Techniques of Insertion and Results with the Threaded Acetabular Component

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In this article, the authors classify the various threaded acetabular component designs, discuss surgical techniques, and share quite successful clinical results.

Threaded acetabular component designs have had a longer history of cementless application in total hip arthroplasty than porous press-fit designs. Europeans have pioneered and championed this concept in both primary and revision surgery. The results of the encouraging findings in Europe have been accompanied by an influx of threaded acetabular components introduced into the United States. It is important to recognize the difference in design concepts and the required surgical technique for each design. In addition, it also is apparent that certain designs have a broader indication (or restricted contraindication) than other designs.

Early experimental results were cited by Sivash,[1] in 1957, and advanced with the work of Ring,[2] Lord,[3] and Mittelmeier.[4] The first generally accepted threaded acetabular component was developed by Mittelmeier in Germany in 197 1. It was a truncated cone, initially made of metal, with the femoral component having a plastic ball. A ceramic version of this prosthesis continues to be used today, and, at least on the acetabular side, reasonable results have been achieved. In 1976, Lord began to use a truncated ellipsoid design made of metal with a polyethylene insert. It initially was partially porous coated, but the pores subsequently were removed with no change in outcome of clinical results. To date, with over 15 years of clinical results, Europeans have remained enthusiastic over threaded devices.

Types of Designs

Threaded acetabular components are divided into four classifications: truncated cones, hemispherical rings, hemispherical shell and conical threads, and hemispherical shell with spherical threads.

The truncated cone should be inserted horizontally, at 35° to 40°, compared with the usual 45° to the vertical. It also should be anteverted 10° to 15°. Conical reaming is required, and the orientation must be correct initially because it cannot be corrected once reaming has begun. Therefore, it is a demanding prosthesis, and in order to properly seat the broad, flat base, the medial wall of the pelvis occasionally must be breached. When it is inserted properly, the results have been reasonably good (Figure 1).

Hemispherical devices are easier to insert because standard spherical reamers can be used and if cup placement is not ideal, removal and reinsertion are possible. The hemispherical ring has a large apical hole, which reduces the stiffness and so potentially can lead to micromotion and possibly polyethylene-wear debris (Figure 2). Although a hemispherical cup may have an apical hole, it is much stiffer and therefore has less of a tendency to deform under load (Figure 3).[5]

Early ring designs had only neutral polyethylene inserts requiring a more horizontal orientation of the cup to ensure joint stability. This type of position

Figure 1 – In this revision case, a Mittelmeier prosthesis was used. It was necessary to breach the inner wall of the pelvis to obtain firm seating. The stern was painful and required revision two years later. At that time, the acetabular component was tight. It functioned well for six years, until the death of the patient.

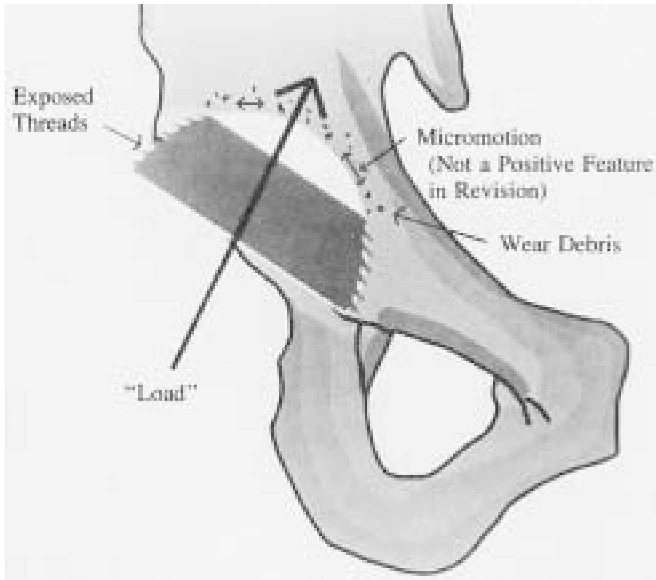


Figure 2 – This threaded ring shows load transmission, resulting in possible micromotion and wear debris.

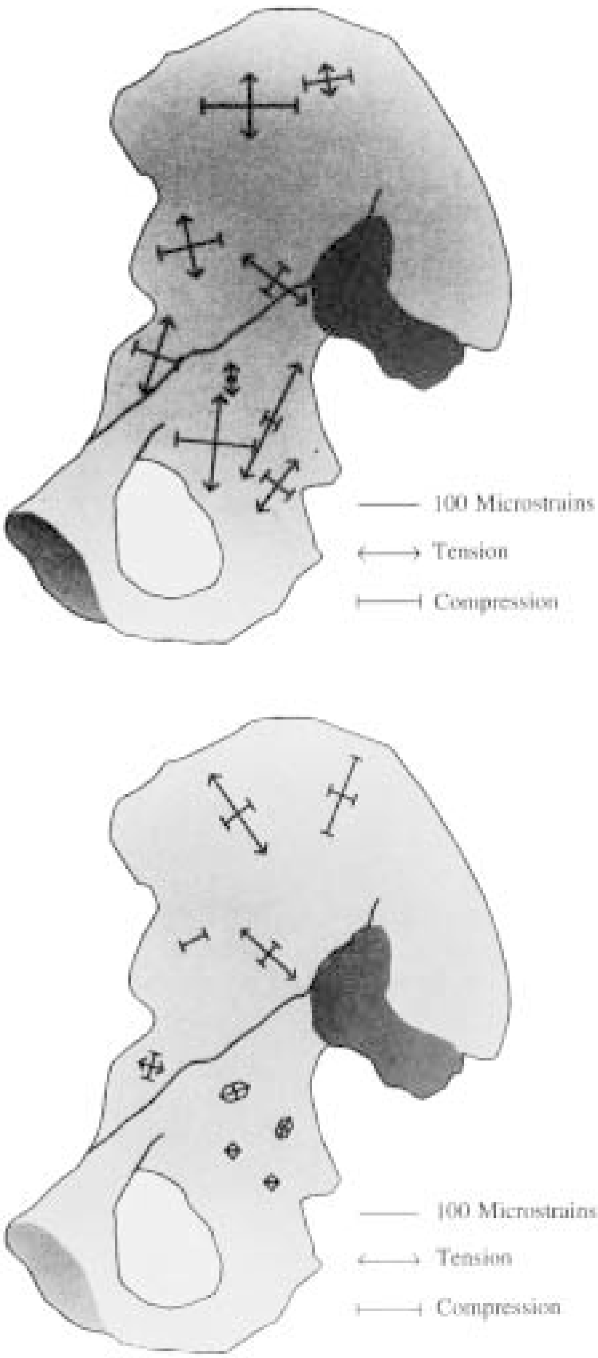
can compromise bony coverage of the implant, resulting in less implant fixation.

The majority of hemispherical cups have conical threads, which are much easier to design and manufacture. However, the conical thread compromises the maximum potential of seating the entire thread into a hemispherically reamed acetabulum. In 1984, the S-ROM™ Acetabular System was manufactured. It has spherical threads, which allow complete seating of the thread into the bone. This larger thread contact area naturally reduces the load per unit area.

Sinkage into the pelvis is the usual method of acetabular cup failure. Therefore, the buttress angle on the threads should be as horizontal as possible to present a compressive, rather than shear, face to this load. When a threaded acetabular component is inserted without pretapping, bone debris is generated. Grooves to accommodate this debris should be incorporated in the acetabular cup design.

Rotatory torque on the acetabulum must be resisted. The addition of screws or studs that penetrate the metal cup not only help with initial fixation, but also absorb rotatory torque (Figure 4).

The polyethylene liner should be detachable to allow visualization during cup insertion and bone grafting, if necessary. The liner locking mechanism must be such that inadvertent disassociation will not occur. An offset plastic lip is a distinct advantage, acting in a sense like the acetabular labrum. The S-ROM System features a unique Poly-DiaL™ insert that allows the surgeon to dial the 10°, 15°, or 20° offset insert out of the way for ease of relocation of the femoral head and, with the head in place, to dial the offset insert to one of six locations to ensure maximum joint stability. The inserts also can be rerotated and removed without damaging the insert itself (Figure 5).



Fipre 3 – A strain gauge for a nonnal pelvis (Top) and a strain gauge for the S-ROM threaded cup (Bottom) are shown.

Technique

The threaded acetabular component can be inserted via any standard approach to the hip. The difference from a cemented implant is that the acetabular exposure must be greater. Threaded components have a major diameter, larger than that of the prepared dimensions of the acetabulum. Therefore, it is necessary to face the acetabulum directly for insertion of these threaded devices.

The acetabulum generally is spherical and its opening is oriented closer to 55', not 45', downward in the coronal and sagittal planes and anteverted approximately 15' to 20' in the midsagittal plane.

The standard approach used by the senior author is a modified Watson-Jones approach. The incision is curved anteriorally and centered over the greater trochanter. The fascia lata is divided in line with the skin incision. If the fascia is tight, a back cut of 2 to 3 cm may be made.

The anterior fibers of the gluteus medius and the tendon of minimus are released from the front of the greater trochanter and blunt Homan passed above and below the femoral neck extracapsularly. With a Cobb periosteal elevator, the soft tissue is cleared off the front of the capsule and a medium Homan placed on the pelvic rim under direct vision with the spike sitting under the rectus femoris. An anterior capsulectomy is performed. The neck is divided and the head withdrawn. The acetabulum is exposed with a medium Homan on the pelvic rim, a long, sharp Homan inferiorly and a bent Homan posteriorly. A complete capsulectomy is performed. If the psoas is very tight, the tendon can be released. If the gluteus medius is large, a Steinmann pin can be driven into the pelvis above the acetabulum to serve as an additional retractor.

Acetabular Preparation

From preoperative templates, the acetabular size roughly will be known, The acetabular fat pad is removed with sharp dissection. An acutely curved hemostat is a useful instrument should bleeding be encountered from the artery in the fat pad, which tends to retract underneath the transverse acetabular ligament.

If large osteophytes are present on the edge of the lunate area, their removal with an osteotome is useful to clearly define the floor. Reaming is then begun. Any hemispherical reamer can be used as long as its dimensions are well defined. Progressively larger reamers are used until the reamer is enclosed completely within the acetabulum. The subchondral bone should be left, if possible, but not at the expense of letting the cup sit proud of the acetabular rim. Acetabular irrigation may be per~ formed during reaming, but the bone debris generated by the final reaming should be left as a bone graft.

The S-ROM reamer itself serves as a trial, with the two levels indicating whether or not a low profile or deep profile cup should be employed. A deep profile cup is essentially a hemisphere. Trial cups are available and are 0.5 mm larger in diameter than the exact size of the S-ROM reamer blade on the assumption that the reamer may cut somewhat oversize but cannot cut undersize. This is certainly true in soft bone. Occasionally, however, especially when the bone is hard, trial insertion may be a little difficult, so gentle eccentric reaming may be necessary to allow the cup to be seated fully.

Component Position and Insertion

The optimal position is 45° to the vertical and 10° to 15° anteversion. Frequently, however, some degree of acetabular retroversion is found. The availability of offset polyethylene liners means that slight malpositioning of the threaded cup can be accepted, but it probably would be a mistake to depend too heavily on the plastic lip for stability. Conceivably, this could cold flow with time and end in a later dislocation, although this has yet to be reported.

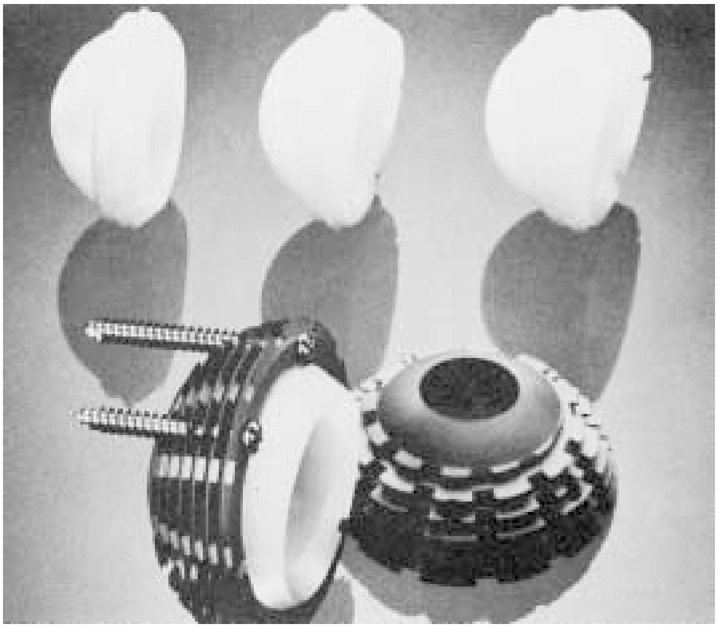


Figure 4 – The peripheral screws for this S-ROM cup not only assist with initial fixation, but also absorb rotatory torque.

Figure 5 – The capacity to adjust the offset insert after fenjoral coniponent reduction is a significant advantage in allowing determination of optimum stability.

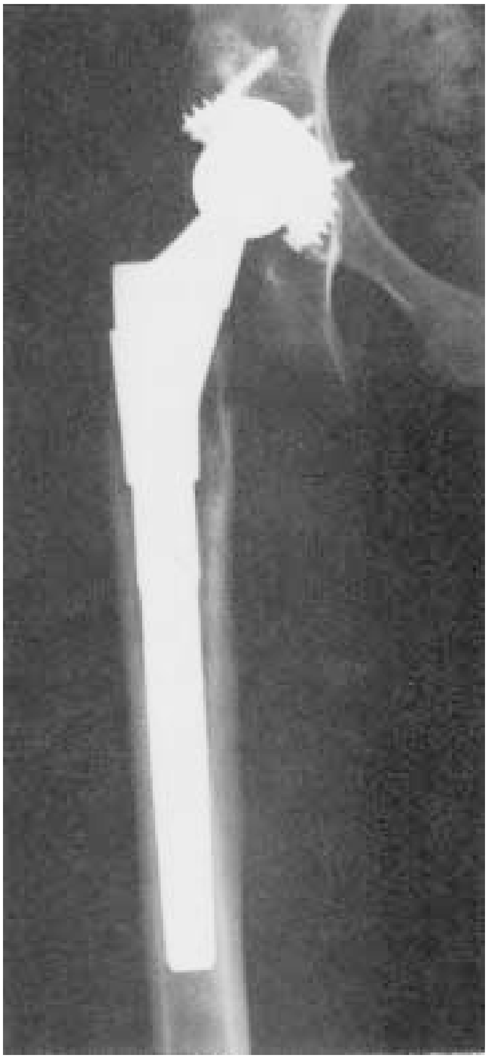


Figure 6 – Multiple screws have been used in this case because the acetabulum was deformed (a shelf procedure was performed years before). The screws penetrate the metal shell. Lying in the grooves in the plastic liner, they prevent further rotation of the plastic. They also help to absorb the rotatory torque forces on the acetabulum.

If the cup is Dot inside the acetabulum before threading has begun, it is possible to damage the bony walls. Therefore, the appropriately sized cup should be locked onto the S-ROM cup impactor and driven into the acetabulum with forceful blows of a mallet. The handle of the impactor serves as an aiming device and allows alignment to be checked. It is then disengaged by rotation and withdrawn.

Threading can be performed with a ratchet wrench or a pneumatic impact wrench. The heads of these devices are not locked onto the cup. If the surgeon, and therefore the drive shaft, wobbles more than 7°, the introducer will disengage. This protects the bony threads. If the driver is locked tightly, the initial bony threads easily could be broken.

The advantage of the pneumatic inserter is that the surgeon need concentrate only on maintaining alignment, rather than also on providing power. The senior author always prefers to check with the offset ratchet wrench in case the pneumatic system has been underpowered. No acetabular fractures have occurred in over 200 cases of cup insertion, although it is theoretically possible, and, therefore, the drive should be removed frequently to visualize the depth of insertion.

If the cup is not seated completely, a bone graft can be passed through the floor and impacted with a punch. If complete coverage cannot be achieved, then consideration should be given to bone grafting. It is probably acceptable to leave up to two threads hanging out in one area. If, however, more than two threads are exposed, then they should be covered with bone graft.

The polyethylene liner is inserted and rotated in place. It is dialed around so that there is no offset superiorly to impede hip reduction. Once the femoral component has been inserted and the hip reduced, the offset can be dialed around to the position of maximum stability of the hip. Once the socket is rotated to its proper position, where the cup spanner slot is in line with the screw hole, at least two bone screws should be inserted to lock the plastic liner. These screws also serve to enhance the rotatory stability of the entire complex (Figure 6).

In revision situations, where bone quality may be less than ideal, it probably is preferable to fill as many of the screw holes with screws as possible. Inferiorly, where the acetabulum is thin and penetration of the pelvis likely, short, tip locking pins, rather than

Figure 7 – This hip resurfacing failed, leaving a huge acetabular floor defect (Left). The floor was heavily grafted (Right). Because the acetabular ring was intact, a threaded cup was used; it obtained an excellent grip. Hemispherical threaded cups are wall bearing. A case such as this is an ideal indication for their use.

screws, should be used to avoid potential vascular damage.

Contraindications to Threaded Cups

Threaded cups must not be used if the acetabulum is too thin to allow proper reaming without large floor perforation. The acetabular size should not be greatly expanded because this may result in the walls becoming too weak to support a threaded cup. If bone grafts encompass more than one-third of the acetabular ring, then a threaded cup should not be used and consideration should be given to a bipolar cup. It is difficult to manufacture a threaded cup with an outer diameter of less than 45 mm because the plastic liner would be too thin. If the acetabulum calls for a smaller component than this, an ingrowth cup is probably preferable. If a grip of more than 600 inch pounds cannot be achieved with the threaded cup due to poor quality bone, some other device, such as a bipolar or a cemented cup, should be used.

Clinical Results

When evaluating uncemented components, it is easier if one side is cemented because the early results of cemented hips are well known. Ninety-eight hybrid hip replacements using an uncemented S-ROM threaded cup combined with a cemented stem have been performed. The follow-up was two to four years. Of the 98 replacements, 67 were primary hip replacements and 31 were revisions. Some bone grafting of the acetabular floor was performed in 60% of primary cases and 100% of revisions (Figure 7). Wall or roof grafts were required in 11%. The majority were not visible as separate structures by six months.

The overall Harris rating was 91% excellent, 4% good, 3% fair, and 2% poor. Four patients had groin pain; one settled with ten days of bed rest. One possible L3-4 disc herniation was explored, and nothing abnormal was found. His pain subsequently settled. One patient has unexplained groin pain and in one revision case the prosthesis has migrated and thus is probably loose.

Acetabular radiolucency has been studied using the Charnley method' and has shown a progressive decrease. At three months, 7% show radiolucency in zone 1, 11% in zone 2, and 6% in zone 3. By two years, 0% show radiolucency in zone 1, 2% in zone 2, and 1% in zone 3. Admittedly, on routine x-rays, it is very difficult to see whether slow migration is occurring. If this is happening, one would expect to see an increase in radiolucency in zone 3. However, the locking screws are not particularly strong in bending and shear and act as a fairly sensitive guide. To date, only one screw fracture, in the loose case, has been noted.

Future Developments

Although the early results with the S-ROM threaded cup have been good, concerns must exist that late migration, as is seen with cemented cups, will occur. After all, the acetabulum is flexible and the cup stiff. One way of reducing acetabular flexibility is to convert it from a horseshoe to a complete ring. Bone grafting under the transverse acetabular ligament may help this, as may the use of locking pins on either side of the transverse acetabular ligament.

A second method is to increase the surface area of contact between metal and bone; the greater the contact area, the less load per unit area. This could be done by making the smooth part of the cup porous, but this adds greatly to the cost.[7] If the smooth areas are roughened, more or less the same effect is achieved at a much lesser cost. Both these alternatives are being explored presently and obviously further follow-up studies will be required to learn whether there is any advantage in doing so.

Further developments contemplated include the use of a hydroxyapatite spray coating on the cup. Hydroxyapatite coatings are not particularly strong and might well be sheared off the threads during insertion. However, hydroxyapatite would remain intact and protected in the depth of the grooves and in the depth of the roughened areas. Again, whether or not this provides any advantage will have to be determined by clinical studies.

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