Reconstructive Review

*Leadership Through Design*

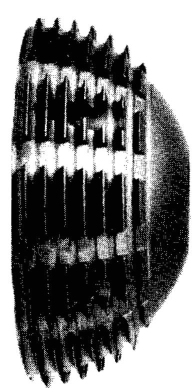
November 1986

Joint Medical Products

## Threaded Acetabular Component Design Concepts

*By Tim McTighe*

Threaded acetabular component designs, as compared to porous press fit designs, have had the longer history of cementless application in total hip arthroplasty. The Europeans have pioneered and championed this concept in both primary and revision surgery.



Sivash[1], in 1957, developed a helical thread on the outer cup surface with a 7 millimeter pitch and a 10 millimeter depth. Difficulty in surgical technique led to a 1962 model which included 4 rows of circumferential blades giving the appearance of a mushroom cap. An important design feature was screw holes through the cutting threads or petals for additional fixation, if needed. *(Figure 1)*

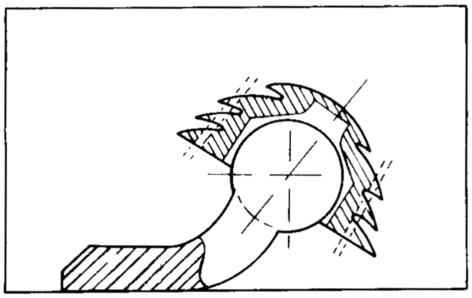


Figure 1

In 1964 Ring[2] began his clinical series using a threaded design in association with a femoral component of Moore's design.

However, Lord and Mittelmeier have been credited with popularizing this concept, both in Europe and the United States.

Lord[3] began his clinical series in 1976, implanting well over 800 devices between 1976 and 1984.

Lord and Mittelmeier have both reported comparable results, with approximately 90% good-to-excellent results for primaries, and 75% good-to-excellent results for revisions.

The Mittelmeier device is a truncated cone, made of ceramic material which articulates with a ceramic femoral head. The Lord device is a threaded ring of a truncated ellipsoid design, made of metal with a polyethylene insert which articulates with a metal or ceramic head. Both surgeons continue to use these devices today.

In North America, Hugh Cameron[4] was the first to implant and report on his experience using the ceramic Autophor system developed by Mittelmeier. Cameron has not experienced any problems with the threaded ceramic cup. However, problems have occurred on the femoral side resulting in Cameron's disuse of this system. He continues his investigation of threaded devices by use of the S-ROM™ Anderson™ acetabular component.

The success of the Europeans using these threaded devices has spurred increasing enthusiasm and usage, particularly in revision surgery, in the United States.

Bierbaum, Cappello, Engh, Mallory, Miller, and Murray are a few of the pioneers of clinical usage of threaded devices in the States. Each has encountered different degrees of success with various designs.

It is the opinion of this editor that there are major areas of concern that must be fully discussed and understood by the operating surgeon concerning design and surgical technique for threaded devices to insure a successful, long term clinical result. The failure to appreciate and use the proper surgical technique and/or indication can predispose these devices to failure.

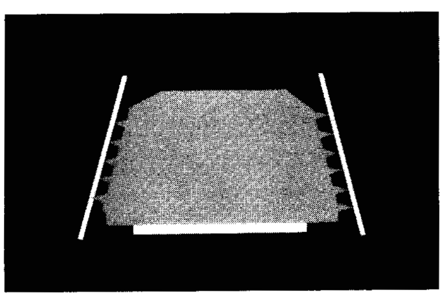
First and foremost in the successful implantation of a threaded device are exposure and surgical technique. Acetabular exposure must be greater for these devices than for conventional cemented cups. Threaded components have a major, or outside diameter, larger than that of the prepared dimensions of the acetabulum. It is, therefore, necessary to directly face the acetabulum for insertion of these threaded devices.

The acetabulum is generally spherical in shape and its opening is oriented closer to 55°, not 45°, downward in the coronal and saggital plane and anteverted approximately 15°-20° in the mid-saggital plane

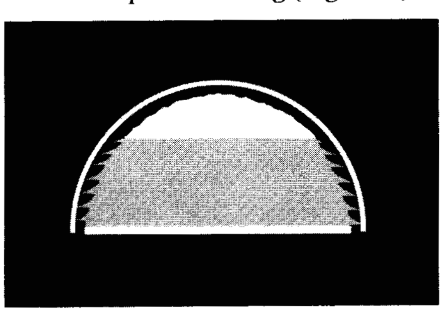
There are four basic classifications of threaded cup designs. It is crucial to understand the difference in these designs and, most of all, to understand the particular design chosen for implantation. A complete understanding of the design will enable the surgeon to maximize surgical techniques to achieve a good result.

## Classification of Threaded Cups

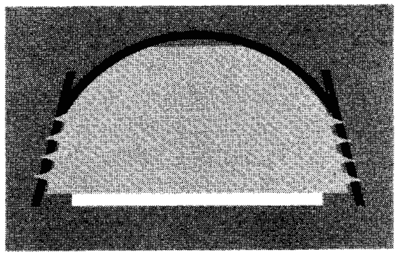
A. Truncated cone *(Figure 2)*



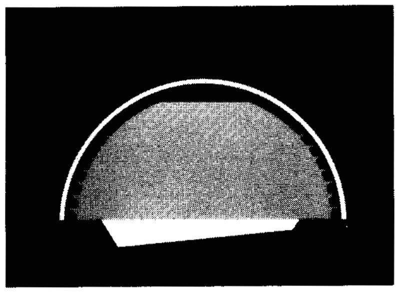
B. Hemispherical ring *(Figure 3)*



C. Hemispherical shell with conical threads *(Figure 4)*



D. Hemispherical shell with spherical threads *(Figure 5)*



## A. Truncated Cone

This is the design of most European systems, including both Lord and Mittelmeier devices. Whether the truncated cone design is a cup or a ring, the geometry of a truncated cone makes the design inherently very stable. However, it does require more bone removal than a hemispherical design.

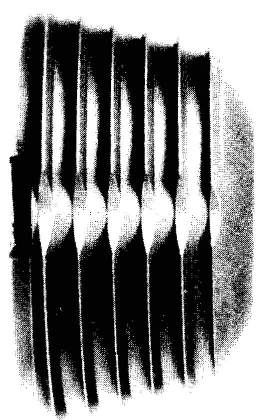


Figure 6

Figure 6 shows a close-up photo of a truncated cone produced in the U.S. Please note the smooth base conical surface at the root of the threads which is intended to abut the bone.

These designs generally require additional reaming and/or pretapping for the device to insure a better fit and apposition to the bone.

Although very successful in Europe, these designs have not met with great acceptance in North America. The surgical technique is quite demanding to insure proper seating for a truncated cone. If reamed spherically the threads engage very little bone *(Figures 7, 8)*.

Figure 7

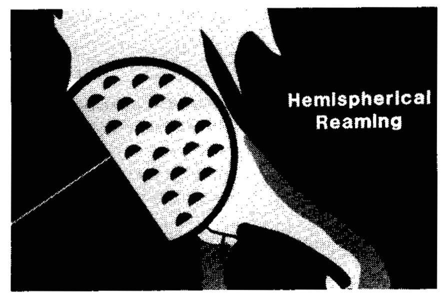
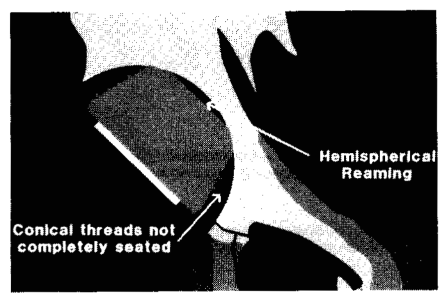



Figure 8




If deepened with the reamer, contact between implant and bone is increased. However, bone stock is sacrificed *(Figures 9, 10)*. It appears the device must penetrate subcondral bone and the medial wall to insure maximum thread purchase *(Figure 11)*.

Figure 9

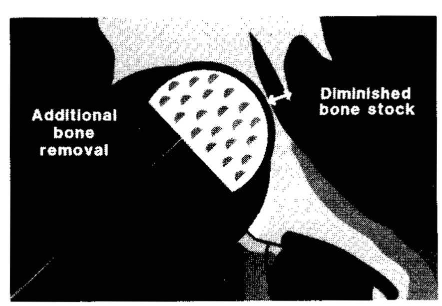


Figure 10

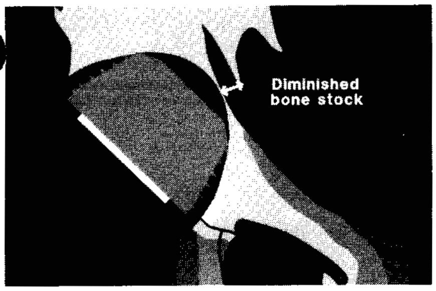
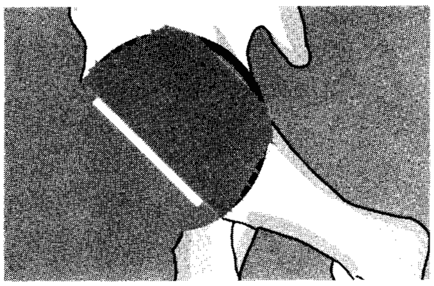



Figure 11



## B. Hemispherical Ring

The Mec-Ring® from Germany appears to be the most popular ring design. It is a threaded ring spherical in shape with a large apical hole. This apical hole allows the poly insert to protrude through the ring, thus interfacing with the prepared acetabular bony bed.

A close look at this design *(Figure 12)* raises some questions and concerns. The thread buttress angle provides for maximum pull-out resistance. However, is this the mode of loading for threaded cups? Since the majority of the loads placed on the acetabular component are in compression, would not a different thread profile be more appropriate for proper load transfer? The extremely large apical hole allows for more load transfer to the thin fossa as compared to designs that have either a small hole or an enclosed dome.

The designs with a smaller hole do not allow the poly inserts to protrude through the hole. These are classified as cups, not rings.

In revision situations where the subcondral bone is diminished or lost, loading should be transfered to the periphery to protect or shield this area.

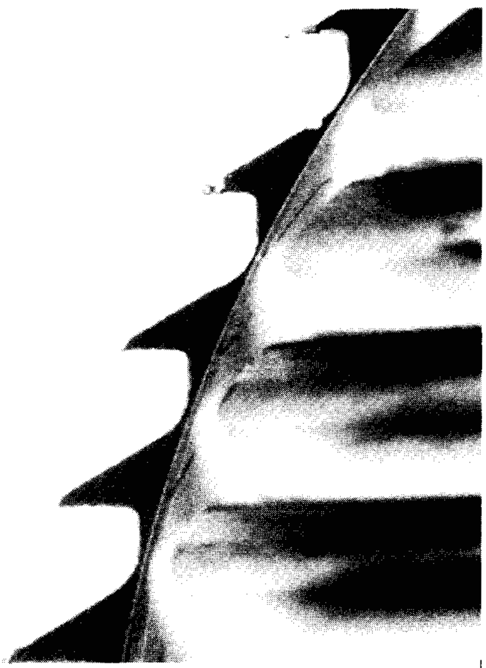
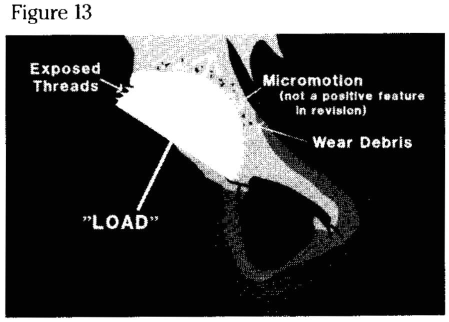


Figure 12

Earlier designs had only neutral angle poly inserts requiring a more horizontal orientation of the cup to insure joint stability. This type of positioning can compromise bony coverage of the implant, resulting in less implant fixation. In addition, if any micromotion occurs between poly insert and bone, the possibility of wear debris exists *(Figure 13)*.

Figure 13




## C. Hemispherical Shell with Conical Threads

This is the design of most U.S. manufacturers. The hemispherical shell is an advantage over a truncated cone because it allows preservation of the subcondral bone by reaming hemispherically. The conical threads are much easier to design and manufacture as compared to spherical threads. However, the conical thread does compromise maximum potential of seating the entire thread into a hemispherically reamed acetabulum. Because of this fact Joint Medical discontinued making conical threads over two years ago. Figure 14 shows a closeup of a competitive U.S. design; again note the smooth base spherical surface of the root threads which is intended to abut the bone. Some manufacturers are not taking into consideration the amount of bony debris that is created during the thread cutting insertion process of seating a threaded acetabular component. Also, most manufacturers use a cheese-grater type reamer that is designed to remove bony debris. These reamers were initially designed to be used with bone cement, not with threaded implants.

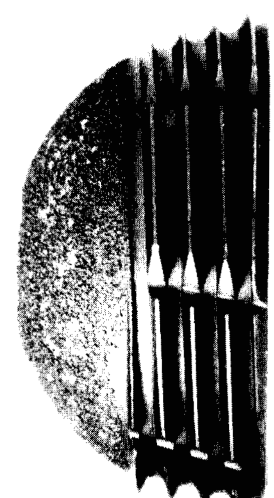


Figure 14

## D. Hemispherical Shell with Spherical Threads

This, in our opinion, is an optimum design for a threaded device *(Figure 15)*. The S-ROM Anderson cup is the first hemispherically domed shell with spherical threads. Note *(Figure 18)* that the thread buttress angle provides maximum resistance to the compressive loads going into the acetabulum.

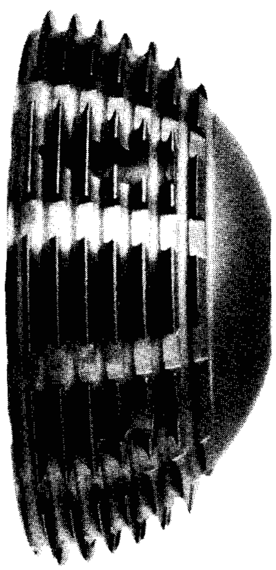
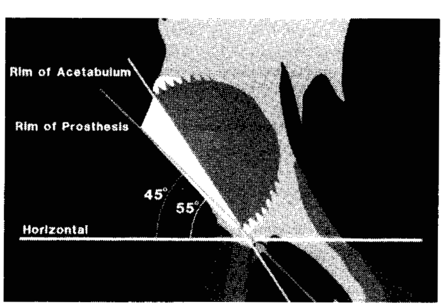


Figure 15

This design together with the POLY-DIAL™ Socket lends itself to optimum positioning of the metal shell and maximum purchase of spherical threads in a spherically reamed cavity *(Figure 16)*. The apical hole is small enough to reduce loads that are transferred through the apex; however, the hole is still large enough for visualization and access for bone graft material.

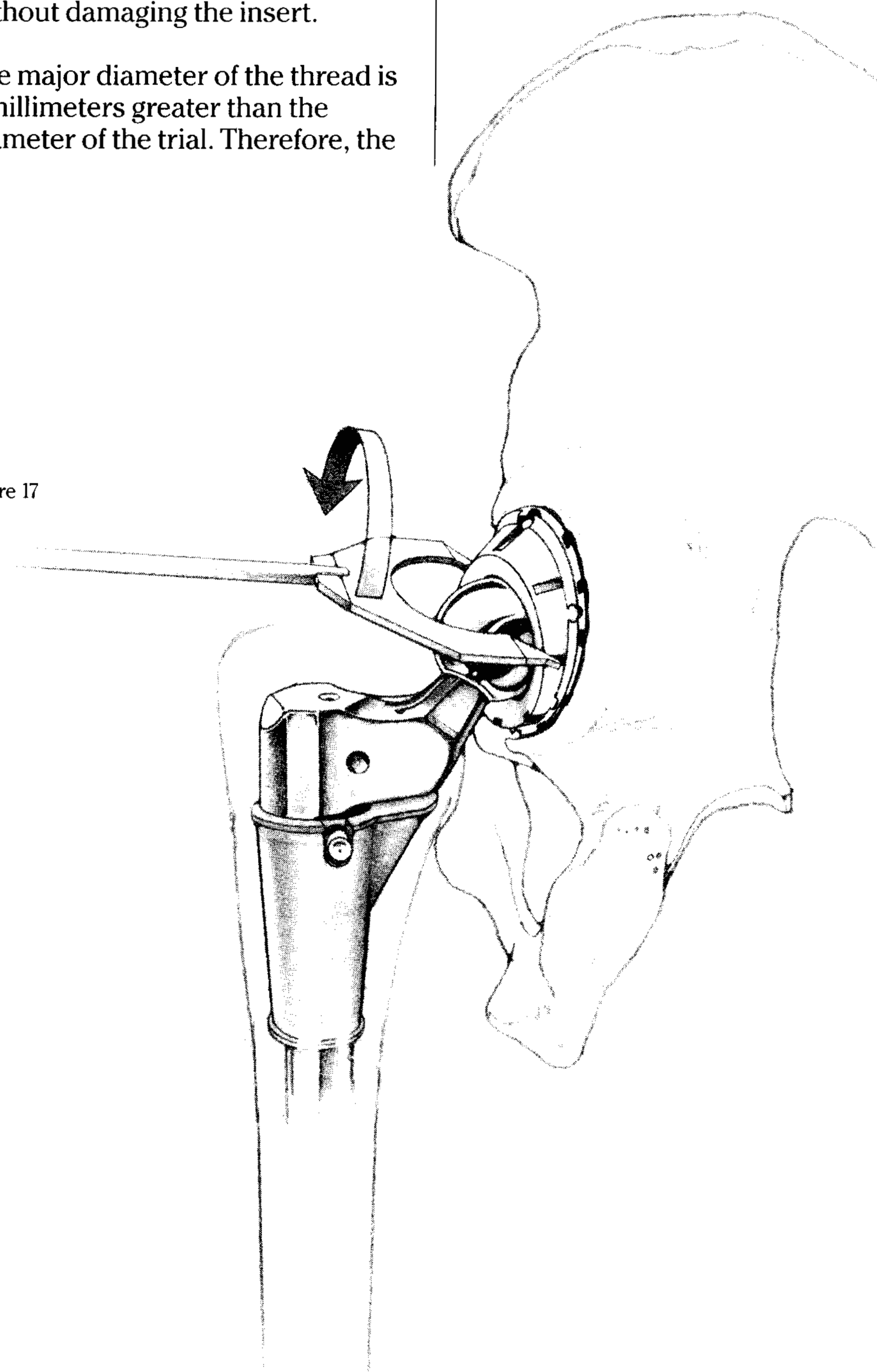
Figure 16




The S-ROM system also is the first and only system that features the unique POLY-DIAL insert system *(Figure 17)*. This truly unique and patent-pending system allows the surgeon to dial the 10°, 15° or 20° insert out of the way for ease of relocation of the femoral head and then, with the head in place, to dial the offset insert to one of six locations to insure maximum joint stability. POLY-DIAL inserts can also be rotated and removed without damaging the insert.

The major diameter of the thread is 5 millimeters greater than the diameter of the trial. Therefore, the penetration of each thread is 2.5 millimeters relative to the dome and flute spherical surface. The actual thread minor diameter, or root diameter, is such that the root of each thread lies 0.5 millimeter below the dome and cutting flute's spherical surface, thus allowing 0.5 millimeter space for bone chips from thread cutting to accumulate *(Figure 18)*. This, again, is a unique design feature found only in the S-ROM Anderson acetabular cup.

Figure 17



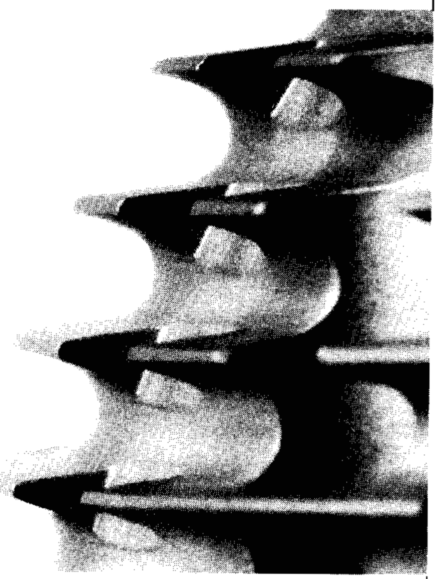


Figure 18

If basket reamers are used to enlarge the acetabular bony bed, the final reamer should be the S-ROM or Myra type which does not collect bony debris. This bony debris will function as a biological graft which will be entrapped between the threads and grooves of the Anderson cup during insertion. It is also recommended that irrigation should be used during reaming to reduce the possibility of burning the bone.

If a femoral allograft has been used in a deficient acetabulum, longer bone screws are available to help stabilize the graft *(Figure 19, 20).* To date, this is a unique design feature found only in the S-ROM Anderson cup.

Figure 19

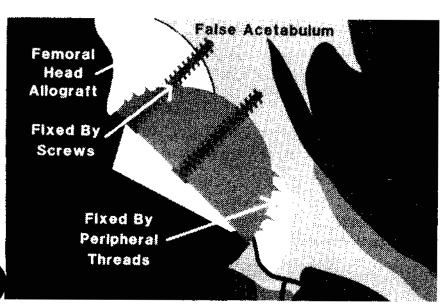
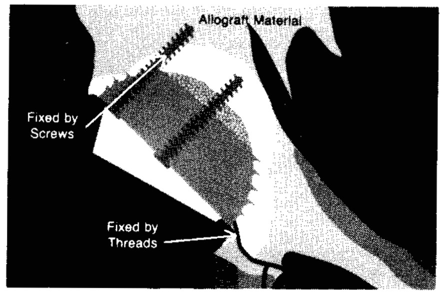



Figure 20




Threaded acetabular components are not all the same, just as porous and cemented designs are not all the same. It is vital to fully understand the chosen design and the required technique for that design to insure a good, long lasting result.

Another unique concept for threaded acetabular components is the S-ROM SuperCup™ threaded device *(Figure 21).* There is no question that this design is a highly sophisticated and exciting concept. This device will be featured separately in a future *Reconstructive Review* article.

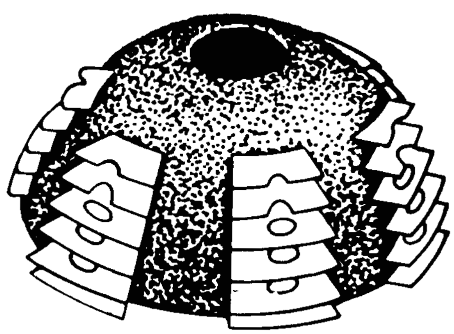


Figure 21

## Key Words

**truncated** (trun′ cā·ted) **1.** cut short or appearing as if cut short. **2.** having the vertex cut off by a plane: said of a cone or pyramid.

**cone** (cōne) **1.** a solid with a circle for its base and a curved surface tapering evenly to an apex so that any point on this surface is in a straight line between the circumference of the base and the apex. **2.** a surface described by a moving straight line passing through a fixed point (called the vertex) and tracing any fixed curve at another point.

**geometrical cone**

**conical** (con′ i·căl) **1.** shaped like a cone.

**ellipse** (el·lipse′) **1.** the path of a point that moves so that the sum of its distance from two fixed points is constant. **2.** a closed curve produced when a cone is cut by a plane inclined obliquely to the axis and not touching its base.

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# A Radiographic Technique For Threaded Acetabular Components

*By Robert C. More, M.D.*
*Harlon C. Amstutz, M.D.*

## Purpose

With the increased use of threaded acetabular components, it is important to have reliable means to objectively assess the quality of result. For the radiographic analysis, the most important parameters to evaluate with serial radiographs include: 1) shift in position of the component, and 2) quality of the bone/component interface. The grid radiograph has greatly facilitated the evaluation of subtle changes in component position[1]. The present study was undertaken to devise a method for reliable interface analysis.

## Methods

On a routine AP radiograph of a hip with a threaded component in place, the bone/component interface is not usually seen well, because the threads appear overlapping, and the bone between the threads is obscured *(Fig. 1)*. The reason is that the threaded cup (like all acetabular components) is usually inserted into the acetabulum with some amount of anteversion. The more anteversion that is present, the more that the threads overlap.

Fig. 1 Mecron Threaded Ring

This can be demonstrated by simply holding a threaded device in front of you, rotating it to simulate different orientations in a pelvis, and viewing the threads of the component.

It is apparent that in order to see the threads in profile, and to see the bone/component interface between the threads, the x-ray beam must be parallel to the plane of the threads. This can be accomplished by moving the x-ray tube in two possible directions:

1. Standard AP Radiograph
2. Caudad Radiograph

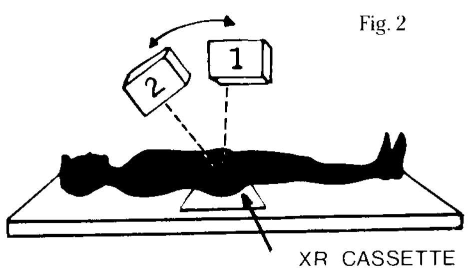



Fig. 2

1. Standard AP Radiograph
2. Oblique Radiograph

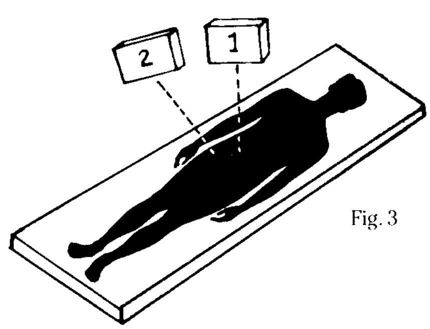



Fig. 3

Since the x-ray tube does not move in this fashion, the patient must be rolled on the table to obtain an oblique. *(Fig. 4)*

1. X-ray Tube Overhead

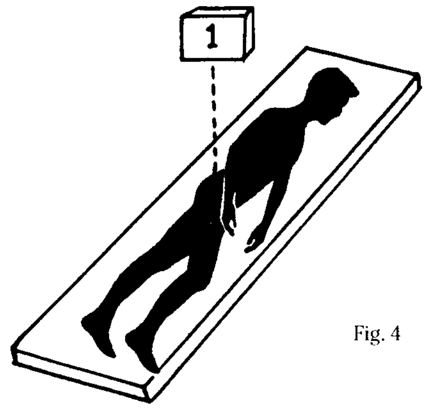



Fig. 4

For this study, a threaded screw-ring component was placed into a dried cadaver pelvis with 20° of anteversion. Serial radiographs were taken of the cadaver pelvis with: a) varying degrees of caudad tilt to the x-ray tube at increments of 2.5 degrees, and b) varying degrees of obliquity of the pelvis at increments of 2.5 degrees.

## Results

### A. Caudad Radiographs.

1. The only angle of tilt which visualized well the threads in profile was 20°. At 17.5 or 22.5 degrees, the threads overlapped and obscured the bone between them. Thus, there was little room for error in terms of angle of tilt.
2. It was evident that with increased anteversion of a component, increased caudad tilt would be required. This would have the undesirable effect of magnifying the image of the component, since the x-ray cassette would be further away from the component *(Fig. 2)*.
3. Since the cassette is not perpendicular to the x-ray beam *(Fig. 2)*, the image of the component is distorted (superior aspect more magnified than inferior aspect).

### B. Oblique Radiographs.

1. The threads were seen best in profile at 20 degrees oblique pelvic tilt (pelvis rotated towards the acetabular component). However, the radiographs at 15, 17.5, 22.5, and 25 degrees were all acceptable in visualizing the bone/component interface between the threads. Thus, the angle of obliquity was not as critical; there was more room for error.

2. The amount of magnification of the component is less than on a standard AP radiograph, since the acetabulum is rotated closer to the cassette *(Fig. 4).*

3. Since the x-ray tube is directly overhead, the beam is perpendicular to the cassette, and there is no distortion in the shape of the component *(Fig. 4).*

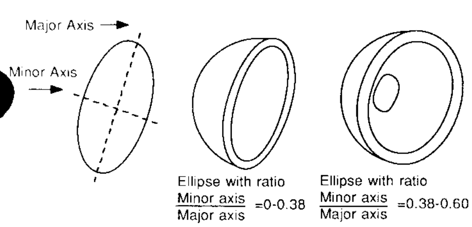
## Discussion

Clearly, oblique radiographs have several advantages over cuadad radiographs. Based on this study our current procedure for radiographing the threaded cups is as follows:

1. The amount of anteversion is estimated from the AP radiograph by examining the ellipse that is formed by the image of the mouth of the component. The anteversion can be estimated as either large or small, or can be determined precisely by measuring the ratio of the minor to major axes. *(Fig. 5)*

2. If there is a small amount of anteversion present, a 15 degree oblique radiograph is used; if there is a large amount, a 30 degree oblique is used. The patient is rotated towards the side to be radiographed.

Fig. 5



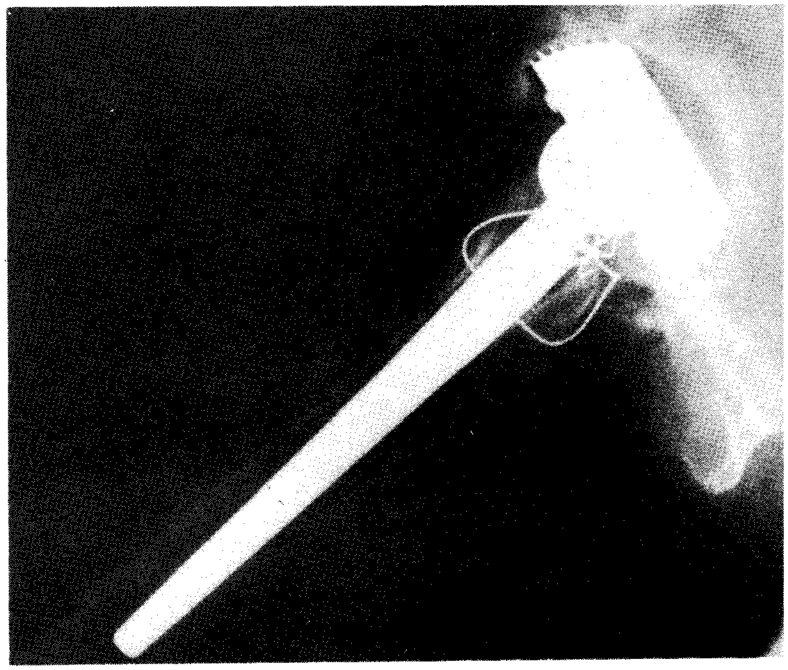



Fig. 6 Mecron Threaded Ring

3. The amount of obliqueness can be reproducibly obtained by placing wedges under the pelvis of the patient. We have constructed ours from Lucite®, but sturdy foam wedges at 15 and 30 degree angles are available commercially. The angle of obliqueness is checked with an inclinometer placed on both anterior superior iliac spines of the patient.

4. For the 30 degree oblique we have found it useful to flex and abduct the patient's hip, and rest the thigh against the table. This helps stabilize the pelvis during the radiograph.

5. If the patient is able to abduct sufficiently, the oblique radiograph can be combined with the modified frog leg lateral, which is the best lateral view of stemmed femoral components. This decreases the x-ray exposure to the patient.

6. Either the 15 or 30 degree oblique is usually sufficient. Rarely, in cases when the anteversion of the component exceeds 40 degrees, it has been necessary to take 45 degree oblique views. This can be done by combining the wedges. We have found it to be more difficult to reproducibly obtain 45 degrees of obliqueness, and the inclinometer on the iliac spines is especially useful.

## Conclusion

With this simple technique, we have been satisfied with the quality and reproducibility of the serial radiographs. Figure 6 shows the oblique radiograph in the same patient as in Figure 1. The threads are well visualized in profile, enabling the bone/component interface to be well seen. A radiolucency is visualized on this view, especially around the inferior threads, which is not seen as well on the AP film. Clinically, this patient has symptoms consistent with loosening of a Mecron screw-ring.

## References

1. Ouzounian, T.O., and Amstutz, H.C.: The Grid Radiograph. J. Bone and Joint Surg., in press 1986.

## Upcoming Events Co-Sponsored by JMP

**"Uncemented Total Joint Replacement,"** postgraduate CME seminar. *November 24-26, 1986 - The Registry Resort, Scottsdale, Arizona.* Presented by Harrington Arthritis Research Center. Course Co-Chairmen: Allan M. Weinstein, Ph.D. and Anthony K. Hedley, M.D. For enrollment information, contact Barbera Hawn at (602) 254-0377.

**"Current Concepts in Implant Fixation,"** postgraduate CME seminar. *December 11-13, 1986 – Marriott's Orlando World Center, Orlando, Florida.* Presented by: The Mt. Sinai Medical Center, Cleveland, Ohio. Course Director: A. Seth Greenwald, D.Phil. (Oxon). For enrollment information, contact Deborah L. Donerson at (216) 421-3968.

**"Current Cementless Concepts and Controversy in Total Hip Arthroplasty."** postgraduate CME seminar. *March 23-27, 1987 – Sandals Royal Caribbean Resort Hotel, Montego Bay, Jamaica.* Presented by: Joint Implant Surgery and Research Foundation. Course Co-Chairmen: J. Dennis Bobyn, Ph.D. and Charles A. Engh, M.D. For enrollment information, contact J. Dennis Bobyn, Ph.D. at (703) 979-0761 or Charles O. Bechtol, M.D. at (213) 874-5031.

**"The Early Results with an Uncemented Acetabular Screw Cup,"** by Hugh U. Cameron, Charles A. Engh and Thomas H. Mallory. A scientific exhibit at the *1987 AAOS Meeting in San Francisco.*

## Next Issue

- Interview with leading orthopaedic surgeons discussing CDH and its surgical treatment.
- Clinical review by leading orthopaedic surgeons of S-ROM Threaded Acetabular Components with a minimum of six month follow-up.

## Editorial Comment

*Reconstructive Review* would like to thank Doctors More and Amstutz for their contributing article in this publication.

We welcome your comments and suggestions concerning this publication. Additional copies are available upon request.

*Timothy McTighe*
*Editor*

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