I. Aetna considers metal-on-metal hip resurfacing by means of a Food and Drug Administration (FDA)-approved device (e.g., Birmingham Hip Resurfacing (BHR) System, Cormet 2000) a medically necessary alternative to total hip arthroplasty for physically active non-elderly (less than 65 years of age) adult members when the following criteria are met:

A. Member has advanced joint disease demonstrated by:

1. Pain and functional disability that interferes with activities of daily living (ADLs) from injury due to osteoarthritis, avascular necrosis, or post-traumatic arthritis of the hip joint; and
2. Limited range of motion (ROM), antalgic gait, and pain in hip joint with passive ROM on physical examination: and
3. Radiographic or MRI supported evidence of severe osteoarthritis (as evidence by 2 or more of the following: subchondral cysts, subchondral sclerosis, periarticular osteophytes, joint subluxation, bone on bone articulation or joint space narrowing) of hip joint
primarily affecting the femoral head, or osteonecrosis (avascular necrosis) of the femoral head when the disease is detected early and there is less than 50% involvement of the femoral head; and

4. Normal proximal femoral bone geometry and bone quality; and

5. Member would otherwise require a conventional primary total hip replacement, but is likely to live longer than the functional lifespan of a traditional prosthesis; and

6. History of unsuccessful conservative therapy (non-surgical medical management) that is clearly addressed in the medical record (see Note). If conservative therapy is not appropriate, the medical record must clearly document why such approach is not reasonable: Members should have at least 12 weeks of non-surgical treatment documented in the medical record, including all of the following, unless contraindicated:

   a. Anti-inflammatory medications or analgesics; and
   b. Flexibility and muscle strengthening exercises, and
   c. Activity modification; and
   d. Supervised physical therapy (ADLs diminished despite completing a plan of care); and
   e. Weight reduction as appropriate; and
   f. Assistive device use, where appropriate; and
   g. Therapeutic injections into the hip, where appropriate.

B. Hip resurfacing is considered not medically necessary in persons with any of the following contraindications:

   1. Active infection of the joint or active systemic bacteremia that has not been totally eradicated; or
   2. Active skin infection (exception recurrent cutaneous staph infections) or open wound within the planned surgical site of the hip; or
3. Allergy to metals used in resurfacing (e.g., cobalt, chromium or alumina); or
4. Inactive and/or older individuals who are unlikely to require revisions of a traditional THR; or
5. Morbid obesity (body mass index (BMI) greater than 40); or
6. Member has inadequate bone stock to support the device; or
7. Member has been diagnosed with avascular necrosis (osteonecrosis) of the femoral head where more than 50% of the femoral head is affected; or
8. Member has severe anatomic deformity of the femoral head; or
9. Member is skeletally immature; or
10. Persons with moderate-to-severe renal insufficiency (glomerular filtration rate [GFR] less than 60 mL/min/1.73 m²); or
11. Multiple femoral neck cysts greater than 1 cm in diameter; or
12. Vascular insufficiency, muscular atrophy, or neuromuscular disease severe enough to compromise implant stability or postoperative recovery; or
13. Immunosuppression (i.e., AIDS) or high doses of corticosteroids; or
14. Females of child-bearing age due to the unknown effect of metal ion release on the fetus.

C. For members with significant conditions or co-morbidities, the risk/benefit of hip resurfacing should be appropriately addressed in the medical record.

II. Aetna considers metal-on-metal hip resurfacing experimental and investigational for developmental dysplasia of the hip and for all other indications because its effectiveness for these indications has not been established.

III. Aetna considers metal-on-polyethylene hip resurfacing
implants experimental and investigational because of insufficient evidence of their safety and effectiveness.

IV. For criteria for revision of hip resurfacing arthroplasty, see CPB 0287 - Total Hip Replacement (.//200_299/0287.html).

V. Aetna considers shoulder resurfacing, including total and hemi-resurfacing, experimental and investigational for the treatment of glenohumeral arthritis, humeral head fractures, osteochondral lesions, and for all other indications because of insufficient evidence of its effectiveness.

VI. Aetna considers knee resurfacing, partial knee resurfacing (e.g., Makoplasty), and isolated patellar resurfacing (e.g., UniCAP, HemiCAP) experimental and investigational because their effectiveness has not been established.

VII. Aetna considers metatarsal phalangeal (MTP) toe joint resurfacing experimental and investigational because its effectiveness has not been established.

See also CPB 0287 - Total Hip Replacement (.//200_299/0287.html) and CPB 0660 - Unicompartmental, Bicompartmental, and Bi-unicompartmental Knee Arthroplasties (0660.html).

Background

Hip Resurfacing:

Joint resurfacing arthroplasty, specifically hip resurfacing arthroplasty (HRA), may be considered as an alternative to conventional total hip replacement (THR). HRA does not remove the femoral head and neck or bone from the femur allowing for conversion to a THR, when necessary. The resurfacing procedure is designed for younger active individuals (typically less than 55 years of age) with viable bone in the proximal femur who is likely to outlive the prosthesis used in the THR procedure. Examples of U.S. Food and Drug Administration (FDA)-approved hip resurfacing systems include, but may not be limited to, Birmingham hip resurfacing system,
Conserve Plus total hip resurfacing system, ReCAP HA Press-Fit femoral resurfacing head and Cormet hip resurfacing system.

Hip resurfacing arthroplasty can either be categorized as a partial (hemi) or total resurfacing:

- Partial HRA is the removal of the damaged surface of the femoral head, which is then resurfaced with a metal shell. The socket is left intact.
- Total HRA involves both the femoral shell and the acetabulum (socket) cup. A metal shell is placed over the head of the femur as in a partial HRA; however, the damaged surface of the hip socket is also resurfaced.

Hip resurfacing has been promoted as an alternative to total hip replacement or for younger patients, to watchful waiting, and involves the removal and replacement of the surface of the femoral head with a hollow metal hemisphere. This hemisphere fits into a metal acetabular cup. The technique conserves femoral bone, maintains normal femoral loading and stresses. Because of bone conservation, it may not compromise future total hip replacements (THRs).

The metal-metal femoral resurfacing technique developed by Amstutz et al (1986) has been proposed as an alternative to metal-on-metal THR. In femoral resurfacing, the femoral head is re-shaped and capped with a metal ball, but the femoral head is not removed as in THR. Compared to THR, femoral resurfacing allows preservation of much more of the patient's own bone. The advantages of femoral resurfacing over THR is that it is less invasive, there is reduced thigh pain since there is no stem in the femoral canal, and that it may allow patients to be more active (an advantage especially for younger patients because the risk of dislocation is theoretically reduced because of the larger ball. In addition, if the femoral resurfacing fails, the surgeon can perform a THR. Unfortunately, the early designs tried by Amstutz had high failure rates. In addition, there are theoretical concerns that resurfacing may increase the risk of avascular necrosis of the femoral head. Femoral
resurfacing may become a first choice procedure (relative to THR) for patients with osteonecrosis of the femoral head, especially for young, active patients.

The United Kingdom National Institute for Clinical Excellence (2002) systematically reviewed the literature supporting hip resurfacing. The NICE review noted that only short-term (less than 5 years) outcomes data are available on metal-on-metal resurfacing hip arthroplasty. Long-term data are important because for THR, failure rates have been noted to increase substantially beyond 10 years. There are no randomized controlled clinical trials of metal-on-metal hip resurfacing arthroplasty. In addition, there are no studies directly comparing the outcomes of metal-on-metal resurfacing hip arthroplasty to THR or other alternatives, which limit the conclusions one can draw about the comparative effectiveness of these procedures.

The NICE recommended that metal-on-metal hip resurfacing be considered an option for people with advanced hip disease who would otherwise receive a conventional primary THR and are likely to live longer than the device is likely to last.

The NICE noted that, when considering a metal-on-metal hip resurfacing, surgeons should bear in mind:

- How active the individual is
- That the evidence resurfacing available at the moment for the clinical effectiveness and cost effectiveness of metal-on-metal hip comes mainly from studies that have involved people less than 65 years of age.

The NICE recommended that surgeons choose a device for hip resurfacing for which there is at least 3 years' evidence. This evidence should show that the device is likely to meet a target of less than 1 in 10 devices needing replacing over 10 years.

In an assessment prepared for the Canadian Coordinating Office for Health Technology Assessment, Allison (2005) stated that
minimally invasive hip resurfacing uses a smaller surgical incision and new techniques to expose the hip joint. Possible advantages include less damage to soft tissue, muscle and bone; smaller scars; less blood loss; and shorter hospital stays and rehabilitation. Possible disadvantages include damage to soft tissue, femur fracture, neurovascular damage, implant mal-position and a longer operating time.

Metal-on-metal resurfacing arthroplasty also represents an alternative for the treatment of patients with hip osteoarthritis. Daniel and colleagues (2004) stated that the results of conventional hip replacement in young patients with osteoarthritis have not been encouraging even with improvements in the techniques of fixation and in the bearing surfaces. Modern metal-on-metal hip resurfacing was introduced as a less invasive method of joint reconstruction for this particular group. The authors presented their findings of a series of 446 hip resurfacings (n = 384) performed by one of the authors using cemented femoral components and hydroxyapatite-coated uncemented acetabular components with a maximum follow-up of 8.2 years (mean of 3.3 years). Their survival rate, Oxford hip scores and activity levels were reviewed. Six patients died due to unrelated causes. There was 1 revision (0.02 %) out of 440 hips. The mean Oxford score of the surviving 439 hips is 13.5. None of the patients was told to change their activities at work or leisure; 31 % of the men with unilateral resurfacings and 28 % with bilateral resurfacings were involved in jobs that they considered heavy or moderately heavy; 92 % of men with unilateral hip resurfacings and 87 % of the whole group participate in leisure-time sporting activity. The extremely low rate of failure in spite of the resumption of high level occupational and leisure activities provided early evidence of the suitability of this procedure for young and active patients with osteoarthritis.

Lilikakis et al (2005) reported preliminary results of an uncemented, hydroxyapatite-coated femoral implant for metal-on-metal hip resurfacing. The pre-operative diagnosis was osteonecrosis in 1 patient, chondrolysis in 1 patient, and
osteoarthritis in the remaining 64 patients (68 hips). The survival rate of 70 implants after at least 2 years follow-up was 98.6%, with an excellent clinical outcome. There have been no femoral fractures, aseptic loosening, or radiolucencies around the stem. Thinning of the femoral neck at the inferomedial cup-neck rim has been a frequent radiological finding but with no clinical implication so far.

Pollard et al (2006) compared the 5- to 7-year clinical and radiological results of the metal-on-metal Birmingham hip resurfacing with a hybrid total hip arthroplasty in 2 groups of 54 hips, matched for gender, age, body mass index and activity level. Function was excellent in both groups, as measured by the Oxford hip score, but the Birmingham hip resurfacings had higher University of California at Los Angeles activity scores and better EuroQol quality of life scores. The total hip arthroplasties had a revision or intention-to-revise rate of 8%, and the Birmingham hip resurfacings of 6%. Both groups showed impending failure on surrogate end-points. Of the total hip arthroplasties, 12% had polyethylene wear and osteolysis under observation, and 8% of Birmingham hip resurfacings demonstrated migration of the femoral component. Polyethylene wear was present in 48% of the hybrid hips without osteolysis. Of the femoral components in the Birmingham hip resurfacing group which had not migrated, 66% had radiological changes of unknown significance.

An assessment by the BlueCross BlueShield Association Technology Evaluation Center (BCBSA, 2007) concluded that metal-on-metal total hip resurfacing meets the TEC criteria. The assessment found that a substantial body of evidence shows hip resurfacing "is associated with consistent and strong symptomatic and functional improvements at follow-up times up to 5 years." The assessment also found that hip resurfacing results are comparable to those obtained with current generation total hip arthroplasty at similar time points in patients younger than 65 years of age. The assessment noted that hip resurfacing differs procedurally from total hip arthroplasty in conserving a patient's native femoral bone.
When hip resurfacing patients subsequently require revision to total hip arthroplasty, the operation is technically similar to primary total hip arthroplasty and likely avoids the complications of revision of a primary total hip arthroplasty. The assessment concluded, therefore, that the benefits comprise initial hip resurfacing results as good as total hip arthroplasty and a simpler revision to total hip arthroplasty when needed. The assessment noted that, although longer-term (i.e., greater than 5 years) data on the relative durability of hip resurfacing compared to total hip arthroplasty are unavailable, current evidence is sufficient to conclude that hip resurfacing is a safe and effective means for initial surgical treatment in younger, properly selected patients who require a THR. The assessment explained that primary use of hip resurfacing in the indicated patient subpopulation thus defers standard total hip arthroplasty.

By contrast, an assessment by the California Technology Assessment Forum (CTAF, 2007) found that metal-on-metal hip resurfacing does not meet CTAF criteria. The CTAF assessment explained that there are no randomized clinical trials with either of the 2 currently approved devices that address the question of whether hip resurfacing is as safe and efficacious as total hip arthroplasty in comparable patients. The assessment noted that the peer-reviewed literature consists primarily of level 5 case series that report on the experience of a single surgeon operating at a single center with relatively short follow-up. The assessment identified several important questions that remain unanswered about hip resurfacing. These include questions about the long-term durability of hip resurfacing compared to total hip arthroplasty, questions about the short- and long-term results of total hip arthroplasty in persons who have undergone hip resurfacing, and whether there will be unforeseen long term complications that will make this revision more problematic than anticipated. The assessment also questioned what are the long-term health consequences of increased low levels of circulating metal ions produced by hip resurfacing. The assessment questioned whether outcomes of hip resurfacing will be as good as the
procedure is disseminated and performed by less experienced surgeons.

In a controlled prospective study, Knecht et al (2004) examined if there are differences in function after resurfacing arthroplasty of the hip in patients with primary osteoarthritis compared to patients with secondary osteoarthritis due to developmental dysplasia of the hip (DDH). Patients with primary osteoarthritis (n = 54, average age of 48.4 years) and osteoarthritis due to high-grade dysplasia (Eftekhari B, n = 34, average age of 55.8 years) were included in this study. Standardized clinical (Harris hip score [HHS]) and radiographical examinations were performed at 6 weeks, 3 months, 6 months, and then every year after the operation. All patients could be followed-up to 1.5 years (1 to 4 years) after surgery. The average HHS improved to 82 to 95 points in both groups 3 months post-operatively. Statistically significant differences could be found in the sub-scales "function" and "limp", where patients with DDH showed somewhat lower results after 6 (function) to 12 weeks (limp) post-operatively. This is probably attributable to extended non-weight-bearing after acetabular reconstruction in these cases, as the difference disappeared with full weight-bearing. Radiographically determined neck-shaft angles are slightly higher in dysplastic hips (142 degrees versus 135 degrees), but these researchers did not recognize any significant differences in implant positioning. The authors concluded that the short-term to mid-term results showed no clinically relevant functional differences after surface replacement in patients with primary osteoarthritis of the hip and patients with secondary osteoarthritis due to higher grade dysplasia. They stated that long-term observation is needed, however, to determine if these positive functional results are reflected by appropriate radiographical survival.

Amstutz and colleagues (2007) analyzed the mid-term results in a consecutive series of middle-aged patients with DDH treated with hybrid resurfacing joint arthroplasty. Metal-on-metal hip resurfacing was carried out in 51 patients (59 hips), 42 of whom were female. The average age at the time of surgery was 43.7
years. Radiographical and clinical data were collected at 6 weeks, at 3 months, and at yearly follow-up visits. Seven hips had Crowe type II DDH and 52 had type I. The follow-up period ranged from 4.2 to 9.5 years (average of 6.0). Initial stability was achieved in all but 3 hips. The clinical outcomes, as rated with the University of California at Los Angeles (UCLA) hip score, improved significantly compared with the pre-operative ratings. On the average, the pain rating improved from 3.2 to 9.3 points; the score for walking, from 6.0 to 9.7 points; the score for function, from 5.7 to 9.6 points; and the score for activity, from 4.6 to 7.3 points (all \( p = 0.0001 \)). The mean Short Form-12 (SF-12) mental score increased from 46.6 to 53.5 points, and the mean SF-12 physical score increased from 31.7 to 51.4 points (both \( p < 0.0001 \)). The mean post-operative HHS was 92.5 points. On the average, the range of flexion improved from 106 degrees to 129.6 degrees; the abduction-adduction arc, from 41.9 degrees to 76.9 degrees; and the rotation arc in extension, from 32.1 degrees to 84.8 degrees (all \( p = 0.0001 \)).

Four patients delivered a total of 6 healthy babies since the time of implantation of the prosthesis. Radiographical analysis showed a decrease in the mean body weight lever arm from 118.5 mm pre-operatively to 103.9 mm post-operatively (\( p = 0.007 \)). There were 5 femoral failures requiring conversion to a total hip arthroplasty. One hip showed a radiolucency around the metaphyseal femoral stem. There were no complete acetabular radiolucencies, and all sockets remained well-fixed. The authors concluded that the mid-term results of metal-on-metal resurfacing in patients with Crowe type I or II DDH were disappointing with respect to the durability of the femoral component. However, the fixation of the porous-coated acetabular components without adjuvant fixation was excellent despite incomplete lateral acetabular coverage of the socket. They stated that more rigorous patient selection and especially meticulous bone preparation are essential to minimize femoral neck fractures and loosening after this procedure.

Li and associates (2008) reported the findings of 21 consecutive patients (26 hips) with osteoarthritis secondary to DDH who underwent metal-on-metal hip resurfacing. Average age at the
time of surgery was 46.5 years (range of 37 to 59 years). Six patients (28.6%) were men and 15 (71.4%) were women. During the same period, another 21 patients (26 hips) with DDH secondary to osteoarthritis were treated with ceramic-on-ceramic total hip arthroplasty (THA). Average patient age at the time of surgery was 48.2 years (range of 38 to 64 years). At follow-up, no complications (e.g., dislocation, infection, or symptomatic deep venous thrombosis) occurred in the 2 groups. No significant difference was noted in HHS between the 2 groups, but the average range of motion (ROM) of the hip resurfacing group was significantly better than the THA group (p < 0.05). All patients reported significant pain relief on their operated hips, with the post-operative visual analog scale scores less than 2. No signs of early loosening were observed on radiographs. The authors concluded that the short-term results of the metal-on-metal hip resurfacing have been encouraging in the treatment of DDH, with better range of motion recovery than conventional THA.

Wang et al (2008) examined the clinical results of metal-on-metal hip resurfacing arthroplasty for patients with DDH. A total of 34 cases of DDH (Crowe types I and II) were attempted to have metal-on-metal hip resurfacing arthroplasty. There were 29 females (32 hips), 5 males (5 hips). The average age was 45 years old (range of 26 to 57). Radiographical and clinical evaluations were taken at 6 weeks, 3 months, 1 year and then once-yearly post-operatively. The average HHS was 35 (range of 25 to 44). Hip flexion was 101 degrees, abduction 24 degrees, adduction 15 degrees. Three patients were turned to THA during operations; 31 patients (34 hips) received hip resurfacing surgery. These 31 patients were followed for an average of 21.4 months (range of 12 to 33 months). The average HHS was 94 (range of 82 to 100) at the latest follow-up, and there was statistical difference compared with the pre-operative score (p < 0.01). Hip flexion increased to 133 degrees, abduction to 48 degrees, adduction to 26 degrees. No radiolucency line was found at both acetabular and femoral sides in all the patients. The average abduction angle of acetabular cup was 43 degrees (range of 40 to 53), and the average stem shaft angle was 139
degrees (range of 130 to 145). The authors concluded that the short-term result is excellent. They stated that mid-term to long-term results for hip resurfacing arthroplasty in patients with DDH are being awaited.

McBryde et al (2008) performed metal-on-metal hip resurfacing for DDH in 96 hips in 85 patients (78 in women and 18 in men) with a mean age at the time of surgery of 43 years (range of 14 to 65). These cases were matched for age, gender, operating surgeon and date of operation with a group of patients with primary osteoarthritis who had been treated by resurfacing, to provide a control group of 96 hips (93 patients). A clinical and radiological follow-up study was performed. The dysplasia group were followed for a mean of 4.4 years (range of 2.0 to 8.5) and the osteoarthritis group for a mean of 4.5 years (range of 2.2 to 9.4). Of the dysplasia cases, 17 (18 %) were classified as Crowe type III or IV. There were 5 (5.2 %) revisions in the dysplasia group and none in the osteoarthritic patients. Four of the failures were due to acetabular loosening and the other sustained a fracture of the neck of femur. There was a significant difference in survival between the 2 groups (p = 0.02). The 5-year survival was 96.7 % (95 % confidence interval [CI]: 90.0 to 100) for the dysplasia group and 100 % (95 % CI: 100 to 100) for the osteoarthritic group. There was no significant difference in the median Oxford hip score between the 2 groups at any time during the study. The medium-term results of metal-on-metal hip resurfacing in all grades of DDH are encouraging, although they are significantly worse than in a group of matched patients with osteoarthritis treated in the same manner.

Naal and associates (2009) evaluated 24 patients (32 hips; mean age of 44.2 years) after hip resurfacing performed for osteoarthritis secondary to DDH. These investigators used the HHS, the UCLA activity scale, and a sports and activity questionnaire. A radiographical analysis also was performed. They followed patients a minimum of 28 months (mean of 43 months; range of 28 to 60 months). The HHS improved from a mean of 54.7 to 97.3 and UCLA activity levels increased from a
mean of 5.3 to 8.6. All patients returned to sports activity at a mean of 11 weeks after surface replacement. There were no major differences in pre-operative and post-operative participation in the most common sports and activities. Two of the 32 replacements (6%) failed. These researchers detected femoral radiolucencies in 10 of the remaining 30 hips. Despite satisfactory outcomes in clinical scores, return to sports, and hip biomechanics, the failure rate of 6% was disappointing. The authors concluded that additional follow-up is important to assess if failure rates increase in these young, active patients.

Prosser and colleagues (2010) stated that the outcome of modern resurfacing remains to be determined. The Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR) started collection of data on hip resurfacing at a time when modern resurfacing was started in Australia. The rate of resurfacing has been higher in Australia than in many other countries. As a result, the AOANJRR has one of the largest series of resurfacing procedures. This study was undertaken to determine the results of this series and the risk factors associated with revision. Data from the AOANJRR were used to analyze the survivorship of 12,093 primary resurfacing hip replacements reported to the Joint Replacement Registry between September 1999 and December 2008. This was compared to the results of primary conventional THR reported during the same period. The Kaplan-Meier method and proportional hazards models were used to determine risk factors such as age, sex, femoral component size, primary diagnosis, and implant design. Female patients had a higher revision rate than males; however, after adjusting for head size, the revision rates were similar. Prostheses with head sizes of less than 50 mm had a higher revision rate than those with head sizes of 50 mm or more. At 8 years, the cumulative percent revision of hip resurfacing was 5.3 (4.6 to 6.2), as compared to 4.0 (3.8 to 4.2) for total hip replacement. However, in osteoarthritis patients aged less than 55 years with head sizes of 50 mm or more, the 7-year cumulative percent revision for hip resurfacing was 3.0 (2.2 to 4.2). Also, hips with dysplasia and some implant designs had an increased risk of
revision. The authors concluded that risk factors for revision of resurfacing were older patients, smaller femoral head size, patients with developmental dysplasia, and certain implant designs.

Hartmann and colleagues (2012) examined if the long-term survival rate of hip resurfacing is comparable to that of conventional THA and certain factors can be identified that influence serum ion concentration 10 years post-operatively. These investigators specifically assessed (i) the 10-year survivorship in the whole cohort and in male and female patients, (ii) serum concentrations of metal ions in patients with hip resurfacing who had not undergone revision surgery, and (iii) potential influencing factors on the serum ion concentration. These researchers retrospectively reviewed their first 95 patients who had 100 hip resurfacings performed from 1998 to 2001. The median age of the patients at surgery was 52 years (range of 28 to 69 years); 49 % were men. They assessed the survival rate (revision for any reason as the end point), radiographical changes, and serum ion concentrations for cobalt, chromium, and molybdenum. The correlations between serum ion concentration and patient-related factors (age, sex, BMI, activity) and implant-related factors (implant size, cup inclination, stem-shaft angle) were investigated. The minimum follow-up was 9.3 years (mean of 10 years; range of 9.3 to 10.5 years). The 10-year survivorship was 88 % for the total cohort. The overall survival rate was greater in men (93 %) than in women (84 %). Median serum ion levels were 1.9 μg/L for chromium, 1.3 μg/L for cobalt, and 1.6 μg/L for molybdenum. Radiolucent lines around acetabular implants were observed in 4 % and femoral neck thinning in 5 %. The authors concluded that although their overall failure rate was greater than anticipated, the relatively low serum ion levels and no revisions for pseudotumors in young male patients up to 10 years post-operatively provide some evidence of the suitability of hip resurfacing in this subgroup.

Vendittoli et al (2013) compared metal-on-metal hip resurfacing
with 28-mm diameter metal-on-metal THR. A total of 219 hips in 192 patients aged between 18 and 65 years were randomized to 28-mm metal-on-metal uncemented THRs (107 hips) or hybrid hip resurfacing (HR, 112 hips). At a mean follow-up of 8 years (6.6 to 9.3), there was no significant difference between the THR and HR groups regarding rate of revision (4.0 % (4 of 99) versus 5.8 % (6 of 104), p = 0.569) or re-operation rates without revision (5.1 % (5 of 99) versus 2.9 % (3 of 104), p = 0.428). In the THR group, 1 recurrent dislocation, 2 late deep infections and 1 peri-prosthetic fracture required revision, whereas in the HR group 5 patients underwent revision for femoral head loosening and 1 for adverse reaction to metal debris. The mean University of California, Los Angeles activity scores were significantly higher in HR (7.5 (S.D. 1.7) versus 6.9 (S.D. 1.7), p = 0.035), but similar mean Western Ontario and McMaster Universities Osteoarthritis Index scores were obtained (5.8 (S.D. 9.5) in HR versus 5.1 (S.D. 8.9) in THR, p = 0.615) at the last follow-up. Osteolysis was found in 30 of 81 THR patients (37.4 %), mostly in the proximal femur, compared with 2 of 83 HR patients (2.4 %) (p < 0.001). At 5 years the mean metal ion levels were less than 2.5 μg/L for cobalt and chromium in both groups; only titanium was significantly higher in the HR group (p = 0.001). The authors concluded that although revision rates and functional scores were similar in both groups at mid-term, long-term survival analysis is needed to determine whether one procedure is more advantageous than the other.

**Shoulder Resurfacing:**

Shoulder resurfacing arthroplasty was designed as a possible alternative to conventional total shoulder replacement and reportedly replaces a smaller portion of the humeral head than the conventional shoulder replacement surgery. Supposedly, this procedure is viewed as a potential alternative for people who are younger, physically active and have advanced or end stage degenerative joint disease or arthritis. Total shoulder replacement is not an option for rotator cuff tear that is not repairable. An example of an FDA-approved device for shoulder
resurfacing arthroplasty includes, but may not be limited to, the Copeland resurfacing head.

Shoulder resurfacing is a more conservative approach to conventional total shoulder replacement (TSR) surgery for the treatment of glenohumeral arthritis, humeral head fractures, and osteochondral lesions. It is being explored as an option for shoulder replacement, especially in younger, more active adults. Resurfacing replaces only the damaged or diseased part of the humeral head instead of the entire joint. During shoulder resurfacing, the humeral head is re-shaped and replaced with a metal covering, or cap, thus preserving the bone of the proximal part of the humerus. Shoulder resurfacing can be performed with devices that provide complete or partial coverage and can be done alone (hemi-resurfacing) or in combination with glenoid replacement (total shoulder resurfacing). If the glenoid is replaced, a polyethylene glenoid replacement prosthesis or an interposed soft tissue graft is used. Shoulder resurfacing is potentially less traumatic, less invasive, and preserves more bone. Since the bone stock has been maintained, revision to a conventional TSR can be undertaken, if needed.

Several prosthetic designs are currently available in the United States. The implants are constructed from cobalt-chromium or a titanium-alloy. Some have a ceramic surface coating, while others provide a titanium porous coating on the undersurface where the implant rests against the bone. Examples of brands of shoulder resurfacing include Copeland Extended Articulating Surface (EASTM) Resurfacing Heads, DePuy Global Cap, CTA Resurfacing Shoulder Humeral Head, Axiom Shoulder Resurfacing System, and HemiCAP (also referred to as Contoured Articular Prosthetic (CAP) Humeral Head Resurfacing Prosthesis).

The Interlok/HA Copeland Resurfacing Heads (Biomet, Inc., Warsaw, IN) received 510(k) marketing clearance from the U.S. Food and Drug Administration in 2001. These devices are intended for uncemented use and are designed to maintain
maximum bone stock by removing minimal bone and replacing only the defective surface. The spherical humeral heads contain a tapered, fluted stem for fixation with an interlok and a hydroxyapatite surface finish to the stem and inside spherical radius.

Levy and Copeland (2001) reported their experience using the Copeland Mark-2 prosthesis (Biomet, Inc., Warsaw, IN) during cementless surface replacement arthroplasty in a case-series study of 103 treated shoulders with a mean follow-up of 6.8 years. The authors reported that 93.9 % of the patients considered their shoulder to be much better or better than before the operation. Radiological review showed no evidence of radiolucency in 61 of 88 humeral implants (69.3 %). Eight shoulders required revision (7.7 %), 5 of which were revised to a stemmed humeral component. Mild subluxation of the humeral head was observed in 15 shoulders, moderate superior migration was observed in 7, and severe superior subluxation with obliteration of the acromiohumeral interval was observed in 8.

In another case-series study of the Copeland prosthesis by the same investigators (Levy and Copeland, 2004), 79 cementless surface replacement arthroplasties (total shoulder resurfacing = 42, hemiarthroplasty = 37) were performed for primary osteoarthritis of the shoulder. The mean follow-up was 7.6 years (range of 48 months to 13 years) for total shoulder resurfacing and 4.4 years (range of 24 months to 6.5 years) for hemiarthroplasty. The investigators reported that 89.9 % of the patients considered the shoulder to be much better or better as a result of the operation. Radiological review showed 1 humeral implant and 3 glenoid implants had evidence of loosening. Four revisions were performed in the total shoulder resurfacing group. No revision surgery was needed in the hemiarthroplasty group.

A case-series study (52 patients, 56 shoulders) by Thomas et al (2005) of humeral head surface replacement hemiarthroplasty using the Copeland prosthesis for treatment of osteoarthritis (n
= 20), rheumatoid arthritis (n = 26), rotator cuff arthropathy (n = 1), and post-traumatic arthroposis (n = 1) with a mean follow-up of 34 months (mean age of 68 years) reported comparable results to Copeland's series.

These small case-series reports with the Copeland prosthesis indicated that most patients experienced improvements in motion, pain, and strength in the short- and mid-term; however, overlap in patients between the same investigators is likely and there are no randomized controlled studies comparing outcomes to traditional shoulder replacement surgery.

Fuerst et al (2007, 2008) evaluated the mid-term results of the DUROM cup (Zimmer, Switzerland) surface replacement in a cohort of 35 patients (42 shoulders) with rheumatoid arthritis affecting the glenohumeral joint. Thirty-five shoulders in 29 patients (average age of 61.4 years) were evaluated prospectively after an average follow-up period of 73 months. The mean Constant score for the 35 shoulders increased from 20.8 points pre-operatively to 64.3 points at a mean of 73.1 months post-operatively. There were 3 revisions: (i) to replace an implant that was too large, (ii) to treat glenoid erosion, and (iii) due to loosening of the implant. Over the 5-year follow-up period, proximal migration of the cup increased in 63% of the shoulders, and the glenoid depth increased in 31%. The authors concluded that these mid-term results of the cemented DUROM cup are very encouraging and that the advantage of cup arthroplasty is the less complex bone-sparing surgery and in the event of failure of the implant, other reliable salvage options remain.

Buchner et al (2008) compared short-term functional results after cementless surface replacement of the humeral head (CUP) with those obtained after TSR for osteoarthrosis of the shoulder. A total of 22 patients (average age of 61.4 years) with primary osteoarthrosis who obtained surface replacement of the humeral head were compared to a control group of 22 TSR patients (average age of 61.1 years). Patients in the CUP group
showed significantly better peri-operative results (time of surgery, blood loss, days of in-patient treatment) compared to the patients in the TSR group. Both groups showed significant improvement in clinical function and pain reduction and had high subjective satisfaction rates; however, the TSR group showed a statistically significant improvement in mobility, abduction, and range of motion compared to the CUP group at 12 months. Two CUP implants had to be removed during the follow-up period owing to secondary glenoidal erosion. The authors concluded that at short-term follow-up, surface replacement is technically less demanding and provided only slightly inferior results to TSR.

Raiss et al (2010) reported the results from a prospective study of cementless humeral surface replacement arthroplasty in 23 patients (26 implants) less than 55 years of age treated with cementless humeral surface replacement with a mean follow-up of 2.5 years. Ten patients had post-traumatic osteoarthritis, 7 had primary osteoarthritis, and 6 had osteonecrosis. Patients were evaluated using the Constant score, shoulder motion, and subjective satisfaction. The mean Constant score increased significantly from 33 points pre-operatively (8 to 69 points) to 61 points post-operatively (25 to 83 points; p < 0.0001), adjusted to age and gender from 38 % (8 to 86 %) to 70 % (28 to 114 %; p < 0.0001). Significant improvement for the whole cohort was found regarding patients’ pain, activity, mobility, shoulder flexion and abduction, and internal and external rotation (p < 0.001). In 1 case, re-operation was necessary due to a superficial wound infection, and in another case, implant revision to a TSR was performed because of glenoid erosion. The authors concluded that cementless humeral surface replacement arthroplasty is a viable bone-preserving treatment option for young and active patients and that later conversion to TSR is possible; however, long-term investigations are necessary to confirm these observations.

Biological glenoid resurfacing with or without prosthetic humeral head replacement has been suggested as a means to
avoid the potential complications of polyethylene use in younger patients with glenohumeral arthritis. A variety of biologic surfaces, including anterior capsule, autogenous fascia lata, and Achilles tendon allograft, have been used; however, there is little evidence in the peer-reviewed literature that these biological grafts can provide a durable bearing surface over time. Poor clinical outcomes related to persistent postoperative infection have also been reported (Elhassan et al, 2009).

de Beer and colleagues (2010) analyzed the intermediate-term findings of arthroscopic debridement and biological resurfacing of the arthritic glenoid in a middle-aged population using an acellular human dermal scaffold. Between 2003 and 2005, a total of 32 consecutive patients underwent an arthroscopic debridement and biological glenoid resurfacing for glenohumeral arthritis. The diagnoses included primary osteoarthritis (n = 28), arthritis after arthroscopic reconstruction for anterior instability (n = 1) and inflammatory arthritis (n = 3). All shoulders were assessed clinically using the Constant and Murley score, and results graded according to Neer's criteria. Statistical analysis was performed to determine significant parameters and associations. A significant improvement (p < 0.0001) in each parameter of the subjective evaluation component (severity of pain, limitation in daily living and recreational activities) of the Constant score was observed. The Constant and Murley score increased significantly (p < 0.0001) from a median of 40 points (range of 26 to 63) preoperatively to 64.5 (range of 19 to 84) at the final assessment. Overall, the procedure was considered as "successful outcome" in 23 patients (72 %) and as a "failure" in 9 patients (28 %). According to Neer's criteria, the result was categorized as excellent in 9 (28 %), satisfactory in 14 (44 %) and unsatisfactory in 9 (28 %). Within the unsatisfactory group, there were 5 conversions to prosthetic arthroplasty. A standard magnetic resonance imaging was performed on 22 patients in the successful outcome group; glenoid cartilage was identified in 12 (thick in 5, intermediate in 1, thin in 6) and could not be identified in 10 patients (complete/incomplete loss in 5,
technical difficulties in 5). Overall, 5 complications included transient axillary nerve paresis, foreign-body reaction to biological material, inter-layer dissociation, mild chronic non-specific synovitis and post-traumatic contusion. Dominance of affected extremity and generalized disease (diabetes, rheumatoid arthritis, generalized osteoarthritis) was associated with an unsatisfactory outcome (p < 0.05). The authors concluded that arthroscopic debridement and biological resurfacing of the glenoid is a minimally invasive therapeutic option for pain relief, functional improvement and patient satisfaction in glenohumeral osteoarthritis, in the intermediate-term. Long-term data are needed to ascertain the value of shoulder resurfacing.

Elser et al (2010) discussed surgical decision making and up-to-date summaries of the current techniques available to treat both focal chondral defects and more massive structural osteochondral defects of the shoulder. These techniques include microfracture, osteoarticular transplantation (osteochondral autograft transfer system [OATS]), autologous chondrocyte implantation, bulk allograft reconstruction, as well as biologic resurfacing. The authors stated that as new approaches to glenohumeral cartilage repair and shoulder joint preservation evolve, there continues to be a heightened need for collaborative research and well-designed outcomes analysis to facilitate successful patient care.

While shoulder resurfacing appears to be a promising new procedure for the treatment of glenohumeral arthritis, humeral head fractures, and osteochondral lesions, long-term data from randomized controlled studies are lacking. Further studies to assess the long-term outcomes and to evaluate alternative surface bearing materials, especially on the glenoid side are needed.

Gobezie et al (2011) noted that the treatment of advanced, bipolar glenohumeral osteoarthritis in the young patient is particularly challenging because of the expected failure of a traditional shoulder arthroplasty within the patient's lifetime.
These investigators have had early success performing osteochondral allograft resurfacing of the humeral head articular surface and glenoid articular surface, and they described a new all-arthroscopic technique for performing this procedure. In the context of their new procedure, these researchers have reviewed the available literature on the topic of biologic resurfacing with osteochondral allograft and have provided an overview of the relevant findings. Although only short-term follow-up data are available, their results in young patients have been promising in terms of regained motion, minimal pain, and accelerated rehabilitation. The authors believed that this new arthroscopic biologic shoulder resurfacing technique has the potential to be superior to other available treatments for this patient population because it preserves bone stock, limits damage to surrounding structures, and allows for early rehabilitation. They stated that although longer-term follow-up is needed, early results have been greatly encouraging.

Longo et al (2011) stated that young patients with degenerative shoulder disease are a therapeutic challenge. To try to delay a shoulder arthroplasty, biological interpositional arthroplasty has been proposed to provide a biologically active bearing surface that could eventually result in the formation of fibrocartilage, fibrous tissue, or hyaline cartilage. Anterior capsule, autogenous fascia lata, Achilles tendon allograft, lateral meniscus allograft, human dermis, and porcine small intestine submucosa have been used as interposition material, either alone or in combination with a hemiarthroplasty or humeral resurfacing procedure. Some investigators have reported favorable long-term results, although others have found this procedure unreliable. Several variables are unknown at present, such as the best biological resurfacing device, healing potential, possible antigenic responses, optimal fixation technique or position, aftercare restrictions. The authors concluded that further prospective studies with long follow-up are necessary to provide data that will help to define the role of biological glenoid resurfacing in young patients with glenohumeral arthritis.
Lee and colleagues (2013) noted that there is a lack of consensus in treating glenohumeral arthritis in younger patients. Hemi-arthroplasty has historically been favored because of complications associated with total shoulder arthroplasty. Biologic resurfacing of the glenoid has been investigated as a potential treatment that would decrease glenoid erosion and pain, the major complications of hemi-arthroplasty. These investigators reported on 19 shoulders treated with meniscal allograft glenoid resurfacing and shoulder hemi-arthroplasty. All patients were followed-up for a minimum of 2 years post-operatively (mean of 4.25 years) with Disabilities of the Arm, Shoulder and Hand (DASH), Simple Shoulder Test (SST), and visual analog scale (VAS) scores. In addition, these researchers compared the outcomes related to pre-operative concentric versus eccentric glenoid wear. At final follow-up, the mean score for the DASH questionnaire was 28; SST, 8; and VAS, 3.5. Whereas the eccentric wear group (DASH score, 19.4; SST score, 9.1; VAS score, 2.5) exhibited better shoulder function and pain scores compared with the concentric wear group (DASH score, 37.6; SST score, 8.4; VAS score, 4.1), the difference was not statistically significant (p = 0.098, p = 0.647, and p = 0.198, respectively). There were 6 complications (32%), all resulting in repeat surgery. Three patients underwent total shoulder arthroplasty and 1 shoulder had revision hemi-arthroplasty, whereas synovectomy was performed in another shoulder. The 6th patient underwent lysis of adhesions and capsular release. The authors concluded that with long-term follow-up, they have observed that biologic resurfacing of the glenoid with meniscal allograft exhibited inconsistent results and high complication rates. They stated that strong consideration should be given to performing total shoulder arthroplasty in patients in whom all conservative treatment options have failed.

Merolla and associates (2013) reported clinical and radiographic mid-term outcomes in a population of 60 patients, aged 50 years or younger, who underwent shoulder resurfacing in osteoarthritis. The mean age was 48 ± 8.4 years, 36 were male and 24 female, dominant arm in 43 cases. Glenoid
arthritis was treated in 36 cases (60%) using a meniscus allograft in 22 cases, biologic patch in 4 cases and microfractures in 10 cases. Clinical and radiographic assessment was performed with Constant-Murley score and standard X-ray. At an average follow-up of 44 months, the mean values of the constant score increased 30 points (p < 0.05), the pain decreased of 4.56 points (p < 0.05) and the Simple Shoulder Test increased 4.3 points (p < 0.05). These researchers found lower scores (p > 0.05) in 9 patients (15%) treated for glenoid arthritis using homologous meniscus (7 cases) and biologic patch (2 cases). A significant narrowing of joint space (5.92 mm post-operative versus 1.65 mm at 37 months) (p < 0.05) was found in the 22 cases treated with meniscus interposition. In 4 cases with type A2 pre-operative glenoid morphology and in 9 cases type B1; these investigators registered significantly lower scores compared with the overall study population (p < 0.01). There were 5 unsatisfied patients (7%) – they underwent meniscus removal and glenoid reaming in 3 cases, and conversion in total shoulder arthroplasty in 2 cases. The authors concluded that resurfacing arthroplasty is an effective device in young patients with advanced glenohumeral arthropathy; however, the high rate of post-operative glenoid erosion and the failure of biologic allograft lead them to consider glenoid replacement as the best option to improve clinical outcomes.

Sweet and colleagues (2015) stated that humeral head defects such as degenerative disease or avascular necrosis are often treated with stemmed hemi-arthroplasty or total shoulder arthroplasty. Despite its historical and clinical significance, stemmed humeral head replacement poses inherent technical challenges to placing spherical implants at the anatomically correct head height, version, and neck-shaft angle. In a case-series study, these investigators evaluated humeral head inlay arthroplasty as a joint-preserving alternative that maintains the individual head-neck-shaft anatomy. Humeral head inlay arthroplasty also allows intra-operative surface mapping and placement of a contoured articular component that is matched to the patient’s defect size, location, and
individual surface geometry. This retrospective case series included 19 patients (20 shoulders), with an average age of 48.9 years (range of 32 to 58 years; 3 women and 16 men). Pre-operative diagnoses were osteoarthritis in 16 shoulders and osteonecrosis in 4 shoulders. Pre- and post-operative evaluations included physical examination, radiographic assessment, the American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form, the Simple Shoulder Test, a pain VAS, and patient satisfaction rating. The mean follow-up period was 32.7 months (range of 17 to 66 months). The mean American Shoulder and Elbow Surgeons score improved from 24.1 to 78.8, mean Simple Shoulder Test score from 3.95 to 9.3, mean VAS score from 8.2 to 2.1, mean forward flexion from 100° to 129°, and mean external rotation from 23° to 43° (p < 0.001 for all). Radiographic follow-up showed no evidence of peri-prosthetic fracture, component loosening, osteolysis, or device failure. Patient shoulder self-assessment was 90 % poor before surgery and improved to 75 % good-to-excellent at last follow-up; 20 % of patients self-rated as somewhat good-to-somewhat poor, and 5 % self-rated as poor; 90 % of patients were satisfied with the choice of the procedure. Three patients had post-operative complications unrelated to the implants, including a partial rotator cuff tear treated with physical therapy, pre-existing glenoid wear treated with arthroscopic debridement and microfracture, and infection complicated by subscapularis rupture requiring several subsequent surgical procedures but with retention of the implant. The authors concluded that humeral head inlay arthroplasty is effective in providing pain relief, functional improvement, and patient satisfaction. They noted that rather than delaying shoulder arthroplasty to end-stage osteoarthritis, humeral head inlay arthroplasty is a promising new direction in primary shoulder arthroplasty for younger and active patients with earlier stage disease. This retrospective case-series study provided level 4 evidence regarding the clinical value of the HemiCAP implant for shoulder arthroplasty.

Schmidutz and colleagues (2015) noted that cementless-
surface-replacement-arthroplasty (CSRA) of the shoulder aims for functional joint restoration with minimal bone loss. Good clinical results have been reported, but due to the radiopaque metal shell no data are available on the structure, osseous integration, and bone stock under the implant. In this study, a total of 14 hemi-CSRAs (4 manufacturers) with 2 geometries (crown \([n = 7]\)/stem \([n = 7]\) fixation) were retrieved from patients undergoing revision due to glenoidal erosion. Histological sections cutting through the implant center and bone were analyzed. Quantitative histo-morphometry evaluated the bone-implant-contact and compared the bone-area to native humeral retrievals \((n = 7)\). The bone-implant-interface was further assessed by scanning- electron-microscopy (SEM) and energy-dispersive-x-ray (EDX). Qualitative histology revealed a reduced and inhomogeneous bone stock. Obvious signs of stress shielding were observed with bone predominantly visible at the stem and implant rim. Quantitative histo-morphometry confirmed the significantly reduced bone-area \((9.2 \pm 3.9 \% \text{ [crown]} 9.9 \pm 4.3 \%, \text{ stem } 8.6 \pm 3.6 \%)) compared to native humeri \((21.2 \pm 9.1 \%); p < 0.05)\). Bone-implant-contact was \(20.5 \pm 5.8 \% \text{ [crown]} 21.8 \pm 6.2 \%, \text{ stem } 19.2 \pm 5.6 \%)\), which was confirmed by SEM and EDX. The authors concluded that CRSA showed satisfactory bone ingrowth at the interface suggesting sufficient primary stability to allow osseous integration. Moreover, they stated that clear signs of stress shielding with an inhomogeneous and reduced bone stock were observed; and the impact on the long-term results is unclear requiring further investigation.

**Knee/Partial Knee/ Patellar Resurfacing**

Knee resurfacing arthroplasty was designed as an alternative to conventional total knee replacement. Reportedly, these devices do not require that bone tissue be removed. This technology is purportedly viewed as an alternative for individuals who are:

- Between 40 and 60 years
- Have early stage osteoarthritic damage which is confined to the inside of the knee
Examples of FDA-approved knee resurfacing systems include, but may not be limited to, the HemiCAP patello-femoral resurfacing prosthesis and the UniCAP compartmental resurfacing implant system.

The UniCAP Bipolar Knee Resurfacing System (Arthrosurface, Inc., Franklin, MA) was introduced in 2008 as an alternative to allow for a delay in traditional joint replacement procedures. It utilizes intraoperative, 3-dimensional joint surface mapping to fit and implant defect-sized components that are matched to the individual joint surface (Miniaci, 2014).

Available evidence for focal resurfacing of the knee joint is limited to small studies without internal comparison groups and with limited followup. The Work Loss Data Institute’s guideline on “Knee & leg (acute & chronic)” (2013) listed focal joint resurfacing (Arthrosurface HemiCAP/UniCAP) as one of the interventions that were considered, but not recommended.

Dhollander et al (2015) described the clinical and radiographical outcome of the HemiCAP resurfacing system as a salvage treatment for a failed index cartilage procedure. A total of 14 patients were treated consecutively and clinically prospectively followed for a mean period of 26.1 ± 12.8 months. All patients were previously treated for their cartilage lesion. Radiographical data were analyzed based on the Kellgren and Lawrence system. The patients involved in this study demonstrated a gradual clinical improvement in time. However, radiographically significant osteoarthritic changes were observed during the follow-up period. The position of the HemiCAP® resurfacing system was adequate in all cases, and no signs of loosening were observed during the follow-up period. The authors concluded that the HemiCAP resurfacing system is feasible as a salvage treatment for a failed index cartilage procedure and resulted in a gradual clinical improvement. However, the favorable clinical outcome was not confirmed by
the radiographical findings.

Imhoff et al (2015) prospectively evaluated the clinical, radiographic, and sports-related outcomes at 24 months after isolated and combined patellofemoral inlay resurfacing (PFIR). Between 2009 and 2010, 29 consecutive patients with patellofemoral osteoarthritis (OA) were treated with the HemiCAP Wave Patellofemoral Resurfacing System. Based on preoperative findings, patients were divided into 2 groups: group I, isolated PFIR (n = 20); and group II, combined PFIR with concomitant procedures to address patellofemoral instability, patellofemoral malalignment, and tibiofemoral malalignment (n = 9). Patients were evaluated preoperatively and at 24 months postoperatively. Clinical outcomes included the Western Ontario and McMaster Universities Arthritis Index (WOMAC), subjective International Knee Documentation Committee (IKDC), pain VAS, Tegner activity score, and a self-designed sports questionnaire. Kellgren-Lawrence grading was used to assess progression of tibiofemoral OA. The Caton-Deschamps Index was used to assess differences in patellar height. The investigators reported that 27 patients (93 %) were available for 24-month follow-up; 81 % of the patients were either satisfied or very satisfied with the overall outcome. Significant improvements in the WOMAC, subjective IKDC, and Pain VAS were seen in the overall patient cohort and in both subgroups. The median Tegner score and sports frequency showed a significant increase in the overall patient cohort and in group II. The number of sports disciplines increased significantly in both subgroups. No significant progression of tibiofemoral OA or changes in patellar height were observed.

Bollars et al (2012) reported on a consecutive case series of 27 patients treated with the Arthrosurface HemiCAP Focal Femoral Condyle Resurfacing Prosthesis between 2004 and 2008. Outcome measures included the Knee Injury and OA Outcome Score (KOOS), IKDC, Hospital for Special Surgery Knee Score (HSS) and WOMAC as well as physical and radiographic evaluation. The investigators reported that 19 patients met the inclusion/exclusion criteria, 18 were available for review at a
median follow-up of 34 months (range of 20 to 57). The
median age was 49 years (range of 43 to 78); 63 % had early
arthritis, 5.2 % localized osteonecrosis, and 31.6 % had a focal
traumatic full thickness defect. The follow-up total WOMAC
score averaged 90.1 ± 9.3. The KOOS showed very good to
excellent scores in all domains and also when compared to
age-matched normative data. Significant improvement was
seen with the HSS Score. On IKDC examination, 83.4 % had
normal or nearly normal results.

Marcacci et al (2011) presented preliminary clinical and
radiographic results in a case series of 13 consecutive patients
who received arthroscopic-assisted focal resurfacing of medial
tibio-femoral compartment. Mean follow-up was 29 months.
All patients were treated with the presented procedure for
Ahlback grade 3 medial compartment OA. Subjective
evaluation was based on a VAS for pain self-assessment.
Objective clinical evaluation was based on Hospital for Special
Surgery score. Range of motion was evaluated with a manual
goniometer. Radiographic evaluation compared hip-knee-ankle
angle pre- and post-operatively. The investigators stated that
clinical and functional results were satisfactory. Hospital for
Special Surgery score and visual analog scale for pain self-
assessment showed significant improvements (p < 0.0001 and
p = 0.0002, respectively). Range of motion and axial alignment
were not significantly different respect to pre-operative values.

Makoplasty partial knee resurfacing is used for knee
osteoarthritis that affects only 1 or 2 components of the knee.
However, there is insufficient evidence that Makoplasty
improves health outcomes in patients undergoing knee surgery.

In a pilot study, Lonner et al (2010) compared the post-
operative radiographical alignment of the tibial component
with the pre-operatively planned position in 31 knees in 31
consecutive patients undergoing unicompartmental knee
arthroplasty (UKA) using robotic arm-assisted bone preparation
and in 27 consecutive patients who underwent
unilateral UKA using conventional manual instrumentation to determine the error of bone preparation and variance with each technique. Radiographically, the root mean square error of the posterior tibial slope was 3.1 degrees when using manual techniques compared with 1.9 degrees when using robotic arm assistance for bone preparation. In addition, the variance using manual instruments was 2.6 times greater than the robotically guided procedures. In the coronal plane, the average error was 2.7 degrees +/- 2.1 degrees more varus of the tibial component relative to the mechanical axis of the tibia using manual instruments compared with 0.2 degrees +/- 1.8 degrees with robotic technology, and the varus/valgus root mean square error was 3.4 degrees manually compared with 1.8 degrees robotically. The authors concluded that further study is needed to examine if a reduction in alignment errors of these magnitudes will ultimately influence implant function or survival.

Werner et al (2014) stated that in comparison with standard surgical techniques robotic-assisted surgery has the advantages of increased surgical accuracy, reproducibility, optimization of component position, and improved patient outcomes in UKA and THA procedures. The MAKO Tactile Guidance System (TGS; MAKO Surgical Corp, Fort Lauderdale, FL) facilitates robotic-assisted arthroplasty procedures currently implemented in many operating rooms. The benefits of this technology are evident, but have not been shown to improve patient outcomes and justify the added financial burden imposed. The authors concluded that further research is needed to determine if this technological advancement will translate into improvements in longevity and clinical outcomes.

Hansen et al (2014) performed a retrospective review in a matched group of patients on the use of robotic-assisted UKA implantation versus UKA performed using standard operative techniques to assess differences between procedures. While both techniques resulted in reproducible and excellent outcomes with low complication rates, the results demonstrate little to no clinical or radiographic difference in outcomes.
between cohorts. Average operative time differed significantly with, and average of 20 minutes greater in, the robotic-assisted UKA group \( (p = 0.010) \). The minimal clinical and radiographic differences lend to the argument that it is difficult to justify the routine use of expensive robotic techniques for standard medial UKA surgery, especially in a well-trained, high-volume surgeon. The authors concluded that further surgical, clinical and economical study of this technology is needed.

An assessment by the Canadian Agency for Drugs and Technologies in Health (CADTH, 2011) concluded that there is insufficient evidence regarding the clinical effectiveness, safety, and impact of the use of the MAKO’s RESTORIS line of implants and the MAKOplasty procedure.

The ECRI Institute (2013) found insufficient published clinical evidence that addresses how well the MAKOplasty robotic-assisted partial knee resurfacing procedure works for patients with early to mid-stage osteoarthritis. In addition, they found insufficient published clinical study results to indicate whether the MAKOplasty procedure is better or worse than alternative procedures for patients with early to mid-stage osteoarthritis.

In a prospective study, Eshnazarov and co-workers (2016) compared radiological outcomes after total knee arthroplasty (TKA) with or without patellar resurfacing in patients with grade IV osteoarthritis on patella-femoral joint. A total of 123 cases with Kellgren-Lawrence grade IV osteoarthritis on patella-femoral joint were enrolled for this study. At the operating room, they were randomly assigned to undergo patella resurfacing (62 cases) or patella retention (61 cases). Among them, 114 cases that could be followed for more than 2 years were included in this study (resurfacing group; 59 cases, retention group; 55 cases). Pre-operative and post-operative radiological outcomes (mechanical femoro-tibial angle, patellar tilt and congruence angles) were evaluated and compared between 2 groups. Pre-operative radiological measures showed insignificant difference between patellar tilt \( (p = 0.13) \), mechanical femoro-tibial angles \( (p = 0.62) \) and congruence
angle ($p = 0.37$). Despite the difference performed methods of surgery, post-operative radiological assessment outcomes between 2 groups were almost identical -- patellar tilt ($p = 0.47$), mechanical femorotibial angles ($p = 0.34$) and congruence angle ($p > 0.05$). The authors stated that the almost the same satisfactory radiological outcomes obtained after patella resurfacing and retention groups after TKA allowed them to conclude that, primary TKA without patella resurfacing is a good therapeutic option in patients with high-grade osteoarthritis of the patella-femoral joint.

Aunan et al (2016) noted that recent research on outcomes after TKA has raised the question of the ability of traditional outcome measures to distinguish between treatments. In a single-center, randomized, double-blind study, these researchers compared functional outcomes in patients undergoing TKA with and without patellar resurfacing, using the KOOS as the primary outcome and 3 traditional outcome measures as secondary outcomes. A total of 129 knees in 115 patients (mean age of 70 years; range of 42 to 82; 67 females) were evaluated. Data were recorded pre-operatively, at 1 year, and at 3 years, and were assessed using repeated-measures mixed models. The mean sub-scores for the KOOS after surgery were statistically significantly in favor of patellar resurfacing: sport/recreation, knee-related quality of life, pain, and symptoms. No statistically significant differences between the groups were observed with the Knee Society clinical rating system, with the Oxford knee score, and with VAS for patient satisfaction. The authors concluded that in the present study, the KOOS, but no other outcome measure used, indicated that patellar resurfacing may be beneficial in TKA.

Ali and colleagues (2016) stated that knee pain after TKA is not uncommon. Patellar retention in TKA is one cause of post-operative knee pain, and may lead to secondary addition of a patellar component. Patellar resurfacing in TKA is controversial. Its use ranges from 2% to 90% worldwide. In this randomized study, these investigators compared the outcome after patellar resurfacing and after no resurfacing.
They performed a prospective, randomized study of 74 patients with primary osteoarthritis who underwent a Triathlon CR TKA. The patients were randomized to either patellar resurfacing or no resurfacing. They filled out the VAS pain score and KOOS questionnaires preoperatively, and VAS pain, KOOS, and patient satisfaction 3, 12, and 72 months post-operatively. Physical performance tests were performed pre-operatively and 3 months post-operatively. The authors found similar scores for VAS pain, patient satisfaction, and KOOS 5 subscales at 3, 12, and 72 months post-operatively in the 2 groups. Physical performance tests 3 months post-operatively were also similar in the 2 groups. No secondary resurfacing was performed in the group with no resurfacing during the first 72 months. The authors concluded that patellar resurfacing in primary Triathlon CR TKA is of no advantage regarding pain, physical performance, KOOS 5 subscales, or patient satisfaction compared to no resurfacing. None of the patients was re-operated with secondary addition of a patellar component within 6 years. They noted that according to these results, routine patellar resurfacing in primary Triathlon TKA appears to be unnecessary.

van Jonbergen et al (2016) noted that when secondary patellar resurfacing is performed, a uniformly and widely used scoring system that is validated for anterior knee pain caused by a retro-patellar degeneration will give more insight into the results of this procedure. The cause of anterior knee pain following TKA is not always related to the patella itself. Other causes have been identified (e.g., an insufficient posterior cruciate ligament in the case of a posterior cruciate-retaining TKA or an internally rotated femoral and/or tibial component). Treatment of anterior knee pain following primary TKA with secondary patellar resurfacing is a controversial procedure with uncertain outcomes. These investigators systematically reviewed the available peer-reviewed literature on patient satisfaction and functional outcomes of secondary resurfacing. The authors performed a systematic computerized database search of the Cochrane Database of Systematic Reviews, Medline, and Embase in October 2014. The quality of the
included studies was assessed using the Grading of Recommendations Assessment, Development and Evaluation approach. A total of 15 articles met the inclusion criteria. In total, 148 (64%) of 232 patients were satisfied with the outcomes of secondary patellar resurfacing. A statistically significant improvement in knee scores was noted in all 9 studies that reported functional outcomes, although no clinically significant improvement in knee scores was observed. Reported complications included infections and impaired wound healing, patellar instability, and patellar fracture. The authors concluded that because the available evidence is of generally low quality, the results of this systematic review only support a weak recommendation for secondary patellar resurfacing if patient satisfaction and clinically important improvement of functional outcomes are the desired endpoints.

Toro-Ibarguen et al (2016) noted that secondary patellar resurfacing (SPR) is a procedure that can be used in patients with persistent anterior knee pain (AKP) after a primary TKA. These investigators analyzed the clinical and functional outcomes as well as the complications of this procedure and identified predictive factors for a favorable outcome. A total of 46 patients who underwent SPR for persistent AKP after primary TKA were retrospectively studied. The patient’s mean age was 68 years (range of 36 to 86). The average follow-up time after SPR was 74 months (range of 24 to 197). Demographic data, Knee Society Score scale, ROM, pain improvement (VAS), overall satisfaction, and complications were recorded. The statistical analysis was performed using STATA tm/SE v10. There was an improvement of the Knee Society scale (from 54 ± 11 to 64 ± 16 points; p < 0.05). However, in 59% of the cases, there was no pain improvement, and 65% of patients were not satisfied; 4 patients showed complications, and in 2 cases, re-operation was necessary. These researchers did not find any pre-operative predictive factor for a favorable outcome after SPR. The authors concluded that despite improvement of the Knee Society scale, many patients continued with AKP and were dissatisfied with
this procedure; therefore, the authors do not recommend it in this clinical scenario.

**Metatarsophalangeal Toe Joint Resurfacing**

Metatarsophalangeal (MTP) toe joint resurfacing was designed to resurface the damaged surface of the metatarsal head caused by arthritis (eg, hallux rigidus, post-traumatic arthritis). This resurfacing purportedly provides a "contoured cap" that matches the individual's cartilage surface, which reportedly protects the remaining cartilage to prevent further damage to the joint. The metatarsophalangeal joints (MTP) are the joints between the heads of the metatarsal bones and bases of the proximal phalanges. The first MTP joint is commonly known as the big toe joint. Hallux rigidus is restricted mobility of the big toe due to stiffness of the MTP joint especially when due to arthritic changes in the joint.

Examples of FDA-approved devices for MTP joint resurfacing include, but may not be limited to, CAP great toe resurfacing hemi-arthroplasty implant and the OsteoMed metatarsal resurfacing implant system.

**Appendix**

Contraindications for metal-on-metal hip resurfacing:

- Females of child-bearing age because of unknown effect of metal ion release on the fetus
- Individuals who are immunosuppressed with diseases such as AIDS or individuals receiving high doses of corticosteroids
- Individuals who are severely over-weight
- Individuals who are skeletally immature
- Individuals with any vascular insufficiency, muscular atrophy, or neuromuscular disease severe enough to compromise implant stability or post-operative recovery
- Individuals with bone stock inadequate to support the device
- Individuals with infection or sepsis
- Individuals with known moderate-to-severe renal insufficiency
- Individuals with known or suspected metal sensitivity.

### CPT Codes / HCPCS Codes / ICD-10 Codes

*Information in the [brackets] below has been added for clarification purposes. Codes requiring a 7th character are represented by "+":*

#### ICD-10 codes will become effective as of October 1, 2015:

**Hip Resurfacing:**

No specific code

**CPT codes covered if selection criteria are met:**

<table>
<thead>
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<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>27125</td>
<td>Hemiarthroplasty, hip, partial (e.g., femoral stem prosthesis, bipolar arthroplasty) [per AAOS for a femoral head resurfacing procedure, when only the head of the femur is replaced (a femoral component hemiarthroplasty)]</td>
</tr>
<tr>
<td>27130</td>
<td>Arthroplasty, acetabular and proximal femoral prosthetic replacement (total hip arthroplasty), with or without autograft or allograft [Hip resurfacing for arthroplasty]</td>
</tr>
</tbody>
</table>

**Other CPT codes related to the CPB:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>27033</td>
<td>Arthrotomy, including exploration or removal of loose or foreign body</td>
</tr>
<tr>
<td>27122</td>
<td>Acetabuloplasty; resection, femoral head (e.g., Girdlestone procedure)</td>
</tr>
<tr>
<td>27132</td>
<td>Conversion of previous hip surgery to total hip arthroplasty, with or without autograft or allograft</td>
</tr>
<tr>
<td>27360</td>
<td>Partial excision (craterization, saucerization, or diaphysectomy) bone, femur, proximal tibia and/or fibula (e.g., osteomyelitis or bone abscess)</td>
</tr>
</tbody>
</table>

**HCPCS codes covered if selection criteria are met:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S2118</td>
<td>Metal-on-metal total hip resurfacing, including acetabular and femoral components</td>
</tr>
</tbody>
</table>
## ICD-10 codes covered if selection criteria are met:

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>M16.0 - M16.12</td>
<td>Primary osteoarthritis, left hip</td>
</tr>
<tr>
<td>M16.2 - M16.7</td>
<td>Secondary osteoarthritis of hip</td>
</tr>
<tr>
<td>M16.9</td>
<td>Osteoarthritis of hip, unspecified</td>
</tr>
<tr>
<td>M87.051 - M87.059</td>
<td>Idiopathic aseptic necrosis, femur [avascular necrosis of the hip joint]</td>
</tr>
<tr>
<td>M87.150 - M87.159</td>
<td>Osteonecrosis due to drugs, pelvis and femur [avascular necrosis of the hip joint]</td>
</tr>
<tr>
<td>M87.251 - M87.256</td>
<td>Osteonecrosis due to previous trauma, pelvis and femur [avascular necrosis of the hip joint]</td>
</tr>
<tr>
<td>M87.350 - M87.353</td>
<td>Other secondary osteonecrosis, pelvis and femur [avascular necrosis of the hip joint]</td>
</tr>
<tr>
<td>M87.850 - M87.859</td>
<td>Other osteonecrosis, pelvis and femur [avascular necrosis of the hip joint]</td>
</tr>
<tr>
<td>M90.551 - M90.559</td>
<td>Osteonecrosis in diseases classified elsewhere, thigh [avascular necrosis of the hip joint]</td>
</tr>
</tbody>
</table>

## ICD-10 codes not covered for indications listed in the CPB (not all-inclusive):

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q65.00 - Q65.6</td>
<td>Congenital dislocation of hip [developmental dysplasia]</td>
</tr>
<tr>
<td>Q65.01 [Q65.32 also required]</td>
<td>Congenital dislocation of one hip with partial dislocation of other hip [developmental dysplasia]</td>
</tr>
<tr>
<td>Q65.89</td>
<td>Other specified congenital deformities of hip [developmental dysplasia]</td>
</tr>
</tbody>
</table>

## ICD-10 codes contraindicated for this CPB:
<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A41.01 - A41.9</td>
<td>Other sepsis</td>
</tr>
<tr>
<td>A46</td>
<td>Erysipelas</td>
</tr>
<tr>
<td>D80.0 - D81.2, D81.4, D81.89 - D82.1 D83.0 - D84.9, D89.810 - D89.9</td>
<td>Certain disorders involving the immune mechanism</td>
</tr>
<tr>
<td>E66.01</td>
<td>Morbid (severe) obesity due to excess calories [BMI greater than 40]</td>
</tr>
<tr>
<td>G70.00 - G70.9 G73.1 - G73.3</td>
<td>Myasthenia gravis and other myoneural disorders [neuromuscular disease]</td>
</tr>
<tr>
<td>I73.9</td>
<td>Peripheral vascular disease, unspecified</td>
</tr>
<tr>
<td>I87.2 I87.8 - I87.9</td>
<td>Other disorders of veins</td>
</tr>
<tr>
<td>I99.8</td>
<td>Other disorder of circulatory system</td>
</tr>
<tr>
<td>M00.051 - M00.059 M00.151 - M00.159 M00.251 - M00.259 M00.851 - M00.859 M00.9 M01.X51 - M01.X59</td>
<td>Pyogenic arthritis, hip Direct infection of hip in infectious and parasitic diseases classified elsewhere</td>
</tr>
<tr>
<td>M62.50 - M62.59</td>
<td>Muscle wasting and atrophy, not elsewhere classified</td>
</tr>
<tr>
<td>Code</td>
<td>Diagnosis</td>
</tr>
<tr>
<td>----------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>N17.0 -</td>
<td>Acute kidney failure</td>
</tr>
<tr>
<td>N17.9</td>
<td></td>
</tr>
<tr>
<td>N18.1 -</td>
<td>Chronic kidney disease (CKD)</td>
</tr>
<tr>
<td>N18.9</td>
<td></td>
</tr>
<tr>
<td>N28.9</td>
<td>Disorder of kidney and ureter, unspecified [acute renal insufficiency]</td>
</tr>
<tr>
<td>Z79.51 -</td>
<td>Long term (current) use of steroids</td>
</tr>
<tr>
<td>Z79.52</td>
<td></td>
</tr>
<tr>
<td>Z68.41 -</td>
<td>Body mass index (BMI) 40 and over, adult</td>
</tr>
<tr>
<td>Z68.45</td>
<td></td>
</tr>
</tbody>
</table>

**Shoulder Resurfacing:**

*There are no specific codes for shoulder resurfacing:

**CPT codes not covered for indication listed in the CPB (not all-inclusive):**

- 23470 Arthroplasty, glenohumeral joint, hemiarthroplasty
- 23472 total shoulder (glenoid and proximal humeral replacement (eg, total shoulder))

**ICD-10 codes not covered for indications listed in CPB (not all-inclusive):**

- M07.611 - M07.619 Enteropathic arthropathies, shoulder
- M12.511 - M12.519 Traumatic arthropathy, shoulder
- M12.811 - M12.819 Other specific arthropathies, not elsewhere classified, shoulder
- M12.9 Arthropathy, unspecified [shoulder]
- M13.0 Polyarthritis, unspecified [shoulder]
- M13.111 - M13.119 Monoarthritis, not elsewhere classified, shoulder
- M19.011 - M19.019 Primary osteoarthritis, shoulder
<table>
<thead>
<tr>
<th>ICD-10 Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>M19.111 -  M19.119</td>
<td>Secondary osteoarthritis, shoulder</td>
</tr>
<tr>
<td>M19.211 -  M19.219</td>
<td></td>
</tr>
<tr>
<td>M19.90</td>
<td>Unspecified osteoarthritis [shoulder]</td>
</tr>
<tr>
<td>M93.20 -  M93.29</td>
<td>Osteochondritis dissecans [osteochondral lesions]</td>
</tr>
<tr>
<td>Numerous options</td>
<td>Fracture of upper end of humerus [humeral head] [Codes not listed due to expanded specificity]</td>
</tr>
</tbody>
</table>

**Knee or Partial Knee Resurfacing/Isolated Patellar Resurfacing:**

No specific code

---

**The above policy is based on the following references:**

**Hip Resurfacing:**

5. Cabanela ME. Bipolar versus total hip arthroplasty for


37. U.S. Food and Drug Administration (FDA). 510(k)
42. BlueCross BlueShield Association (BCBSA), Technology Evaluation Center (TEC). Metal-on-metal total hip resurfacing. TEC Assessment Program. Chicago, IL: BCBSA; June 2007;22(3).


58. Garbuz DS, Tanzer M, Greidanus NV, et al. The John Charnley Award: Metal-on-metal hip resurfacing versus large-diameter head metal-on-metal total hip
69. Woon RP, Johnson AJ, Amstutz HC. Results of Conserve Plus® metal-on-metal hip resurfacing for post-traumatic


Shoulder Resurfacing:


15. Uribe JW, Botto-van Bemden A. Partial humeral head


**Knee Resurfacing**

1. U.S. Food and Drug Administration (FDA). 510(k)


11. Canadian Agency for Drugs and Technologies in Health (CADTH). MAKO's RESTORIS Implants and MAKOplasty Procedure for early to mid-stage osteoarthritic knee


MTP Resurfacing


2. U.S, Food and Drug Administration (FDA). Summary and effectiveness data: CAP great toe resurfacing hemi-arthroplasty. Rockville, MD: FDA; February 18,
Rockville, MD: FDA; February 21, 2008.
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