A preoperative adduction contracture is also corrected by an adductor tenotomy in close proximity to the origin of the tendons, releasing the tendons progressively until the hip can be abducted beyond neutral by at least 5-10°. In the face of a significant adduction contracture the chronically stretched and attenuated abductor muscles will become lax and functionally deficient following the deformity correction. Consequently, in the interest of lengthening and strengthening the lateral moment arm of the hip balancing mechanism, the insertion of the gluteus medius is advanced laterally and distally around the greater trochanter and is reattached securely to the origin of the vastus lateralis with heavy sutures. However, this should be done only at the discretion of the on-site surgeon.

A significant externally rotated contracture is similarly corrected by releasing the tendon insertions of the external rotator muscles to the extent necessary to allow passive internal rotation to at least the neutral position.

Following closure of the wound the patient leaves the operating room with an abducting appliance in place and with the hip in neutral rotation and slight flexion.

**IN PATIENT HOSPITAL MANAGEMENT**

The abduction device is left in place during in-bed sleeping hours but is removed during the day to allow the early resumption of walking-aid-assisted ambulation, bathroom privileges, etc., usually commencing on the first or second postoperative day. The magnitude of weight bearing is limited with the use of a walker or crutches to approximately one-half of the patient’s body weight, particularly if the abductors have been advanced. A patient self-motivated, in-room multi-planed exercise program is also commenced on the first postoperative day and is progressed aggressively within limits of pain tolerance (a “normal” physical therapy regimen is rarely necessary). The patient is discharged from the hospital 3-5 days postoperatively.

**POST DISCHARGE CARE**

The instructed in-home exercise program is resumed and the prescribed 50% status of limited weight bearing is continued for 3-4 weeks. Thereafter, the magnitude of weight bearing is gradually increased to full over the subsequent 3 weeks, i.e., within limits of inducing discomfort and/or an abductor weakness limp. The patient is graduated progressively to the use of a cane, which is continued until the hip has reached a plateau of functional recovery, particularly relative to the restorative recovery status of the abductor muscles and the associated proclivity for a Trendelenburg limp.

**Technique:**

Charles O. Townley, M.D.
Port Huron, Michigan

**Design:**

Charles O. Townley, M.D.
Port Huron, Michigan

**Total Articular Replacement Arthroplasty for the Hip Joint**

**Indications**

Indications include advanced avascular necrosis and disabling rheumatoid disease or degenerative coxarthrosis in healthy patients with an anticipated life expectancy of 10 years or greater, i.e., irrespective of age. However, in patients who are otherwise candidates for the procedure the feasibility of a resurfacing arthroplasty may be compromised and occasionally interdicted by anomalies in the configuration of the head/neck complex or by severe developmental or pathologically induced bone stock deficiencies associated with the acetabulum and/or the femoral head.

The feasibility of a total resurfacing versus a femoral hemiarthroplasty is based on a balance between the age of the patient and the nature of the disease. Hemiarthroplasty is advocated primarily for younger patients with severely advanced AVN or an irreparable fracture involving the articular surface of the femoral head, particularly in hips with reasonable retention of the acetabular cartilage. Hemiarthroplasty is not recommended for rheumatoid disease, but may be considered as an option for an uncommon, early-age incidence of disabling osteoarthritis, i.e., under the age of 45 years. However, in view of the not uncommon incidence of some variable degree of latent acetabular pain and protrusio that is associated with an unreplaced socket, the patient is forewarned that this procedure is essentially a “time-buying” operation that may require additional surgery at some time in the future, particularly in the younger and long-living age group.

**Forward**

Detailed information concerning the design rationale and surgical technique for the Total Articular Replacement Arthroplasty resurfacing hip procedure is available for review in a publication that appeared in a 1982 issue of Orthopedic Clinics of North America (Townley, Charles O.: Hemiar and Total Articular Replacement Arthroplasty of the Hip with the Fried Femoral Cup, Vol. 13, No. 4, October 1982). The design of the components and the implantation technique have remained essentially unchanged over the subsequent 16 years except for the development of improved instrumentation to remodel the femoral head, the conversion to poroected, uncemented implants in conjunction with a self-locking metal backed acetabular component in 1985 and, commencing in June 1995, the introduction and favored use of an ultra-low friction, cement-fixed ceramic femoral resurfacing implant matched with a cemented, uni-backed polyethylene acetabular cup.

Although the components’ is addressed singularly to the cemented ceramic-on-poly Total Articular Replacement Arthroplasty resurfacing ensemble, the modular, metal-backed poroected acetabular component remains available as a viable uncemented option and can be used in match with the current cement-fixed ceramic cups.

**Total Articular Replacement Arthroplasty for the Hip Joint**

**Technique:**

Charles O. Townley, M.D.
Port Huron, Michigan

**Design:**

Charles O. Townley, M.D.
Port Huron, Michigan

**Total Articular Replacement Arthroplasty for the Hip Joint**

**Technique:**

Charles O. Townley, M.D.
Port Huron, Michigan

**Design:**

Charles O. Townley, M.D.
Port Huron, Michigan

**Total Articular Replacement Arthroplasty for the Hip Joint**

**Technique:**

Charles O. Townley, M.D.
Port Huron, Michigan

**Design:**

Charles O. Townley, M.D.
Port Huron, Michigan
The Implants

The acetabular and femoral components for total resurfacing are made available in six matching sizes ranging from 38 mm to 50 mm (38, 41, 43, 45, 47, 49). The femoral component is also supplied in three additional larger dimensions (51, 53, 55 mm) in the interest of providing a complete complement of components, i.e., a sufficient range of sizes that will not only accommodate their use for total arthroplastic replacement but that will also assure a reasonably precise acetabular fit for an optional hemiarthroplasty resurfacing. Modular, interchangeable femoral stems with a Morse-taper fitting arrangement with the femoral component are supplied in two lengths (standard and short). The short stem is indicated in the face of an obstruction of the proximal medullary canal due to an old fracture or a prior corrective osteotomy, or in the presence of a significant varus deformity.

The acetabular polyethylene components for total resurfacing are supplied in two dimensions of thickness (6 and 7 mm) and have been designed with an outer acetabular-facing surface that serves the dual capacity of providing built-in, dovetailed spacers that assure both an evenly distributed and concentrically thick cement mantle and, concurrently, a secure cement interdigitated prosthetic interface. The anteroinferior and posteroinferior marginal extensions of the implant have been reduced by curvilinear “cut-outs” (a) to accommodate the anterior anatomical indentation of the socket containment and avoid an unsupported, non-contained, peripheral “hang-over” of the cup rim anteriorly that could compromise the latent stability of the component and (b) to minimize the potential for premature abutment of the posteroinferior aspect of the rim against the opposing femoral neck with external rotation and/or adduction of the hip. The appropriate intraoperative technical placement of the marginal rim cut-outs is assured by identifying the designated superiorly positioned rim of the implant with a small squared surface projection. Pre-implantation trial components are made available for all of the variably sized acetabular and femoral prostheses.

Implant Size Selection

An adequate selection of sequentially sized implants must be available in the operating room at the time of the surgery to assure an accurate intraoperative fit of the components. This can be done in advance of the surgery by utilizing x-ray templates or by having available a complete inventory of the implants in all sizes. If x-ray templates are utilized to pre-determine the size selection it is advisable to have the implants available in four additional sizes, i.e., one size that is larger and three that are smaller than the estimated template size (this sequential array of sizes should be adequate to accommodate either a hemiarthroplasty or a total resurfacing).

Surgical Exposure

The hip joint may be exposed through any standard incision at the discretion and preference of the operating surgeon. In the following description of the procedure the hip is exposed through a modified antero-lateral Watson-Jones incision as described in the foregoing cited article.

Cementing the Femoral Component

With properly matched sizing, the inner diameter of the marginal cutter and the resultant dimension of the head/neck bone cylinder will be a fraction larger than the inner diameter of the femoral component, thus providing a tight press fit and self-sustaining, immobile, head/cup interface. Consequently, the use of cement in this procedure is not perceived as a requirement for “fixation”, per se, but rather as a means to a) grout the bone-prosthetic interface in the interest of assuring universal and even distribution of stress sustained by the supporting bone surfaces and to b) seal the interface against the latent ingress of wear debris and the associated potential for debris-induced periprosthetic osteolysis.

1. The reserved, pre-chilled portion of the methacrylate is sponge dried and the bone cylinder is completely cleared of residual blood, soft tissue or bone debris.

2. A thin layer of cement is manually compressed severely into all of the remodeled bone surfaces, avoiding excessive intrusion of the cement into the head aperture. With the Morse fitted stem/head ensemble securely and intractably conjoined, an additional small portion of cement is deposited in the ceiling of the cup and the assembled component is impacted into the trial tested, fully seated position, i.e., until the cup rim reaches the identifying burn mark. If, in the judgement of the surgeon, the reserved cement has become too firm to allow its extrusion and complete seating of the implant a new batch is prepared.

3. Extruded methacrylate around the complete rim of the cup is cleared while it is still soft and potential motion-restricting marginal bone that extends beyond the level of the implant rim is resected with a curved osteotome. Hardened, first-batch residual cement extensions around the periphery of the acetabulum are also cleared with a curved osteotome and/or rougeur.

4. All grossly apparent cement fragments are meticulously cleared and the acetabulum is finally and thoroughly cleansed by profuse irrigation and the intermittent use of a completely dry, debris-adherent sponge. An appropriately cleansed socket is confirmed by demonstrating a fully seated and concentrically fitted articulation with the hip reduced.

5. The reduced hip is evaluated for the range of motion and stability. The hip should demonstrate a reasonably normal range of passive motion in all planes, particularly relative to external rotation and adduction. A meaningful restriction of external rotation or adduction and an associated propensity for subluxation of the joint is most commonly due to premature abutment of residual, inadequately resected postero-inferior acetabular rim extensions of bone or cement against the opposing femoral neck.
CEMENTING TECHNIQUE

After the methacrylate has been thoroughly but expeditiously mixed and while still in an early semi-liquid, soft stage of polymerization, approximately 1/3 of the cement mass is immersed in a pre-prepared, refrigerator chilled solution of sterile saline (the colder the better). This commonly delays the onset and the progression of the polymerization process for an additional 15 minutes, i.e., usually for a sufficient time interval to allow the later use of the chilled cement on the femoral side following the acetabular implantation.

CEMENTING THE ACETABULAR COMPONENT

1. With the unchilled portion of the methacrylate still in an early soft stage of polymerization, cement is compressed firmly into the interfacing surfaces of the implant and the reamed acetabulum. The cement must be sufficiently soft and malleable to allow its extrusion and complete medialization of the component.

2. An additional portion of cement is deposited in the dome of the acetabulum and onto the surface of the implant on the order of a 2 mm additionally thickened layer. An adequate quantity of cement must be used to assure a complete, concentric fill of the final bone-prosthetic interface.

3. The finished component is inserted in the appropriate “top-side-up” placement, i.e., with the identifying squared rim projection positioned precisely at the uppermost superior aspect of the acetabular margin.

4. Utilizing the cup impactor, the implant is impacted progressively into the fully seated, medialized position. Toward the later phase of seating, the implant is “wobbled” multidirectionally by applying manual, intermittent appositional pressure on the rim and is rotated into the appropriately aligned, multiplaned and fully seated position.

5. With the implant held in a persistently immobilized and pressurized position with the dome-directed impactor, all accessible extruded cement is cleared from around the margin of the implant to the extent possible while it is still in a sufficiently soft stage of polymerization. Impacting pressure is continued for only the time necessary to allow the cement to harden, i.e., only until the implant has become immovably fixed. (This can be judged by intermittently evaluating the polymerized stage of an extruded or an otherwise unused, room-exposed portion of the cement). Immediate attention is now directed to implantation of the femoral component.

6. With the stem inserter/handle removed, the cut head surface is leveled with the axle-trunion of the appropriately sized, drill-mounted cutting instrument into the pre-formed aperture.

7. The axle stem is extracted with the reattached inserter/handle and the level of marginal head resection is delineated by introducing the axle/trunion of the drill-mounted cutting instrument into the pre-formed aperture.

IMPLANTATION TECHNIQUE

Femoral Head Remodeling

1. With the femoral head dislocated anteriorly and adequately exposed, the dimension of the acetabular-contained, functional portion of the head is measured with a caliper. This provides a reasonably precise determination of the acetabular dimension and, consequently, the appropriate size of the head component that would be required for an optional hemiarthroplasty.

2. Remodeling of the femoral head commences by resecting approximately 30% of the head in a common flat plane. The angle of the resection plane should approximate 135-140 degrees of valgus and five degrees of anteversion (Figure 1).

3. The appropriately sized surface template, commencing initially with the measured size for hemiarthroplasty (functional head dimension) is placed flush with the superior and anterior margins of the cut head surface (Figure 2). The template duplicates the inner cylindrical dimension of the selected cup component and, consequently, delineates the marginal level of peripheral head resection/remodeling. In hemiarthroplasty, the eccentric antero-superior placement of the template limits the peripheral resection predominantly to the normally greater head “overhang” inferiorly and posteriorly and positions the implant properly in relation to the femoral neck, i.e., in a centered position that avoids the danger of “notching” the cervical cortex. This is particularly relevant in total resurfacing, which requires downsizing of the femoral component to accommodate the spacing required for an appropriately sized acetabular implant without the need for excessive over-reaming of the socket.

4. A small starter hole is punched into the cut head surface for 3/4” through the template-centering hole. This establishes the ultimate position of the head component and the point of ingress for the insertion of the intramedullary stem.

5. The starter hole is enlarged and extended distally into the proximal medullary canal with a 1/4” (6mm) drill, directing the drill in a valugused and anteverted, 5 degree orientation toward the center of the manually palpated neck (Figure 3). The drill is carefully advanced until it enters the medullary canal, which will be signaled by a “give” to the drill and the extension of fatty medullary material. Care must be taken to avoid misdirecting the drill and possibly perforating the femoral cortex. In the unlikely event that the tactile signs for medullary penetration do not appear after 1 1/2” of drilling, the drill is withdrawn and redirected appropriately.

6. The trial axle stem is inserted and is driven down the medullary canal in the prescribed position of valgus and anteversion until the end of the inserter handle is flush with the cut head surface (Figures 4 – 6).

7. With the stem inserter/handle removed, the cut head surface is leveled with the axle-fitted facing planer, recessing the axle stem progressively distally to the extent necessary to obtain a universally flat plane throughout the total dimension of the osteotomized head (Figure 7).

8. The axle stem is extracted with the reattached inserter/handle and the level of marginal head resection is delineated by introducing the axle/trunion of the appropriately sized, drill-mounted cutting instrument into the pre-formed aperture.
9. With the marginal cutter aligned initially and consistently square with the osteotomized head surface, the peripheral resection is advanced slowly distalward, maintaining the motorized drill at high speed (Figure 8). If the marginal overhang of the head has not been resected completely free (particularly superiorly) by the time the cutting instrument has "bottomed out", the bone cylinder is shortened by removing additional bone from the top surface with the oscillating saw until the repositioned cutter extends just sufficiently beyond the head-neck juncture to embrace the cervical cortex.

10. With the cutting instrument removed, the marginal bone is resected free from periosteal attachments and a small pressure relieving, channeled aperture is made along the full length of the interior surface of the bone cylinder with a small beak-nosed ronguer. This facilitates the release of trapped air, casual blood or excessive cement and allows uninhibited and complete, bottom-out seating of the tightly fitted cup during implantation. The trial component is implanted and the reduced hip is evaluated for the range of motion, stability and joint tension. In hemiarthroplasty, an excessively tight joint may limit motion and increase the incidence of postoperative pain and the rate of latent protrusio associated with the unreplaced socket.

11. Following a satisfactory trial-tested evaluation the appropriate, completely seated final position of the prosthesis is pre-determined by a cauterized burn mark that is localized on the bone cylinder at the level of the rim extension of the trial implant (the measured depth of the cup).

12. To complete the procedure for hemiarthroplasty the trial is removed and is replaced with the finished, appropriately sized prosthesis, utilizing cement fixation (see technique for "Cementing the Femoral Component").

DOWNSIZING THE FEMORAL HEAD FOR TOTAL RESURFACING

The magnitude of head downsizing that is required to accommodate an acetabular implant without notching the cervical cortex or over-reaming the socket is determined by a) the ratio between the size of the femoral head and the diameter of the neck and b) the structural status of the acetabular concavity. In females the head/neck dimensional ratio is commonly substantially greater (large head/small neck) than in the male gender. Consequently, the head in females can usually be downsized safely on the order of two to three component sizes versus one or two dimensions in the male. Fortunately, on the other hand, the commonly more substantial structural status of the male versus the female acetabular bone, i.e., relative to thickness and density, will usually allow sufficient reaming/enlargement to accommodate the required larger femoral head component.

1. The marginal head resection is initiated by first utilizing the peripheral cutting instrument that is sized to accommodate hemiarthroplasty replacement.

2. The marginal cutter, which is provided in 2 mm increments, is downsized progressively and incrementally, short of notching the cervical cortex. With the marginal cutter aligned initially and consistently square with the osteotomized head surface, the peripheral resection is advanced slowly distalward, maintaining the motorized drill at high speed (Figure 8). If the marginal overhang of the head has not been resected completely free (particularly superiorly) by the time the cutting instrument has "bottomed out", the bone cylinder is shortened by removing additional bone from the top surface with the oscillating saw until the repositioned cutter extends just sufficiently beyond the head-neck juncture to embrace the cervical cortex.

3. Osteophytic marginal projections that extend significantly beyond the approximated normal head surface, the peripheral resection is advanced slowly distalward, maintaining the motorized drill at high speed (Figure 8). If the marginal overhang of the head has not been resected completely free (particularly superiorly) by the time the cutting instrument has "bottomed out", the bone cylinder is shortened by removing additional bone from the top surface with the oscillating saw until the repositioned cutter extends just sufficiently beyond the head-neck juncture to embrace the cervical cortex.

4. With the trial component implanted and completely seated, the level of the rim is identified by the cauterized burn mark and the trial is left in place to provide a protective shield against the potential for traumatizing the bone cylinder during the process of reaming the acetabulum.

ACETABULAR REMODELING

The socket must be enlarged and deepened sufficiently to accommodate both the thickness and the peripheral dimension of the implant without producing an overly tight joint or a meaningful intrusive defect in either the dome or the rim of the acetabular concavity. Obtaining the appropriate articular spacing required for the implant becomes a balance between the tolerable magnitude of space relief associated with downsizing the femoral component versus the amount of bone that can be removed safely from the socket, i.e., without compromising the acetabular containment. With each incremental downsizing of the femoral head the magnitude of socket enlargement that is required to accommodate the acetabular component is reduced by 2 mm. For example, assuming the use of a 6 mm thick component, downgrading the head by two sizes reduces the dimension of the otherwise required 12 mm enlargement of the acetabulum to 8 mm which, in turn, reduces the acetabular wall reaming/resection to a relatively safe thickness of 4 mm.

(Advisory note: at any point in the course of the procedure if, in the judgement of the surgeon, the anatomy and/or the pathology of either the acetabulum or the proximal femur is not safely amenable to a Total Articular Replacement Arthroplasty resurfacing, it is advised that the replacement be converted to a conventional PSL total arthroplasty)

1. With the femoral trial in place the acetabular reconstruction commences by the initial use of a "starter" reamer that is a size smaller than the pre-measured functional dimension of the socket.

2. With the reaming instrument directed medially and posteriorly, i.e., away from the superior supporting acetabular margin and the thinner and more vulnerable anterior wall, the socket is deepened and enlarged progressively with incrementally larger reamers to the extent allowable without producing a meaningful defect in either the dome or the anterior margin of the acetabulum. During the later stages of the reaming process the reamer is "wobbled" in a multi-directional rotatory fashion to provide a complete, concentrically reamed concavity.

3. With the femoral trial in place the acetabular reconstruction commences by the initial use of a "starter" reamer that is a size smaller than the pre-measured functional dimension of the socket.

4. The femoral head-matching acetabular trial implant, commencing initially with the larger 7 mm dimensional thickness is inserted and seated in a position of neutral anteversion and at a non-verticalized, varus/valgus angle of 135 degrees. If the appropriately positioned larger implant cannot be fully seated against the dome of the socket and/or the rim of the acetabulum to 8 mm which, in turn, reduces the acetabular wall reaming/resection to a relatively safe thickness of 4 mm.

5. With the hip dislocated and the trial removed, the reamed socket is prepared for cement fixation by punching multiple, widely disseminated small (1/8") anchoring holes into the firm bone of the acetabular crescent.

6. With the hip dislocated and the trial removed, the reamed socket is prepared for cement fixation by punching multiple, widely disseminated small (1/8") anchoring holes into the firm bone of the acetabular crescent.
9. With the marginal cutter aligned initially and consistently square with the osteotomized head surface, the peripheral resection is advanced slowly distalward, maintaining the motorized drill at high speed (Figure 8). If the marginal overhang of the head has not been resected completely free (particularly superiorly) by the time the cutting instrument has "bottomed out", the bone cylinder is shortened by removing additional bone from the top surface with the oscillating saw until the repositioned cutter extends just sufficiently beyond the head-neck juncture to embrace the cervical cortex.

10. With the cutting instrument removed, the marginal bone is resected free from periosseous attachments and a small pressure relieving, channeled aperture is made along the full length of the inferior surface of the bone cylinder with a small beak-nosed rongeur. This facilitates the release of trapped air, casual blood or excessive cement and allows uninhibited and complete, bottom-out seating of the tightly fitted cup during implantation. The trial component is implanted and the reduced hip is evaluated for the range of motion, stability and joint tension. In hemiarthroplasty, an excessively tight joint may limit motion and increase the incidence of postoperative pain and the rate of latent protrusio associated with the unreplaced socket.

11. Following a satisfactory trial-tested evaluation the appropriate, completely seated final position of the prosthesis is pre-determined by a cauterized burn mark that is localized on the bone cylinder at the level of the rim extension of the trial implant (the measured depth of the cup).

12. To complete the procedure for hemiarthroplasty the trial is removed and is replaced with the finished, appropriately sized prosthesis, utilizing cement fixation (see technique for "Cementing the Femoral Component").

**DOWNSIZING THE FEMORAL HEAD FOR TOTAL RESURFACING**

The magnitude of head downsizing that is required to accommodate an acetabular implant without notching the cervical cortex or over-reaming the socket is determined by a) the ratio between the size of the femoral head and the diameter of the neck and b) the structural status of the acetabular concavity. In females the head/neck dimensional ratio is commonly substantially greater (large head/small neck) than in the male gender. Consequently, the head in females can usually be downsized safely on the order of two to three component sizes versus one or two dimensions in the male. Fortunately, on the other hand, the commonly more substantial structural status of the male versus the female acetabular bone, i.e., relative to thickness and density, will usually allow sufficient reaming/enlargement to accommodate the required larger femoral head component.

1. The marginal head resection is initiated by first utilizing the peripheral cutting instrument that is sized to accommodate hemiarthroplasty replacement.

2. The marginal cutter, which is provided in 2 mm increments, is downsized progressively and incrementally, short of notching the cervical cortex, particularly relative to the superior one-half of the head-neck juncture.

3. The head remodeling is completed by channelizing the pressure release exit along the inferior surface of the bone cylinder as heretofore described.

4. With the trial component implanted and completely seated, the level of the rim is identified by the cauterized burn mark and the trial is left in place to provide a protective shield against the potential for traumatizing the bone cylinder during the process of reaming the acetabulum.

**ACETABULAR REMODELING**

The socket must be enlarged and deepened sufficiently to accommodate both the thickness and the peripheral dimension of the implant without producing an overly tight joint or a meaningful intrusio defect in either the dome or the rim of the acetabular concavity. Obtaining the appropriate articular space required for the implant becomes a balance between the tolerable magnitude of space relief associated with downsizing the femoral component versus the amount of bone that can be removed safely from the socket, i.e., without compromising the acetabular containment. With each incremental downsizing of the femoral head the magnitude of socket enlargement that is required to accommodate the acetabular component is reduced by 2 mm. For example, assuming the use of a 6 mm thick component, downgrading the head by two sizes reduces the dimension of the otherwise required 12 mm enlargement of the acetabulum to 8 mm which, in turn, reduces the acetabular wall reaming/resection to a relatively safe thickness of 4 mm.

(Advisory note: at any point in the course of the procedure if, in the judgement of the surgeon, the anatomy and/or the pathology of either the acetabulum or the proximal femur is not safely amenable to a Total Articular Replacement Arthroplasty resurfacing, it is advised that the replacement be converted to a conventional PSL total arthroplasty).

1. With the femoral trial in place the acetabular reconstruction commences by the initial use of a "starter" reamer that is a size smaller than the pre-measured functional dimension of the socket.

2. With the reaming instrument directed medially and posteriorly, i.e., away from the superior supporting acetabular margin and the thinner and more vulnerable anterior wall, the socket is deepened and enlarged progressively with incrementally larger reamers to the extent allowable without producing a meaningful defect in either the dome or the anterior margin of the acetabulum. During the later stages of the reaming process the reamer is "wobbled" in a multi-directional rotatory fashion to provide a complete, concentrically reamed concavity.

3. Osteophytic marginal projections that extend significantly beyond the approximated normal level of the acetabular rim are resected with a curved osteotome. This is particularly relevant to severe extensions involving the inferior and posterior margins of the socket which, if left intact, may result in premature abutment against the femoral neck and induce the potential for anteo-superior luxation with adduction and external rotation of the hip. Although an unresected, excessively abnormal superior extension of the acetabulum will have no deleterious effect on joint motion or stability, the extended rim must not be used to delineate the varus/valgus alignment of the implant, which could result in incomplete acetabular medialization.

4. The femoral head-matching acetabular trial implant, commencing initially with the larger 7 mm dimensional thickness is inserted and seated in a position of neutral anteversion and at a non-verticalized, varus/valgus angle of 135 degrees. If the appropriately positioned larger implant cannot be fully seated against the dome of the socket and/or the rim of the reamed acetabulum to 8 mm which, in turn, reduces the acetabular wall reaming/resection to a relatively safe thickness of 4 mm.

5. The assembled trial hip ensemble is reduced and is evaluated for joint tension. The joint must be sufficiently lax to allow slight separation of the articulation when moderate manual traction is applied to the extremity with the hip in the completely extended position.

6. With the hip dislocated and the trial removed, the reamed socket is prepared for cement fixation by punching multiple, widely disseminated small (1/8") anchoring holes into the firm bone of the acetabular crest.
CEMENTING TECHNIQUE

After the methacrylate has been thoroughly but expeditiously mixed and while still in an early semi-liquid, soft stage of polymerization, approximately 1/3 of the cement mass is immersed in a pre-prepared, refrigerator chilled solution of sterile saline (the colder the better). This commonly delays the onset and the progression of the polymerization process for an additional 15 minutes, i.e., usually for a sufficient time interval to allow the later use of the chilled cement on the femoral side following the acetabular implantation.

CEMENTING THE ACETABULAR COMPONENT

1. With the unchilled portion of the methacrylate still in an early soft stage of polymerization, cement is compressed firmly into the interfacing surfaces of the implant and the reamed acetabulum. The cement must be sufficiently soft and malleable to allow its extrusion and complete medialization of the component.

2. An additional portion of cement is deposited in the dome of the acetabulum and onto the surface of the implant on the order of a 2 mm additionally thickened layer. An adequate quantity of cement must be used to assure a complete, concentric fill of the final bone-prosthetic interface.

3. The finished component is inserted in the appropriate “top-side-up” placement, i.e., with the identifying squared rim projection positioned precisely at the uppermost superior aspect of the acetabular margin.

4. Utilizing the cup impactor, the implant is impacted progressively into the fully seated, medialized position. Toward the later phase of seating, the implant is “wobbled” multidirectionally by applying manual, intermittent appositional pressure on the rim and is rotated into the appropriately aligned, multiplaned and fully seated position.

5. With the implant held in a persistently immobilized and pressurized position with the dome-directed impactor, all accessible extruded cement is cleared from around the margin of the implant to the extent possible while it is still in a sufficiently soft stage of polymerization. Impacting pressure is continued for only the time necessary to allow the cement to harden, i.e., only until the implant has become immovably fixed. (This can be judged by intermittently evaluating the polymerized stage of an extruded or an otherwise unused, room-exposed portion of the cement). Immediate attention is now directed to implantation of the femoral component.

6. With the stem inserter/handle removed, the cut head surface is leveled with the axle-trunion of the appropriately sized, drill-mounted cutting instrument into the pre-formed aperture.

IMPLANTATION TECHNIQUE

**Femoral Head Remodeling**

1. With the femoral head dislocated anteriorly and adequately exposed, the dimension of the acetabular-contained, functional portion of the head is measured with a caliper. This provides a reasonably precise determination of the acetabular dimension and, consequently, the appropriate size of the head component that would be required for an optional hemiarthroplasty.

2. Remodeling of the femoral head commences by resecting approximately 30% of the head in a flat plane. The angle of the resection plane should approximate 135-140 degrees of valgus and five degrees of anteversion (Figure 1).

3. The appropriately sized surface template, commencing initially with the measured size for hemiarthroplasty (functional head dimension) is placed flush with the superior and anterior margins of the cut head surface (Figure 2). The template duplicates the inner cylindrical dimension of the selected cup component and, consequently, delineates the marginal level of peripheral head resection/remodeling. In hemiarthroplasty, the eccentric antero-superior placement of the template limits the peripheral resection predominantly to the normally greater head “overhang” inferiorty and posteriorly and positions the implant properly in relation to the femoral neck, i.e., in a centered position that avoids the danger of “notching” the cervical cortex. This is particularly relevant in total resurfacing, which requires downsizing of the femoral component to accommodate the spacing required for an appropriately sized acetabular implant without the need for excessive over-reaming of the socket.

4. A small starter hole is punched into the cut head surface for 3/4” through the template-centering hole. This establishes the ultimate position of the head component and the point of ingress for the insertion of the intramedullary stem.

5. The starter hole is enlarged and extended downward into the proximal medullary canal with a 1 1/4” (6mm) drill, directing the drill in a valgused and antverted, 5 degree orientation toward the center of the manually palpated neck (Figure 3). The drill is carefully advanced until it enters the medullary canal, which will be signaled by a “give” to the drill and the extension of fatty medullary material. Care must be taken to avoid misdirecting the drill and possibly perforating the femoral cortex. In the unlikely event that the tetraneal signs for medullary penetration do not appear after 1 1/2” of drilling, the drill is withdrawn and redirected appropriately.

6. The trial axle stem is inserted and is driven down the medullary canal in the prescribed position of valgus and anteversion until the end of the inserter handle is flush with the cut head surface (Figures 4 – 6).

7. With the stem inserter/handle removed, the cut head surface is leveled with the axle-fitted facing planer, recessing the axle stem progressively distalward to the extent necessary to obtain a universally flat plane throughout the total dimension of the osteotomized head (Figure 7).

8. The axle stem is extracted with the reattached inserter/handle and the level of marginal head resection is delineated by introducing the axle/trunion of the appropriately sized, drill-mounted cutting instrument into the pre-formed aperture.
The Implants

The acetabular and femoral components for total resurfacing are made available in six matching sizes ranging from 38 mm to 49 mm (38, 41, 43, 45, 47, 49). The femoral component is also supplied in three additional larger dimensions (51, 53, 55 mm) in the interest of providing a complete complement of components, i.e., a sufficient range of sizes that will not only accommodate their use for total arthroplasty replacement but that will also assure a reasonably precise acetabular fit for an optional hemiarthroplasty resurfacing. Modular, interchangeable femoral stems with a Morse fitted trunion arrangement with the femoral component are supplied in two lengths (standard and short). The short stem is indicated in the face of an obstruction of the proximal medullary canal due to an old fracture or a prior corrective osteotomy, or in the presence of a significant varus deformity.

The acetabular polyethylene components for total resurfacing are supplied in two dimensions of thickness (6 and 7 mm) and have been designed with an outer acetabular-facing surface that serves the dual capacity of providing built-in, dovetailed spacers that assure both an evenly distributed and concentrically thick cement mantle and, concurrently, a secure cement interdigitated prosthetic interface. The anteroinferior and posteroinferior marginal extensions of the implant have been reduced by curvilinear “cut-outs” to a) accommodate the anterior anatomical indentation of the socket containment and avoid an unsupported, non-contained, peripheral “hang-over” of the cup anteriorly that could compromise the latent stability of the component and to b) minimize the potential for premature abutment of the posteroinferior aspect of the rim against the opposing femoral neck with external rotation and/or adduction of the hip. The appropriate intraoperative technical placement of the marginal rim cut-outs is assured by identifying the designated superiorly positioned rim of the implant with a small squared surface projection. Pre-implantation trial components are made available for all of the variably sized acetabular and femoral prostheses.

Implant Size Selection

An adequate selection of sequentially sized implants must be available in the operating room at the time of the surgery to assure an accurate intraoperative fit of the components. This can be done in advance of the surgery by utilizing x-ray templates or by having available a complete inventory of the implants in all sizes. If x-ray templates are utilized to pre-determine the size selection it is advisable to have the implants available in four additional sizes, i.e., one size that is larger and three that are smaller than the estimated template size (this sequential array of sizes should be adequate to accommodate either a hemiarthroplasty or a total resurfacing).

Surgical Exposure

The hip joint may be exposed through any standard incision at the discretion and preference of the operating surgeon. In the following description of the procedure the hip is exposed through a modified antero-lateral Watson-Jones incision as described in the foregoing cited article.

Cementing the Femoral Component

With properly matched sizing, the inner diameter of the marginal cutter and the resultant dimension of the head/neck bone cylinder will be a fraction larger than the inner diameter of the femoral component, thus providing a tight press fitted and self-sustaining, immobile, head/cup interface. Consequently, the use of cement in this procedure is not perceived as a requirement for “fixation”, per se, but rather as a means to a) grout the bone-prosthetic interface in the interest of assuring universal and even distribution of stress sustained by the supporting bone surfaces and to b) seal the interface against the latent ingress of wear debris and the associated potential for debris-induced periprosthetic osteolysis.

1. The reserved, pre-chilled portion of the methacrylate is sponge dried and the bone cylinder is completely cleared of residual blood, soft tissue or bone debris.

2. A thin layer of cement is manually compressed severely into all of the remodeled bone surfaces, avoiding excessive intrusion of the cement into the head aperture. With the Morse fitted stem/head ensemble securely and intractably conjoined, an additional small portion of cement is deposited in the ceiling of the cup and the assembled component is impacted into the trial tested, fully seated position, i.e., until the cup rim reaches the identifying burn mark. If, in the judgement of the surgeon, the reserved cement has become too firm to allow its extrusion and complete seating of the implant a new batch is prepared.

3. Extruded methacrylate around the complete rim of the cup is cleared while it is still soft and potential motion-restricting marginal bone that extends beyond the level of the implant rim is resected with a curved osteotome. Hardened, first-batch residual cement extensions around the periphery of the acetabulum are also cleared with a curved osteotome and/or rougeur.

4. All grossly apparent cement fragments are meticulously cleared and the acetabulum is finally and thoroughly cleansed by profuse irrigation and the intermittent use of a completely dry, debris-adherent sponge. An appropriately cleansed socket is confirmed by demonstrating a fully seated and concentrically fitted articulation with the hip reduced.

5. The reduced hip is evaluated for the range of motion and stability. The hip should demonstrate a reasonably normal range of passive motion in all planes, particularly relative to external rotation and adduction. A meaningful restriction of external rotation or adduction and an associated propensity for subluxation of the joint is most commonly due to premature abutment of residual, inadequately resected poste-ro-inferior acetabular rim extensions of bone or cement against the opposing femoral neck.
A preoperative adduction contracture is also corrected by an adductor tenotomy in close proximity to the origin of the tendons, releasing the tendons progressively until the hip can be abducted beyond neutral by at least 5-10°. In the face of a significant adduction contracture the chronically stretched and attenuated abductor muscles will become lax and functionally deficient following the deformity correction. Consequently, in the interest of lengthening and strengthening the lateral moment arm of the hip balancing mechanism, the insertion of the gluteus medius is advanced laterally and distally around the greater trochanter and is reattached securely to the origin of the vastus lateralis with heavy sutures. However, this should be done only at the discretion of the on-site surgeon.

A significant externally rotated contracture is similarly corrected by releasing the tendon insertions of the external rotator muscles to the extent necessary to allow passive internal rotation to at least the neutral position.

Following closure of the wound the patient leaves the operating room with an abduction appliance in place and with the hip in neutral rotation and slight flexion.

**IN PATIENT HOSPITAL MANAGEMENT**

The abduction device is left in place during in-bed sleeping hours but is removed during the day to allow the early resumption of walking-aid-assisted ambulation, bathroom privileges, etc., usually commencing on the first or second postoperative day. The magnitude of weight bearing is limited with the use of a walker or crutches to approximately one-half of the patient’s body weight, particularly if the abductors have been advanced. A patient self-motivated, in-room multi-planed exercise program is also commenced on the first postoperative day and is progressed aggressively within limits of pain tolerance (a “normal” physical therapy regimen is rarely necessary). The patient is discharged from the hospital 3-5 days postoperatively.

**POST DISCHARGE CARE**

The instructed in-home exercise program is resumed and the prescribed 50% status of limited weight bearing is continued for 3-4 weeks. Thereafter, the magnitude of weight bearing is gradually increased to full over the subsequent 3 weeks, i.e., within limits of inducing discomfort and/or an abductor weakness limp. The patient is graduated progressively to the use of a cane, which is continued until the hip has reached a plateau of functional recovery, particularly relative to the resistive recovery status of the abductor muscles and the associated proclivity for a Trendelenburg limp.

**Indications**

Indications include advanced avascular necrosis and disabling rheumatoid disease or degenerative coxarthrosis in healthy patients with an anticipated life expectancy of 10 years or greater, i.e., irrespective of age. However, in patients who are otherwise candidates for the procedure the feasibility of a resurfacing arthroplasty may be compromised and occasionally interdicted by anomalies in the configuration of the head/neck complex or by severe developmental or pathologically induced bone stock deficiencies associated with the acetabulum and/or the femoral head.

The feasibility of a total resurfacing versus a femoral hemiarthroplasty is based on a balance between the age of the patient and the nature of the disease. Hemiarthroplasty is advocated primarily for younger patients with severely advanced AVN or an irreparable fracture involving the articular surface of the femoral head, particularly in hips with reasonable retention of the acetabular cartilage. Hemiarthroplasty is not recommended for rheumatoid disease, but may be considered as an option for an uncommon, early-age incidence of disabling osteoarthritis, i.e., under the age of 45 years. However, in view of the not uncommon incidence of some variable degree of latent acetabular pain and protrusio that is associated with an unplaced socket, the patient is forewarned that this procedure is essentially a “time-buying” operation that may require additional surgery at some time in the future, particularly in the younger and long-living age group.