CUSTOMIZED MRI NAVIGATED KNEE REPLACEMENT SURGERY

INTRODUCTION:
Total knee replacement surgery through advances in implant design, sizing options and surgical techniques has experienced shortened recovery times and improved knee function. However there has been little improvement in the advance planning of knee replacement surgery. Now new MRI based technology offers the surgeon the opportunity to precisely plan a customized three-dimensional surgical strategy for each patient.

CONVENTIONAL SURGICAL PLANNING:
In the past, planning was based on use of transparent “templates” that were superimposed on a patient’s knee x-rays. This type of templating is inaccurate and the variability in the degree of magnification of standard images can range from as little as 10% to as much as 25%. For digitized x-rays on a disk or computer there is no standardization of image size making pre-op templating of these films often useless.

As a result, surgeons typically depend on planning the knee replacement intra-operatively. Leg alignment is set by the use of rods placed inside the canal of the femur and tibia or by use of an external rod system that the surgeon “eyeballs” to make parallel to the bones of the leg. Implant size and rotational position is determined by use of intra-operative tools that measure dimensions and configuration of the knee. Bone loss and deformity due to arthritic wear can lead to inaccuracies when using intra-operative tools.

MRI BASED CUSTOMIZED SURGICAL PLANNING:
General Concepts: To overcome these surgical planning deficiencies new customized MRI based technology has evolved. This technology allows the surgeon to precisely determine in advance the appropriate size and three-dimensional position of the knee replacement components relative to the overall alignment of the leg.

Technique of MRI Customized Surgical Planning: The customized planning technique requires performing a pre-operative MRI of the affected leg. The MRI maps the anatomy of the arthritic knee and its position relative to the hip and the ankle. Deformities such as a “bowed” or “knock kneed” alignment are measured. This MRI data is then digitally sent to the implant manufacturer. Biomet, through it’s proprietary “Signature” technology utilizing its “Vanguard” knee implant system is the leader in this field (www.biomet.com/patients/signature.cfm). The MRI data once received is analyzed via the programmed Signature protocol and the surgical plan created. The implant size that provides for the best fit according to body type and gender is selected. Bone cut depth, alignment and three dimensional implant rotational position is planned. After its creation, the plan is then e-mailed to the surgeon for review. If correct, the surgeon may approve the plan as is. A major advantage of Biomet’s Signature technology though is that if the surgical plan is not felt to be optimal, the surgeon has the opportunity at this time to alter the plan in any manner desired. Once approved the surgical plan is then e-mailed back to Biomet. Customized guides based on the plan are manufactured. These guides are then shipped to the surgeon and become the intra-operative tools used to align and position the implants. The “turn around time” from MRI to receipt of the surgery ready custom guides is 5 weeks.
ADVANTAGES OF THE MRI NAVIGATED CUSTOMIZED SYSTEM:
The Signature MRI based customized planning system has several advantages:
1. Shorter operative time – Intra-operative time spent making decision regarding size and implant position is minimized.
2. Minimally invasive surgery - The custom Signature guides are very low profile. The result is that the surgeon can avoid extensive cutting into the quadriceps muscle. Protection of the quadriceps muscle (quad sparing) is the single most important factor in minimally invasive surgery leading to a more rapid recovery.
3. Greater accuracy in sizing and aligning implants.
4. Better balance and stability of the knee ligaments – Knee ligament stability is dependent on many factors, but a key factor is accurately positioning the implants in the knee.
5. Greatly reduced inventory of instruments required to perform the surgery. Simplifying surgical instrumentation reduces costs and streamlines operating room instrumentation setup. This streamlined OR setup reduces risk of contamination and infection.

CANDIDATES FOR MRI CUSTOMIZED KNEE REPLACEMENT SURGERY:
Most patients who can safely undergo the 30 minute MRI procedure are candidates for MRI customized knee replacement surgery. Very heavy patients may have trouble with the confines of the MRI machine. MRI testing for a patient with a heart pacemaker is usually contra-indicated. Also patients with metal hardware in the knee, hip (including the presence of a hip replacement) or ankle are excluded.

CONCLUSION
MRI based customized advance planning of knee replacement surgery has several potential advantages over conventional x-ray based pre-operative planning. These include shorter operative times, more accurate implant positioning and sizing, more minimally invasive surgery, and potentially fewer complications due to a more streamlined and simplified operative procedure.

Figure 1. The customized tools are pinned onto the end of the femur and tibia. Bone cutting guides are then positioned over these pins. For animation see: http://www.biomet.com/patients/signatureTechniqueAnimationVideoPopup.cfm