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Patient matched total knee replacement

The early results of this exciting new technology are very promising. Patient matched surgery allows accurate cuts and implant placement which should improve the end result of the operation.

Total knee replacement is probably the only operation that has been shown to be cost effective for the community. It restores function to patients, reducing their reliance on other people and therefore reduces the burden on society. Six months after joint replacement significant improvements are seen in global health and in functional status[1]. Currently it has better than a 95% success rate with most implants lasting up to 15 years.

Traditional surgery

Knee replacement has been around since the 1970's. Over the years techniques evolved to make the cutting guides more accurate and easier to use. Unfortunately this involved placing metal rods in the patients medullary canal. This was used to judge alignment and rotation and often resulted in fat embolism and blood loss. Even with this technique it was possible to malrotate the components because rotation was determined by visual inspection or manual palpation of anatomic landmarks.

Computer assisted surgery

In the last five years or so new technologies have been used to improve the alignment of the prosthesis during the surgery. Tools to measure how accurately we are able to implant the prosthesis have improved tremendously and this should result in better outcomes for patients.

We know that if an implant is inserted more than three degrees away from it's optimal position then it tends to wear out faster. Alignment of the prosthesis can be difficult to judge when using a small incision around the knee.

Computer assisted surgery was a major breakthrough because it allowed the surgeon to measure the alignment of the implant during the operation for the first time. Bony landmarks were registered by the surgeon into a computer and tracking markers were drilled into the femur and tibia. The computer was able to give feedback to the surgeon as to the alignment of the cutting blocks and the bone resections.

Unfortunately the computers did not help control the rotation of the implant and only partly reduced the likelihood of creating a fat embolism. The disadvantage of using computer assisted systems is that they require extra instrumentation, lengthen the surgical time and create extra

potential complications for the patient (such as a fracture where the guide pins are inserted). The hospitals also have to buy expensive computer systems and an extra person is required at each operation to run the computer.

Patient matched surgery

The next generation of computer assisted surgery attempts to address these short comings. Computer analysis is now used in the planning stage of the surgery rather than during the operation itself. This is called "patient matched instrumentation" and no longer requires the previous expensive computer systems in the operating theatres or staff to run them. Slightly more effort is required from the surgeon before the operation but this is more than compensated for by having a quicker and easier operation

Which companies?

Currently the main companies using this technology are: Smith & Nephew's Visionaire Patient Matched System; OtisMed Custom-Fit Knee Replacement System; Depuy Tru-Match Personalized Solutions for Knee Replacement; Biomet Vanguard and ConforMIS Patient Specific Knee Implants but most companies are following suit.

What is patient matched instrumentation?

The patient matched system is based on achieving a neutral mechanical axis so that the tibial and femoral components are aligned perpendicular to the mechanical axis of the tibia and femur. The preoperative planning helps the surgeon achieve appropriate axial rotation, sagittal alignment, flexion and extension gaps and sizing of the components.

The patient has an MRI and long leg Xray of the knee performed. The data from these images is processed by an engineer (with input from the surgeon) and a physical model of the patient’s bone is created. Specific anatomic points such as the center of the femoral head, the center of the distal femur, the center of the proximal tibia, and the center of the ankle are identified and used to establish mechanical axes of the femur and the tibia in the coronal and sagittal planes. Axial rotation of the knee is established using landmarks such as the geometric centers of the medial and lateral tibial plateau and the femoral epicondyles.

Measurements of the bone model are taken and the exact size of prosthesis to be implanted can be calculated before the surgery. Based on these models (and the surgeons clinical examination of the patient); a cutting block is generated for the patient. The cutting block guides the surgeon to cut off the exact amount of bone that will be replaced by the implant.

After the jigs are used to guide bone resection the operation proceeds as usual and the customary components are implanted. The surgeon is not constrained to the preoperative plan and can make adjustments during surgery if necessary.

The following items can be adjusted by the surgeon:

Thickness of resection

- Distal femur
- Posterior femoral condyles
- Proximal tibia

Alignment of components

- Varus/valgus of femoral component
- Varus/valgus of tibial component
- Rotation of femoral component
- Rotation of tibial component
- Flexion/extension of femoral component
- Slope of tibial component

Translation of components/bone resection

- Medial/lateral femoral component
- Medial/lateral tibial component
- Anteroposterior femoral component
- Anteroposterior tibial component

Referencing options for components/bone resection

- Anteroposterior axis of femur (Whiteside line)
- Transepicondylar axis
- Posterior condylar axis
- “Anterior referencing” for femur
- “Posterior referencing” for femur

‘SAW CUTTING THROUGH FEMORAL BLOCK’

Cost Savings

Significantly less equipment needs to be sent to the hospital because the exact size of the prosthesis to be implanted is known before the surgery. Less instrumentation is required during the surgery and so sterilization and courier costs are reduced. The blocks are shipped sterile for use during the operation.

Advantages during the surgery

During the surgery a standard (or slightly smaller) approach is undertaken to the knee. The block ‘locks into place’ on the femur in the exact position planned prior to the surgery. Since the block can only fit correctly in one position less exposure of the bone is required than was required for traditional surgery. This ensures that the alignment and rotation are correct with far less tissue trauma.

“TIBIAL CUT THROUGH BLOCK WITH BONE SAW”

Traditionally 6 blocks were used to check alignment and rotation but using the femoral cutting block eliminates the need to perform these steps. The surgery is quicker and reduces the chance of a fat embolism by eliminating instrumentation of the femoral canal. This reduces blood loss and surgical time which should lead to faster recovery and less pain. The surgeon is assured of good alignment and rotation and the patient has a shorter anaesthetic which also improves outcomes.

Benefits to the patient include:

- less time in surgery (shorter anaesthetic)
- reduced chance of a fat embolism
- reduced blood loss
- perfect alignment and rotation
- potentially a faster healing time

CONCLUSION

The early results of Patient Matched Total Knee Replacement Surgery are extremely promising. Those of us who have used the technique are convinced that it is a huge improvement over the previous surgical methods.

1. Arthritis Rheum. 1986 Aug;29(8):937-43 - **Cost-effectiveness of total joint arthroplasty in osteoarthritis;** Liang MH, Cullen KE, Larson MG, Thompson MS, Schwartz JA, Fossel AH, Roberts WN, Sledge CB.